Pacific Pests, Pathogens, Weeds & Pesticides - Online edition

Maximising biocontrol (outdoor vegetables) (472)

Important biocontrol agents (BCAs)

In this fact sheet we list the important biological control agents (BCAs); how to attract and conserve them, the risks from using different pesticides, and show how to maximise BCAs within an integrated pest management (IPM) framework.

Photo 1. Ladybird beetle larvae can be very numerous on foliage, and large larvae can eat many small insects every day.

Photo 2. The most important ladybird beetle predators are those that breed in crops where eggs, larvae, pupae and adults occur.

Photo 3. A large hoverfly larva eating aphids. A large larva can eat 20 to 30 aphids a day.

Photo 4. Rove beetle searching a bean flower for food.

Predatory insects: ladybird beetles; hoverflies (or syrphid flies); lacewings. Note, they:

- Reproduce in crops or in weeds nearby.
- Often eat many kinds of insects, whether pests or BCAs (i.e., they are polyphagous).
- Are continuously available from planting to harvest.
- Lay their eggs near pest prey.
- Differ according to the life stage that attacks pests. For some it is the adult, but for others it is the larva (or maggot), or both, i.e.:
    - **Ladybird beetles** (Photos 1&2): the adults and larvae eat other insects (**see Fact Sheet no. 083**).
    - **Hoverflies** (Photo 3): only the larvae (maggots) eat other insects; adults feed on nectar and pollen (**see Fact Sheet no. 084**).
    - **Rove beetles** (Photo 4): adults and larvae eat other insects.
    - **Lacewings**: green lacewings - only the larvae eat other insects, and the adults feed on nectar, pollen and honeydew; brown lacewings - adults and larvae eat other insects (as well as spider mites) (**see Fact Sheets nos. 270 & 406**).

Parasitic wasps (Photos 5-11, Diagram). Note, they:

- Usually they attack one or a few species of pests.
- Reproduce by female wasps laying eggs in or on bodies of host insects - eggs, larvae, pupae or adults. The eggs hatch and wasp larvae consume the host insect eventually killing it and forming pupae. Some species produce one pupa from a host, others produce many.
- Require nectar-producing plants; adult wasps need sugar resources to develop their eggs.
- Lay eggs inside larvae, pupae or adults of pests, depending on the species. They kill their prey and are called *parasitoids*. Some attack many different pests, e.g., *Aphidius* species prey on aphids, others are specialists with a very narrow host range, e.g., *Cotesia vestalis* preys on diamondback moth caterpillars. (**See Fact Sheets nos. 287 & 285**).

Spiders. Note, they:

- Are not insects; they have eight legs (Photos 12&13)
- Eat many types of insects (polyphagous), pests and other biocontrol agents.

Management of Biocontrol Agents

- Conserve BCAs by avoiding broad-spectrum pesticides - synthetic pyrethroids, organophosphates and carbamates.
- There is no need to attract many of the important BCAs. Note the following:
    - Many BCAs move into crops very soon after crop germination, or when transplants are moved to the field.
    - Spiders and lacewing adults can be located in the middle of newly transplanted crops within 1-2 days.
    - Many BCAs use signals from plants that help them detect when crops are infested with their prey; for example:
        - Hoverfly and lacewing females can detect prey and will lay a small batch of eggs next to them.
        - Female parasitoid wasps can detect volatiles from damaged plants to attract them to chewing pests, such as caterpillars.
- If there is need to attract BCAs, do the following:
    - Grow flowering plants near crops, providing food sources (pollen and nectar) for hoverfly adults, parasitoid wasps, and pollinating insects. Note, it is probably best to limit this to brassica crops to avoid growing flowering plants that harbour thrips, polyphagous aphids and those aphids that spread viruses.
    - Plant grasses near vegetable crops to attract BCAs such as ladybird beetles and lacewings; they will be attracted initially by the grass aphids and other insects, and later spread to the vegetable crops. Note, grass insects are not likely to infest vegetable crops.

Pesticides compatible with BCAs

- Pesticides belong to several different chemical groups and so their impact on BCAs differs. Those that contain active ingredients that are toxic to a wide range of pests and non-target pests should be avoided, the so-called broad-spectrum insecticides.
- Impacts on bees must be considered for any product. Remember bees and parasitic wasps are in the same order, the Hymenoptera, so their reaction to any pesticide is likely to be similar.
- Also, consider the behaviour of BCAs. Many are on the foliage when sprays are applied, and also come into contact with residues after spraying as they move about the foliage.

A summary of the risks that pesticides present to parasitic wasps, bees and predators is given below (Table 1).

Table 1. Active ingredients of insecticides and miticides, their mode of action (MoA) group numbers, risks to non-target natural enemies (parasitic wasps, bees and predators). [Risks of toxicities are averages of reported effects and should only be used as a guide. Toxicity of a specific insecticide depends on several factors, including formulation, application rate, environmental conditions, and life stage and species of the parasitoid or predator. The information for parasitoids is mainly on risks to parasitic wasps, but likely similar to that for bees, as both are beneficial insects in the Hymenoptera, the wasp family.]

