Guide to

EARLY SEASON FIELD CROP PESTS

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Cover photo:
European chafer grub
A. Schaafsma

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INTRODUCTION

Field crops occupy a significant proportion of the cultivated area in Ontario. In 2013, about 2,700,000 ha were planted to grains, oilseeds and dry field beans, of which nearly 75% were corn and soybeans. While these acres were mostly planted with seed treated with neonicotinoid insecticides, soil borne insect pest infestation levels often do not justify the use of insecticide treated seeds. Although the use of insecticide can be a solution that is both practical and effective for protection against insect pests, profitability as well as risks to the environment and human health must also be considered. As such, it is important to implement an integrated pest management (IPM) strategy to help target insecticide use to where it is absolutely necessary. The best strategies inevitably start with a good knowledge of crop pests.

This guide is a tool to help identify pests that attack field crops early in the growing season. Under each pest, the guide outlines how to identify the pest, explains their life cycle and the damage they cause. It also details scouting techniques, thresholds and integrated pest management strategies including cultural, biological and chemical control. Additional information on protecting natural enemies as well as pollinators is also available at the end of the guide.

In short, this guide provides the basics for establishing an integrated pest management strategy for soil borne and early season pests in field crops, which will help target the use of insecticide treated seed to where it is necessary.

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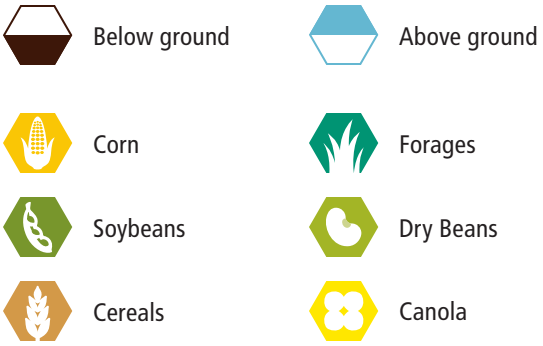


COMMON PESTS OF FIELD CROPS

PEST	PAGE NO.	CORN	SOYBEAN	CEREALS	FORAGES	DRY BEANS	CANOLA
Below Ground Pests							
Wireworms	50	✓	✓	✓	✓	✓	O
Millipedes	54	O	O				
Garden symphylans	55	R					
White grubs (June beetle)	56	✓	✓	✓	✓		
European chafer grubs	56	✓		✓			
Japanese beetle grubs	56		✓		✓		
European crane fly	64	R					
Seedcorn maggot	65	✓	✓			✓	
Alfalfa snout beetle	68				✓		
Northern and Western corn rootworm	72	✓					
Above Ground Pests							
Black cutworm	80	✓	✓				
Dingy cutworm	85	✓					✓
Redbacked/dark sided cutworm	86						✓
Variegated cutworm	87	✓	✓				
Slugs	88	✓	✓	✓	✓	✓	✓
Corn flea beetle	92	✓					
Crucifer and striped flea beetles	96						✓
Bean leaf beetle	100		✓		✓	✓	
Soybean aphid	105		✓				
Potato leafhopper	110		R		✓	✓	

