14. Integrated Pest Management and Protecting Natural Enemies and Pollinators

Integrated Pest Management

Integrated pest management (IPM) is an approach to pest management that integrates all available practices and technologies to keep pest populations below economic thresholds while minimizing the impact to the environment. In this approach, chemical control is applied only when thresholds are reached and when other available approaches have not effectively managed the pest. Some of the first steps to IPM are to better understand each pest, its life cycle and its impact on the crop, so that scouting and preventative and cultural measures can be timed appropriately. Often producers are implementing cultural components of IPM under typical farming practices without always realizing they are considered part of IPM. Examples include crop rotation, variety selection, tillage and early harvest to reduce disease and quality concerns.

The principles of IPM include:

1. **Knowledge and proper identification of pests, diseases and weeds**

- knowing the key pests for each crop grown, and how to properly identify them and the damage they cause
- understanding the different crop stages and which are most at-risk from each pest
- knowing what weather conditions allow the pest to thrive
- understanding the impact each pest can have on the crop
- understanding that the presence of a pest does not necessarily result in economic damage
- being aware of the pest's life cycle and which stages do damage
- recognizing each pest's natural enemies and being aware of the presence of natural enemies

2. **Preventative measures (also known as cultural control)**

- rotating crops to ensure susceptible crops are not planted in the same field each year, helping to break some pest life cycles
- preparing the field to reduce risk (e.g., good weed management prior to planting and tillage practices to remove crop residue for certain disease management)
- planting certified seed and keeping field equipment free of soil and plant debris
- cleaning bins before storage
- selecting varieties proven to tolerate disease and that yield well under stress
- adjusting planting times to avoid damage from pests
- planting into good growing conditions to ensure good crop establishment
- managing nutrients to maintain good soil and plant health without increasing the risk to the environment or promoting certain pests
- encouraging biodiversity through natural habitat establishment for natural enemies (e.g., cover crops and buffer strips)

3. **Assessing fields for pest populations**

- understanding and using prediction models that indicate level of risk
- timely and regular scouting to determine presence of pests and natural enemies
- setting up traps and using appropriate monitoring tools where needed (e.g., sweep nets, hand lens, scouting guides and identification books)
- understanding economic injury levels versus thresholds and knowing when management is required
- being aware of secondary pests that may become a problem once chemical control is applied and natural enemies become absent
- seeking help with proper diagnosis/identification when needed

4. **Managing pests using the least destructive methods**

- cultural control — removing weed escapes, maintaining good soil health, planting Bt hybrid corn and refuge, timely harvest and other preventative measures
- biological control — helping to encourage predators, parasitoids and pathogens that control pests and giving them a chance to control the pest

- chemical control — applying pesticide only when thresholds have been reached, selecting products that are the least harmful to natural enemies and pollinators, paying attention to re-entry and pre-harvest intervals and rotating chemical families and technologies to reduce the risk of resistance developing

5. **Evaluation and modification**

- returning to the field after control measures have been implemented to determine their success
- looking for secondary pests or resurgence of the main pest
- monitoring for resistance development
- maintaining good scouting records each year for reference when susceptible crop is planted again or pest issues arise

Promoting and Protecting Natural Enemies

There is an increased interest in "conservation biological control," which involves managing the agricultural landscape to promote natural enemies and help suppress pest infestations. Though much research is still needed in this area, there is evidence of some successful practices that can increase natural enemy abundance. It is well known that monoculture cropping systems tend to decrease natural enemy diversity and therefore increase the frequency of pests. Perennial crops like mixed forages tend to support a diverse community of natural enemies compared to annual crop species. By increasing plant biodiversity across the agricultural landscape, particularly with perennial species like trees and shrubs along field boundaries, natural enemy abundance increases. These buffer strips, or natural habitats, help to provide predators and parasitoids with shelter, pollen and nectar sources and some protection from the pesticide applications taking place in adjacent fields. However, plant selection is important to not encourage pest populations that may be equally attracted to these plant species. Also, these buffer strips should not be encouraged in a food-grade cropping system where plant viruses carried by these bordering plants can be vectored to the crop by aphids and other pests, and can impact quality. Intercropping/strip cropping has also shown some potential but requires a thorough understanding of the pest history of each field before pursuing, to ensure pest problems do not increase because of the companion crops planted.

Tillage can have a negative impact on natural enemies, as many species use the crop residue as shelter and overwintering habitats. Moving towards a no-till or reduced tillage system needs to be well thought out, as it can increase the risk of some soil pests and diseases depending on soil type and crop rotation.