Active ingredient	Mode of Action*	RISKS to parasitoids and bees	RISKS to Predators	Comments and Exceptions
Biopesticides and natural products				
Bacillus thuringiensis var. *kurstaki*	11	Very low	Very low	
Bacillus thuringiensis var. *aizawai*	11	Very low	Very low	Reports of some risk to honey bees in laboratory feeding experiments
Beauveria bassiana	UNB3	Low	Low	Potentially pathogenic to bees. Some negative impacts on predators
Helicoverpa NPV	virus	Very low	Very low	
Soap	NA	Low	Low	
Mineral oils	NA	Low	Low	Some toxicity to bees observed in field studies
Vegetable oils	NA	Low	Low	
azadirachtin/Neem oil	UN2	Low	Low	Toxic to bees if ingested. Indirect effects on early instars of some natural enemies
oxymatrine	UN	Low	Very low	
sulphur	NA	Low	Low	Some risk to egg parasitoids
spinosad	5	Moderate	Low	Direct spray is toxic to bees, but dry residues should not affect foraging bees. High risk to egg parasitoids
rotenone	21B	High	Low	Moderate risk to bees
pyrethrin/pyrethrum	3	High to moderate	Moderate	Very toxic to all beneficials on contact short term, but not persistent
Other IRAC* Mode of Action (MoA) groups				
pirimicarb	1	Low	Low	Some risk to bees, egg parasitoids and hoverfly
Other carbamates, carbaryl, methomyl, etc.	1	High	High	Not suitable for use
Organophosphates	1	High	High	Not suitable for use
fipronil	2	High	Moderate to low	Dangerous to bees. High risk to egg parasitoids
Synthetic pyrethroids	3	Very high	Very high	Not suitable for use
imidacloprid, thiamethoxam, clothianidin (as seed treatment or soil drenches)	4A	Low to moderate	Variable	Toxic to predatory sucking bugs. Some indirect effects on predators feeding on intoxicated sucking bugs
acetamiprid, thiacloprid	4A	Moderate	Moderate	This 'cyano' group of neonicotinoids exhibit lower toxicity to bees than the 'nitro' group
imidacloprid, thiamethoxam, clothianidin, dinotefuran (as foliar sprays)	4A	High to moderate	Moderate to high	This 'nitro' group of neonicitinoids are high risk to bees and egg parasitoids. Toxic to bees exposed to direct treatment or residues. Toxic to predatory sucking bugs and chewing beetles
spinetoram	5	High	Variable	Direct spray is toxic to bees, but dry residues should not affect foraging bees

emamectin benzoate	6	Moderate	Low to moderate	Some risk to bees and predatory sucking bugs
abamectin	6	High	Moderate to high	Prolonged impact on bees, predatory mites, some parasitoids and predators
pyriproxyfen	7	Low to moderate	Low to moderate	Indirect impact on larvae and pupae of bees and parasitoids. Some toxicity with direct contact with predatory sucking bugs and predatory beetles
pymetrozine	9	Low	Low	Some impact to bees observed in the field. Minor impact on parasitoids and ladybird beetles
diafenthiuron	12	High	Moderate	High risk to bees
chlorfenapyr	13	Moderate	Low	High risk to egg parasitoids. Foraging behaviour affected in bees
novaluron, lufenuron, diflubenzuron	15	Low	Low to moderate	Some toxicity to bees. Indirect effects on larval stages of some general predators
buprofezin	16	Low	Low	Risks to larvae of ladybird beetles. Indirect effects on early instars of some natural enemies
fenpyroximate	21A	Very low	Very low	High risk to predatory mites
indoxacarb, metaflumizone	22	Moderate	Low	Some risk to bees and predatory beetles
spiromesifen, spirotetramat	23	Low	Low	
chlorantraniliprole, flubendiamide	28	Low	Low	
cyantraniliprole	28	Low	Very low	High risk to bees if applied during flight, but dried residues have minimum impacts
^metaldehyde	NA	Low	Low	High risk to ground predators that consume metaldehyde-intoxicated snails and slugs
^iron phosphate	NA	Low	Low	

*IRAC (Insecticide Resistance Action Committee, www.irac-online.org)
^for control of snails and slugs.

Main sources for Table 1

Gardner-Gee R, Puketapu A, MacDonald F, Walker G, Connolly P (May 2013) Effect of selected oils and insecticides on beneficial insect species: 2013/14 results. A report prepared for: Potatoes New Zealand Ref: SFF11-058: Developing IPM tools for psyllid management in potato. Plant & Food Research Milestone No. 58208. Contract No. 30308. Job code: P/336016/12. PFR SPTS No. 10059.

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Ndakidemi B, Mtei K, Ndakidemi P (2016) Impacts of Synthetic and Botanical Pesticides on Beneficial Insects. Agricultural Sciences 7:364-372.

Walsh B (2005) Impact of insecticides on natural enemies found in brassica vegetables. Poster, National Diamondback moth project team, Horticulture Australia Ltd.

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University of California Statewide Integrated Pest Management Program [accessed February 2021] http://ipm.ucanr.edu/GENERAL/pesticides.html.