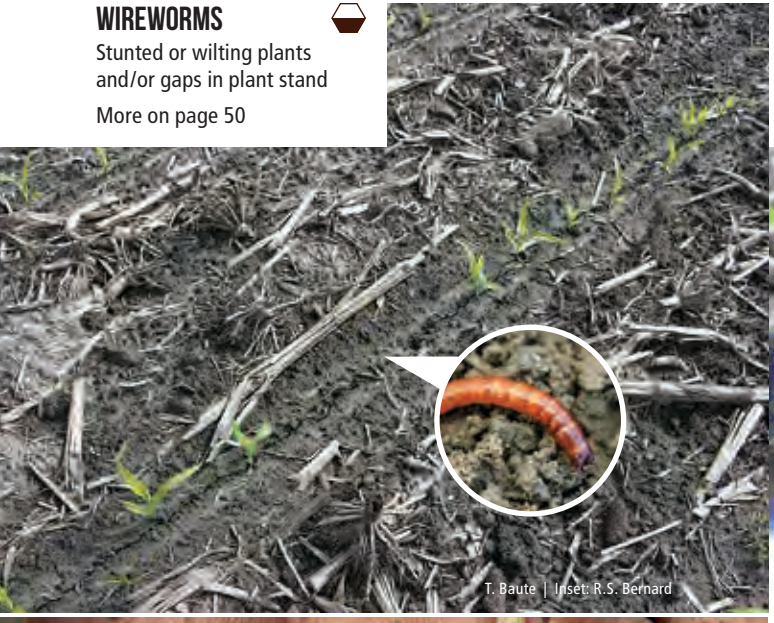
O = Occasional, R = Rare

PESTS IN CORN

WIREWORMS

Stunted or wilting plants and/or gaps in plant stand

More on page 50



T. Baute | Inset: R.S. Bernard

T. Baute

MILLIPEDES

Stunted or wilting plants and/or gaps in plant stand

More on page 54

T. Tyhurst | Inset: T. Baute

GARDEN SYMPHYLANS

Stunted or wilting plants and/or gaps in plant stand

More on page 55

E. Cullen | Inset: P. Pellitteri

PESTS IN CORN

GRUBS

Stunted or wilting plants and/or gaps in plant stand

More on page 56

A. Schaafsma

SEEDCORN MAGGOT

Tunnels or scars on seed or seedling, poor crop emergence and gaps in stand

More on page 65

T. Cowen | Inset: R.S. Bernard

EUROPEAN CRANE FLY

Similar to grub damage, gaps in stand, wilting plants

More on page 64

C. DiFonzo | Inset: T. Baute

BLACK CUTWORM

Holes in leaves with irregular edges, hollowed out stem or cut plants at soil level

More on page 80

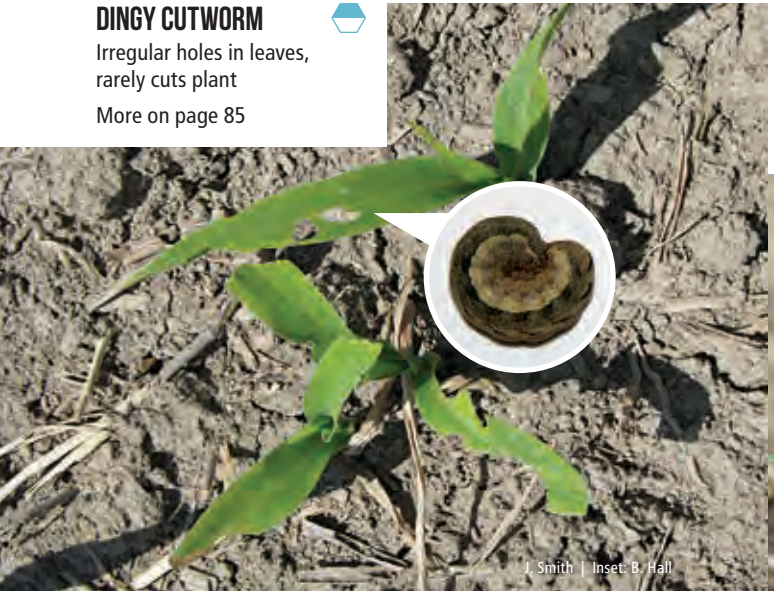
J. Smith | Inset: T. Baute

PESTS IN CORN

DINGY CUTWORM

Irregular holes in leaves, rarely cuts plant

More on page 85



J. Smith | Inset: B. Hall

SLUGS

Seeds hollowed.
Strips of leaf scrapped off, resembling hail damage.

More on page 88

T. Baute | Inset: J. Smith

VARIEGATED CUTWORM

Irregular shaped holes on leaves. No plant cutting.