A significant component of natural enemy conservation is selective use of pesticides. Applying pesticides only when pests have reached threshold can help reduce harm to the natural enemies. Selecting reduced-risk insecticides belonging to chemical families that are less harmful to natural enemies is a positive step. Spot treating where the pest problem occurs can also reduce the risk to natural enemies. Frequent use of foliar fungicides has been shown to reduce the presence of entomopathogens (fungi) that control insects. Use foliar fungicides only when necessary. The use of systemic insecticide seed treatments can have a negative impact on natural enemies in two ways:

- indirectly, by suppressing the pest population year after year so that the fields are not able to sustain a natural enemy population
- directly, by the natural enemy feeding on prey that contains the insecticide, which then kills the natural enemy

Weather can have a big impact on natural enemies. Harsh winters tend to greatly impact some species and can delay their ability to respond to spring pest infestations. Cool wet conditions can also be more detrimental to natural enemies than the pest species, while warm moist conditions, particularly when the crop canopy is closing, can help promote entomopathogens. Hot dry conditions are harsh to many natural enemy species and increase the crop's susceptibility to stress incurred by pests and diseases.

Simply recognizing some of the key natural enemies of the pests of field crops can increase awareness of their importance and help determine if and when chemical control is necessary. The natural enemies of soybean aphids in particular have proven their value in keeping aphid populations below threshold. Some of the most common natural enemies that can be found in field crops are described below.

For detailed information on the Neonicotinoid Regulations in Ontario and the Pollinator Health Strategy see Appendix G.

Predators

GROUND BEETLES

(Pterostichus melanarius, Carabus serratus, Agonum sp., Bembidion sp. and other species)

Description: Ground dwellers. Adult ground beetles are large (maximum 25 mm or 1 in.) flattened and oblong, typically dark black or brown though some have a variety of colours on their wings (Photo 14–1). Their heads are narrower than the thorax and they have very large mandibles (jaws). Adults can live for 1–4 years. Larvae are beige to black, with very large mandibles at the head and a pair of cerci (which look like tails) at the end of the abdomen.

Photo 14–1. Ground beetle adult.

Importance: Both adult and larvae play a major role in biological control and attack any insect or pest they encounter while walking along the soil surface. These insects very rarely fly. Some also eat weed seeds they find in the soil, including ragweed, lamb's-quarters, pigweed and foxtail. They are favoured by soil conservation practices and reduce pesticide use. Key pests they feed on include slugs, corn rootworm, caterpillars such as armyworm and cutworm, grubs and wireworms, to name a few.

LADY BEETLES

(Coleomegilla maculata, Coccinella septempunctata, Harmonia axyridis, Propylaea quatuordecimpunctata and other species)

Description: Plant dwellers. Adult lady beetles range in size from 1–10 mm (up to 0.4 in.) Most are oval in shape, though some are oblong. They vary in colour from red, pink, yellow or orange, with most having some spots or markings (Photo 14–2). The larvae are approx. 8–11 mm (0.4 in.) in size and look somewhat like tiny alligators in shape with spines along their back. They vary in colour but are usually black to blackish-grey with orange, red or yellow markings (Photo 14–3).

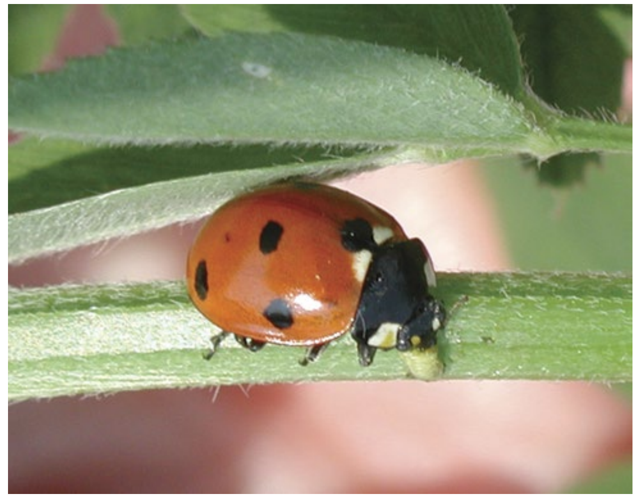

Photo 14–2. Lady beetle feeding on alfalfa weevil.

Photo 14–3. Lady beetle larvae look somewhat like tiny alligators.

Importance: Both adults and larvae are very important predators of many plant pests. Many overwinter in homes or sheltered areas like woodlots and under leaf litter. They are the most important natural enemies of soybean aphids, but also feed on many other pest species.