IPM decision pathways

IPM consists of a number of linked actions which are most effective when coordinated by a Decision Pathway. The key components are as follows:

1. Scout crops:

- Careful, continuous observations in crops to:
  - Identify BCAs and pests present.
  - Carry out twice weekly surveys in tropical countries.
  - Assess increase/decrease in pest numbers and/or crop damage.

2. Identify infestations and record findings:

- After every scouting, summarise and record results:
  - Identify changes in infestations over time:
    - Record fresh damage.
    - Record crop growth stage.
    - Record over all health of the crop.

3. Assess RISKS:

- Stage of crop growth:
  - Seedlings - at high risk from virus vectors.
  - Leafy growth stage - relatively low risk from most pests.
  - Flowering stage - relatively high risk from flower thrips.
- Stage of pest life cycle:
  - Eggs and pupal stages - low risk (they cause no damage).
  - Small caterpillars - relatively low but increasing risk.
  - Large caterpillars - relatively higher risk.
  - Increasing numbers of high risk pests - increased risk.
- Wellness, weeds and weather:
  - Healthy plants with good nutrition and appropriate irrigation - low risk.
  - Weeds within a crop or nearby - increases risk.
  - Virus-infected plants adjacent to crop - high risk.
  - Cool weather - decreases risk from insect and mite pests (they develop and reproduce slowly).
  - Hot weather - increases risk from insect and mite pests (they develop and reproduce rapidly).
- Market:
  - A market that rejects or downgrades produce with minor pest damage - higher risk.

4. Make decision to Spray or Not-to-Spray (based on scouting results and risk assessment).

5. Choose pesticide (if decision is to Spray).

- Choose effective active ingredient to control target pest or pests:
- Low hazard to humans and animals.
- Low hazard to BCAs.

6. Assess history of local pesticide use:

- Rotate between different MoA groups if needed.
- Rotate between different MoA groups after 3-4 applications or 2-3 weeks of same pesticide.

7. Apply pesticide safely and effectively:

- Read the pesticide label.
- Check pesticide sprayer is operating correctly; check nozzle type.

8. Continue to scout crop:

- Assess:
  - Infestations.
  - Change of risks.
  - Efficacy of spray application.


Photo 5. A cocoon of a *Cotesia vestalis* that has killed a diamondback moth (*Plutella xylostella*) caterpillar (larva). Other *Cotesia* species attack the larvae of other important pests.


Photo 6. Wasp parasitoid emerging from a cocoon.


Photo 7. Cocoon mass of *Cotesia* species that parasitise *Spodoptera* and other caterpillars.

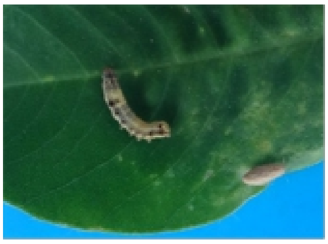
Photo 8. A cocoon formed by the larva of a parasitoid wasp that emerged from the body of the dying *Spodoptera* caterpillar.


Photo 9. An empty skin of an aphid (called a mummy) that has been parasitised by a parasitic wasp, *Aphidius* species.

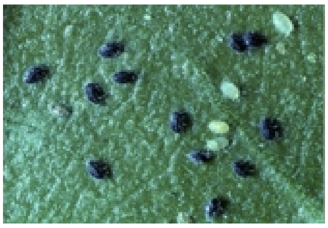

Photo 10. Whitefly nymphs change from white to black when parasitised by *Encarsia* species.

Photo 11. An adult parasitoid wasp.

Photo 12. Lynx spider (Oxyopid); a foliage-dwelling predator that mostly ambushes its prey.

Photo 13. Wolf spider (Lycosid); a soil-dwelling predator, commonly found where plastic mulch is used.

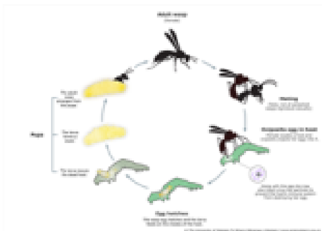

Diagram. Life cycle of a larval parasitoid (one adult wasp emerges from each host caterpillar).

AUTHORS Graham Walker & Grahame Jackson

Information from Gardner-Gee *et al.* (2014) Effect of selected oils and insecticides on beneficial insect species: 2013/14 results. Report for Potatoes NZ. Plant & Food Research; and May *et al.* (2015) Minimizing Pesticide Risk to Bees in Fruit Crops. Extension Bulletin E3245, May 2015, Michigan University; and Ndakidemi B, *et al.* (2016) Impacts of Synthetic and Botanical Pesticides on Beneficial Insects. Agricultural Sciences: 7, 364-372; and Walsh B (2005) Impact of insecticides on natural enemies found in brassica vegetables. Poster, National Diamondback moth project team, Horticulture Australia Ltd.; and from University of California Statewide Integrated Pest Management Program.

(http://ipm.ucanr.edu/GENERAL/pesticides.html). Diagram Science Learning Hub. Pokapū Akoranga Pūtaiao, University of Waikato.

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