More on page 87

J. Smith | Inset: T. Cowen

CORN FLEA BEETLE

Long feeding scratches running parallel with leaf vein

More on page 92

T. Baute | Inset: F. Pearis

PESTS IN CORN

CORN ROOTWORM

Root clipping, goosenecking, silk clipping and window-paned leaves

More on page 72


A. Hitchon


C. DiFonzo


A. Hitchon


J. Smith | Insets: R.S. Bernard

PESTS IN SOYBEANS

WIREWORMS

Stunted and wilting plants and gaps in stand

More on page 50


R.S. Bernard

MILLIPEDES

Stunted and wilting plants and gaps in stand

More on page 54


A. Schaafsma | Inset: T. Baute

PESTS IN SOYBEANS

GRUBS

Stunted and wilting plants and gaps in stand

More on page 56

T. Cowan | Inset: R.S. Bernard

JAPANESE BEETLE

Adults feed on leaf tissue between the veins, causing leaves to be skeletonized

More on page 56

H. Bohner

SEEDCORN MAGGOT

Tunnels or scars on seed or seedling, poor crop emergence and gaps in stand

More on page 65

J. Gavloski

H. Bohner

PESTS IN SOYBEANS

BLACK CUTWORM

Plants cut off at or above soil surface

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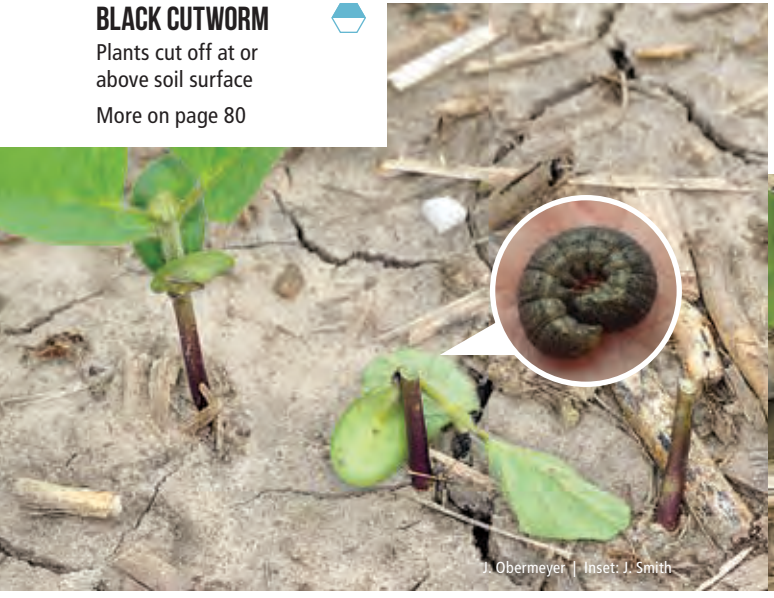
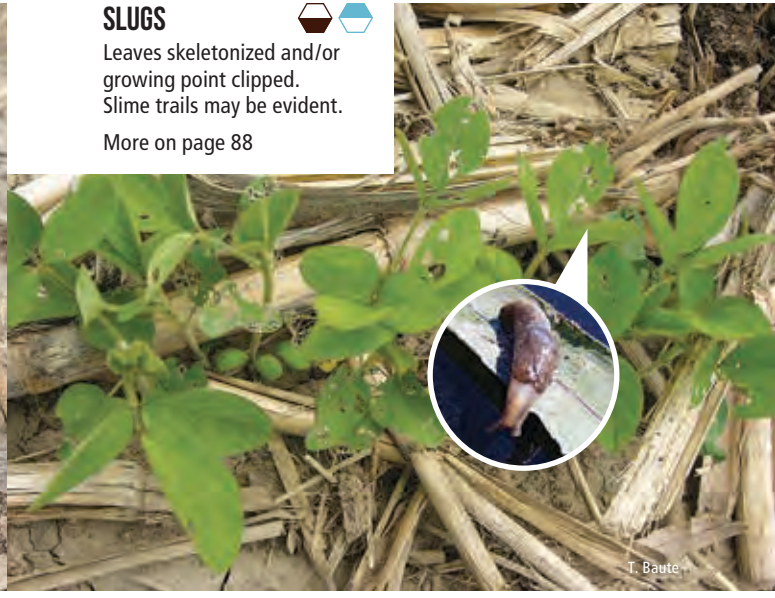


J. Obermeyer | Inset: J. Smith

SLUGS

Leaves skeletonized and/or growing point clipped. Slime trails may be evident.

More on page 88



T. Baute

VARIEGATED CUTWORM

Irregular holes in leaves. Plants not cut.

More on page 87

T. Cowan

PESTS IN SOYBEANS

BEAN LEAF BEETLE

Pitting on cotyledons, circular holes in leaves and pods. Seedlings clipped.