ROVE BEETLES

(Aleochara bilineata, Philonthus fuscipennis and other species)

Description: More often ground dwellers. Adult beetles from this family range in size up to 35 mm (1.4 in.). Most species have very short wings, which exposes most of their abdomen. This allows them to be very flexible, curling up the tip of their abdomen like a scorpion when disturbed or running. Larvae look somewhat similar to adults, but lack wings and are smaller in size (up to 25 mm or 1 in.). Having large mandibles at the front of the head, they are often mistaken for ground beetle larvae.

Importance: Both larvae and adults are predators. They can be found in almost all types of habitats though thrive in no-till and high residue fields. They are mainly predators or scavengers and feed on maggots, mites, small caterpillars and others.

PIRATE BUGS
(Orius insidiosus and others)

Description: Plant dwellers. Adult pirate bugs are tiny (up to 5 mm or 0.2 in.), teardrop shaped with black and white pattern on their backs (like a pirate flag) (Photo 14–4). Nymphs are similar in size and shape to adults, but lack wings and are yellow-orange to red in colour.

Photo 14–4. Minute pirate bug adult.

Importance: Pirate bugs feed on field crop pests including aphids, mites and small caterpillars but can also be found in flowers feeding on nectar. They are considered one of the more important predators of soybean aphids. Pirate bugs are very sensitive to insecticides. Use insecticides for pest management only when necessary.

SYRPHID FLIES
(Allograpta obliqua, Toxomerus germinatus, T. marginatus and others)

Description: Plant dwellers. Also known as hover flies or flower flies, many species of syrphid adults closely resemble bees with yellow and black markings, however, like all flies, they only have two wings — unlike bees which have four (Photo 14–5). Adults are often found hovering over flowers and plants as they feed on nectar and pollen of many different host plants. The larvae are headless, legless maggots, somewhat transparent green to yellow in colour with tapered bodies (Photo 14–6). They crawl along the surface of plant leaves, sucking on and killing any aphids or other small prey they come across.

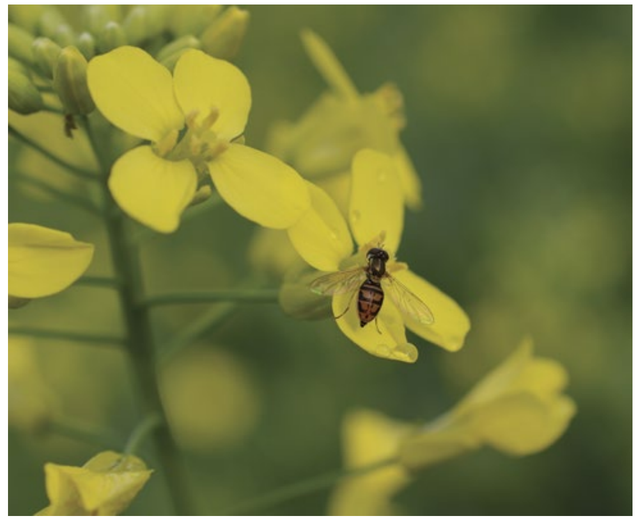

Photo 14–5. Syrphid fly.

Photo 14–6. Syrphid fly larvae.

Importance: Adult syrphid flies are very important pollinators. Syrphid fly larvae are very important in aphid, thrip and mite biocontrol and are one of the more significant predators of soybean aphids.

SOLDIER BEETLES
(Cantharis rufa, Ancistronycha bilineata and other species)

Description: Adults often found on plants, while larvae tend to roam the soil surface. Adults can be as large as 17 mm (0.7 in.) in size, vary in colour from red to orange or tan-brown, are long, somewhat rectangular in shape and slightly flattened. Wings are often shorter than the abdomen with a few abdominal segments exposed. Larvae are dark in colour, with very large visible mandibles and stubby, hairy bodies. They resemble rove beetle larvae but do not have cerci.

Importance: Adults mainly feed on pollen though some are predators. Larvae feed on slugs and other ground-dwelling insects.

Vertebrates

Many vertebrates including birds, like starlings and blackbirds, and mammals, particularly skunks and racoons, are generalist feeders and can be considered natural enemies of field crop pests. Unfortunately in some cases, vertebrates damage some crop while digging around in the soil for grubs or clawing open an ear of corn to get at western bean cutworm larvae. Their presence can help indicate a pest problem. It is not uncommon to see trenches dug by skunks along soybean rows in grub-infested fields. The observation of birds swooping into an alfalfa or wheat crop is a good indication that caterpillar pests like alfalfa weevil larvae or armyworm are present, and further scouting is necessary to determine if management is required.

Parasitoids

Parasitoids are organisms that lay their eggs on or in another organism. The larvae feed on their host then emerge as adults to begin the parasitism cycle again.

DIPTERA (FLIES)
(Tachinidae and other families)

Description: Tachinid adults often resemble the common house fly and are either grey, black or striped with many species possessing abdominal bristles. Their conspicuous white eggs can be easily spotted since the adult flies lay the eggs directly on the backs of the host insect. These eggs hatch and the tiny maggots (larvae) mine into the host to feed on it internally (Photo 14–7).

Photo 14–7. Armyworm and parasite.

Importance: Tachinid flies play a very important role as parasitoids of armyworm, but can also parasitize other pests such as black cutworm, European corn borer, cabbage looper, tomato hornworm and potato stem borer. True armyworm thresholds are based on the number of unparasitized larvae found, in hopes to reduce unnecessary insecticide applications when parasitism is high. Insecticides are detrimental to the tachinid flies.

HYMENOPTERA (WASPS)
(Aphelinidae, Braconidae, Campopleginae, Ichneumonidae and other families)

Description: Adults are wasps that are rarely larger than 15 mm (0.6 in.). They are usually dark coloured, though some are bright orange or red. These wasps lay their eggs on or inside their hosts (Photo 14–8). The eggs hatch and the larvae feed inside the host, eventually resulting in the death of the host.

Photo 14–8. Aphid and parasitoid wasp.

Importance: Some wasps will attack many different pests though often they are very specialized, adapted to parasitize one particular stage of one host species. They play a major role in the biological control of many different field crop pests including alfalfa weevil, European corn borer and soybean aphids, to name a few. There are many examples of successful classic biological control programs, where specific parasitoid wasps from the native countries of invasive species were found, reared and released in North America to help control the newly invading pest species. Two braconid wasps, *Microctonus aethiopoides* and *M. colesi,* are considered one of the most effective biocontrol agents for alfalfa weevil in Ontario and eastern North America after their release in the 1960s and 1970s.

Pathogens

These organisms (fungi, nematodes, bacteria and viruses) penetrate inside the insect and infect and kill the organism within a short time, if environmental conditions are ideal.

FUNGI
(Entomophthora muscae, Beauveria bassiana and other species)

Several fungal pathogens can infect insect pests. They do best when pest populations are higher, resulting in crowding and frequent contact, which helps to encourage spore development and spread. These pathogens typically require warm temperatures and higher humidity within the crop canopy to flourish. Pandora spp. in particular have been found to be very important entomopathogens of soybean aphids, particularly later in the season when the aphids start to migrate to buckthorn (Photo 14–9). Arriving aphids continue to spread the pathogen on the colonizing aphids on buckthorn, reducing the overwintering success of the pest. Unfortunately some research indicates that foliar fungicide applications can have a negative impact on these entomopathogens, increasing the risk of pest populations after their application.

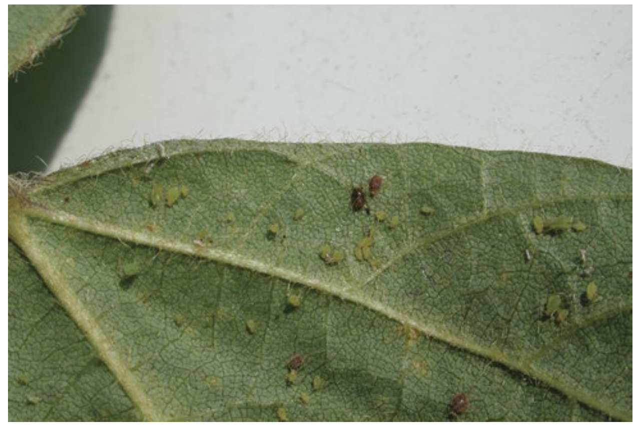

Photo 14–9. Fungal growth.

BACTERIA
(Bacillus thuringiensis, B. cereus, Burkholderia cepacia and other species)

The bacteria that attack insects naturally occur in the soil and are used to control a specific group of insects. The most common is *Bacillus thuringiensis* (Bt). Once ingested, the crystals produced by the bacteria are modified into toxic molecules of protein that destroy the host's stomach wall. The insects stop feeding within hours after exposure and usually die 2–5 days later. Foliar formulations of Bt are safe options for organic production systems. Bt corn, a.k.a. transgenic corn, is corn that has been modified to produce the insecticidal proteins that occur naturally in Bt. These Bt corn hybrids are targeted for control of either European corn borer or corn rootworm, or contain 2 strains of Bt that can control both pests.

NEMATODES
(Steinernema feltiae and other species)

Parasitic nematodes are naturally occurring, microscopic worms that enter their host and produce offspring, eventually killing the host. Nematodes require specific soil conditions to thrive, which sometimes limits their usefulness. Moist warm soils are more suitable for survival, often requiring irrigation to help maintain correct moisture levels. Nematodes have become a common biocontrol option for grub control in manicured lawns.