More on page 100


R. Hammond


J. Smith


H. Bohner


J. Smith

SOYBEAN APHID

Plants may be yellowing, stunted, coated with honeydew

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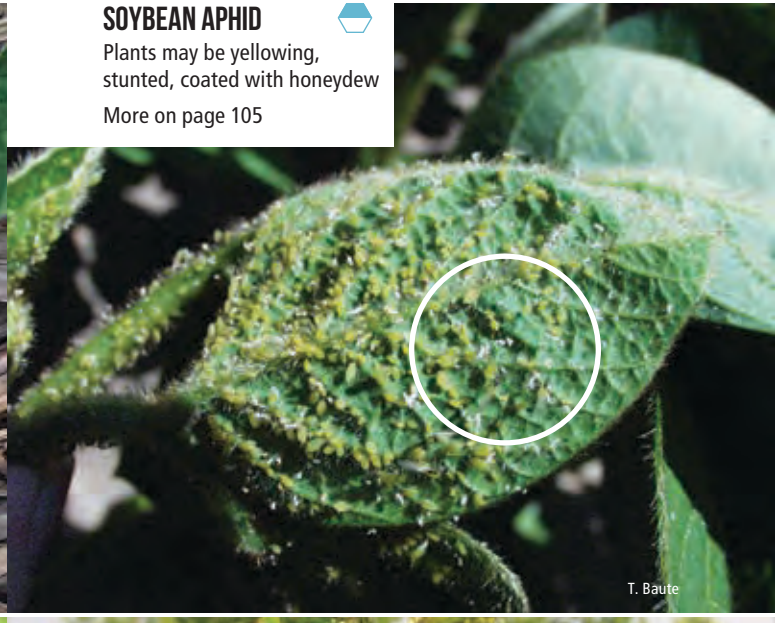
T. Baute


T. Baute

PESTS IN CEREALS

WIREWORMS

Stunted or wilting plants and gaps in stand

More on page 50

T. Baute

SLUGS

Leaf tissue scrapped and ragged, resembling hail damage

More on page 88

T. Baute

GRUBS

Stunted or wilting plants and gaps in stand

More on page 56

R. Moloney | Inset: R.S. Bernard

PESTS IN FORAGES

WIREWORMS

Stunted and wilting plants with gaps in stand

More on page 50

R.S. Bernard

GRUBS

Stunted and wilting plants with gaps in stand

More on page 56

R. Moloney | Inset: R.S. Bernard

ALFALFA SNOUT BEETLE

Roots clipped, taproot girdled, plants yellowing and leafless

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G. Quesnel

G. Quesnel

PESTS IN FORAGES

SLUGS

Leaves scrapped or skeletonized, resembling hail damage. Slime trails may be evident.

More on page 88

T. Baute

POTATO LEAFHOPPER

V-shaped yellowing at leaf tip, plants stunted

More on page 110

G. Quesnel | Inset: T. Baute

PESTS IN DRY BEANS

SEEDCORN MAGGOT

Tunnels in seeds and seedlings, poor emergence and gaps in stand

More on page 65

J. Gavloski | Inset: R.S. Bernard

SLUGS

Leaves skeletonized and/or growing point clipped. Slime trails may be evident.