VIRUSES

Naturally occurring insect-killing viruses are present on the soil and plant surfaces. Once ingested, the infected insect usually climbs to the top of the plant before dying and disintegrating, aiding in the further spread of the virus. Baculoviruses are the most common viruses that infect insects, particularly caterpillars. Armyworm found dead, stuck to the tops of wheat heads or other host plants have been killed by a virus (Photo 14–10).

Photo 14–10. Armyworm killed by virus.

Protecting Pollinators and Beneficials

Honeybees, native bee species and other pollinating insects are important pollinators for many Ontario crops. Beneficial insects also play an important role in helping to keep pest populations below threshold. Protecting pollinators and beneficial insects requires careful management of insecticide use.

Follow integrated pest management practices and use insecticides only when necessary. This approach can include implementing cultural methods to discourage pests, correctly identifying the pest problem and understanding the factors that put each field at risk.

- Scout and determine if pests are present at threshold levels or that fields are at high pest risk before making a decision to treat with insecticide seed treatment, soil insecticides or foliar insecticides. Use insecticides only where necessary.
- If insecticide treatment is required, use the lowest effective rate available.
- Select insecticides that are less toxic to bees and other beneficial insects when possible.

Reduce risk of drift and time applications wisely

- Time insecticide applications to minimize bee exposure (e.g., apply post bloom).
  - daytime treatments, when bees are foraging, are most hazardous
  - insecticide applications in the evening are the safest, unless there is evidence of a strong temperature inversion
  - under normal circumstances, spraying after 8 p.m. allows the spray to dry before the bees are exposed to it the next day
  - early morning is the next best time, but complete spraying well before 7 a.m.
  - while honeybees and most other pollinating insects do not usually forage at temperatures below 13°C, bumblebees do
- Do not spray any flowering crop on which bees are foraging.
- To prevent drift toward nearby hives, do not apply insecticides on windy days.
- Take measures to reduce movement of insecticide-contaminated dust emitted from vacuum planters onto flowering plants and trees that are in or adjacent to the target field.
- Bees and other pollinators may be poisoned by visiting flowering weeds (e.g., dandelions) or flowering cover crops (e.g., clover) that have come in contact with an insecticide or dust contaminated with insecticide. Avoid drift to flowering weeds that are adjacent to or within the target field.
- Where possible, mow down flowering cover crops or flowering plants in and bordering target fields prior to the application to help safeguard the bees. Control dandelions and other flowering weeds within fields before spraying or planting seeds treated with an insecticide.
- Refer to the "Field Crop News" blog at fieldcropnews.com for current information on ways to reduce planter dust movement.
- Systemic insecticides may also pose a high risk to bees. Bees can be exposed to insecticide residues in or on flowers, leaves, pollen, nectar and surface water.
- Research indicates that use of vacuum (i.e., negative pressure) planters poses a significant risk of pollinator exposure, to drift of insecticide containing dust exhausted from these planters during planting. Take care to reduce/control insecticide containing dust exhausted from planters.
  - Follow the directions provided by planting equipment manufacturers and keep up to date on new use practices.

- Clean and maintain planting equipment regularly, including the fan housing and hoppers of air-assisted planters. For example, vacuum any dust remaining in the fan housing and hopper.
- Use deflector equipment, where appropriate, to direct exhaust to the ground level and thus reduce dust drift onto flowering plants and trees.

Communication and cooperation among producers, custom operators/applicators and beekeepers is important for honey bee protection. Before applying an insecticide (seed treatment, foliar, etc.), provide beekeepers within 5 km of the site advanced notice of the application, to ensure hives can be located strategically, temporarily protected or relocated where feasible. Beekeepers also need to communicate with producers as to where hives are in relation to their fields so producers can properly inform the beekeeper when an application is being made.

Contact information for the local beekeepers' associations can be found on the Ontario Beekeepers' Association website at http://www.ontariobee.com/community/local-beekeepers-associations.

Alternatively there may be "an app for that." Smartphone and websites have been developed to enhance communication. For example, CropLife and the Canadian Honey Council have developed BeeConnected to enable two-way communication on the location of hives and crop protection activities. This app opens up a line of communication between registered beekeepers and registered producers and contractors, through an internal messaging system. For additional information visit www.beeconnected.ca.

Related Information

Additional information and best management practices can be found at Health Canada's pollinator protection webpage healthcanada.gc.ca/pollinators.

Additional IPM information can be found on the OMAFRA website at ontario.ca/crops.