More on page 88

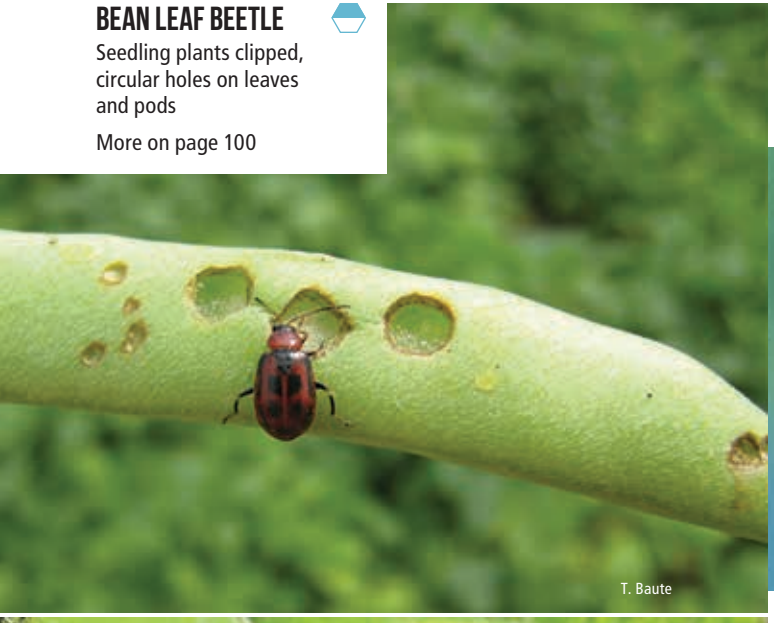
J. Smith

PESTS IN DRY BEANS

BEAN LEAF BEETLE

Seedling plants clipped, circular holes on leaves and pods

More on page 100



T. Baute

J. Smith

POTATO LEAFHOPPER

V-shaped yellowing at leaf tip

More on page 110

T. Baute

PESTS IN CANOLA

CUTWORMS

Irregular holes in leaves and plants cut at base

More on page 80

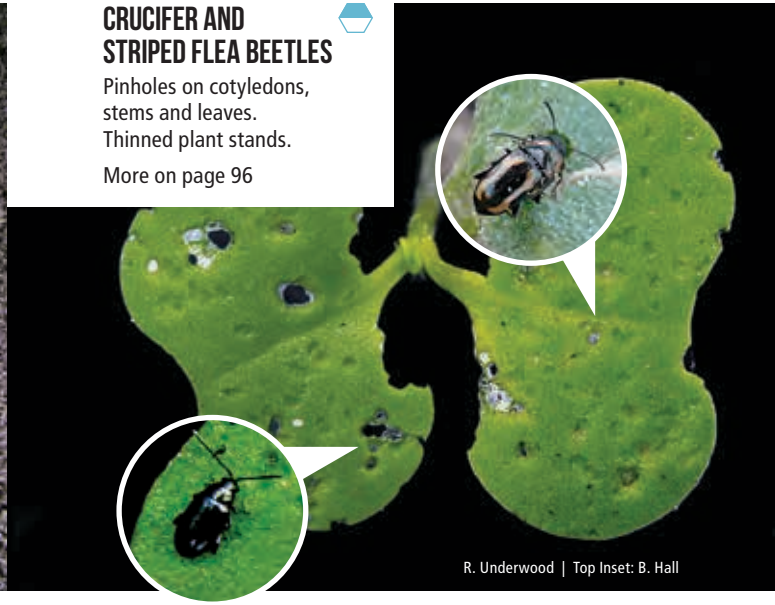

J. Gavloski


J. Gavloski

CRUCIFER AND STRIPED FLEA BEETLES

Pinholes on cotyledons, stems and leaves. Thinned plant stands.

More on page 96


R. Underwood | Top Inset: B. Hall

SLUGS

Leaves scrapped and skeletonized. Plant clipped at growing point.

More on page 88


B. Hall | Inset: J. Smith

INTEGRATED PEST MANAGEMENT FOR FIELD CROPS

Integrated pest management for field crops is a decision method that uses all available technologies to efficiently and economically reduce the pest population while respecting health and the environment.

The principles to IPM include the following:

1. **Knowledge and proper identification**
   - Key pests
   - Crop damage/impact
   - Pest life cycles
   - Natural enemies
   - Type of management strategy

2. **Prevention (indirect methods)**
   - Site selection
   - Variety/hybrid selection
   - Planting/harvesting timing
   - Fertilizer management
   - Irrigation management
   - Crop rotation
   - Certified seed
   - Good plant health
   - Habitat development

3. **Field and pest assessment**
   - Scouting
   - Sampling
   - Thresholds
   - Monitoring
   - Prediction models
   - Trapping

4. **Intervention (combination of methods)**
   - Cultural control
   - Biological control
   - Chemical control

5. **Evaluation and feedback**
   - Evaluate effectiveness of control measure
   - Look for secondary pest issues, resurgence or resistance development
   - Modification and adjustments
   - Planning

Pedigo, L. P. *Entomology and Pest Management*. Third Edition. 1999. Prentice-Hall, Englewood Cliffs, NJ. 691 pp.

SCOUTING METHODS

There are many scouting techniques and the method used varies according to the pest of concern. Not all scouting methods are covered here, but focus on those most needed to evaluate early season pest issues.

Wireworm baits

- Most effective when soil temperatures are just above 10 °C, so that baits release CO_2 to attract wireworms. Once soil temperatures increase, the baits will be less attractive and wireworms will likely move deeper down in the soil to avoid the heat.
- Establish two bait stations per "high-action" site in each field. High action sites include sandy or silty knolls, areas that had weedy patches, problem areas of field where gaps in stand noticed. The more baits you put out the more accurate the sampling.
- Dig a hole at each station, approximately 15 cm (6 in.) wide and deep.
- Take 1 cup of all purpose flour and drop it into the hole.
- Bury the bait, breaking up any clumps and mound the soil to prevent standing water.
- Place a flag at the bait station to make it easier to find again and return seven days later to dig the bait out and determine the presence of wireworms.

Wheat flour bait ▲
Flag identifying wireworm bait station ►

Traps – e.g. sticky traps, light traps, pheromone traps

There are several types of traps but most are used to detect the presence of a pest and are not typically effective at controlling or eliminating the pest, at least not in a field setting.

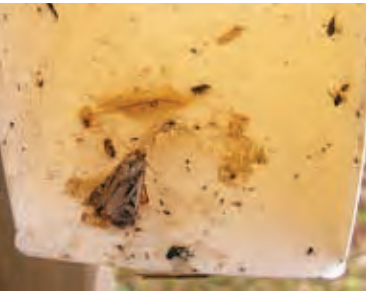
Some action thresholds are based on the number of insects captured per trap, but most traps only indicate when to scout for the pest in the field. For example, when traps capture a peak number of moths, this also indicates that egg laying is soon to peak within the field, making it the ideal time to scout for eggs and young larvae.

Sticky traps

- Available in white, yellow or blue, are coated with a sticky adhesive to capture any insects that land on them. Colour used depends on the insect that you want to attract.

Light traps

- Light traps are used to capture those insects that fly at night, mainly moths and some beetles, though they are not discriminating and capture many species that take time to sort and identify. These contain a black light bulb and some form of a bucket or collection unit and killing agent to collect all insects that are attracted to the light. These traps require a power source which makes them less convenient to use in a field setting.



Pheromone traps

- These traps are used to capture a specific species of insect by luring the males using a sex pheromone that the female would emit. Most pheromone traps are used to capture moths and in some cases beetles.

Shelter traps for slugs

- Fall is the best time to monitor for slugs to predict issues in the spring, though spring sampling can also be done.
- To determine population levels, research has found that white rolled roofing cut into 30 cm by 30 cm pieces works best for assessing population. Other items can be used instead including shingles, small pieces of plywood or wet cardboard. These will act as shelters for the slugs and allow you to find them easily if present in the field.
- Position each trap directly on the soil surface (brushing away any crop debris/residue) and place a rock on top to keep the trap from blowing away.
- Use 10 to 15 shelter traps randomly scattered across the field to provide a good indication of population levels.
- Visit the boards every five days for approximately one month, looking for the presence of adults and juveniles.
- Morning is the best time to visit the traps, since slugs will still be in their shelters before the day warms up.

J. Tooker

Sweep sampling – e.g. bean leaf beetles, potato leafhoppers, etc.

- Best method for evaluating a solid stand crop such as alfalfa, canola or solid seeded soybeans though they can be used in short standing row crops.
- Use a standard 37 cm (15 in.) diameter sweep net, commercially available at trap supply companies.
- While walking through the canopy, sweep the net from side to side in a pendulum-like motion, across the top of the crop canopy so that the top of the net is roughly positioned within the top 37 cm (15 in.) of the canopy.
- Take 20 sweeps in five areas of the field, closing the net up with your hand in between subsamples so that insects do not escape while walking to the next area of the field to be sampled.
- Avoid collecting soil by hitting the ground during the sweeping procedure. Avoid sweeping along the field edge. There are likely more than the average number of insects present in this area and does not represent the average population within the field, unless you are scouting for a pest that tends to remain along the edge of the field (e.g. brown marmorated stink bug).
- Some thresholds are based on the definition of one sweep consisting of two 180° arcs; bringing the net across from one side of the body to the other and back again while walking slowly forward. Other established thresholds are based on one sweep consisting of only one 180° arc; bringing the sweep net only from one side of the body to the other, once. It is therefore important to determine which definition of a sweep has been used for each threshold recommendation, before determining pest populations in a field.

Digging and visual assessment – e.g. for grubs, wireworms and other soil pests

- Scout for soil insects such as grubs or wireworms in the fall or spring prior to planting when they are most actively feeding.
- Scout in high risk areas of the field such as sandy or silty soils, knolls, near tree lines or where damage was observed in previous years. Fields that were in pasture for one to two years previous are also at high risk.
- Use a shovel to dig up approximately 30 cm^2 (1 ft^2) of soil about 7 to 10 cm (3 to 4 in.) deep in at least five areas of the field. Sift through the soil by hand, breaking up any clumps and count the number of insects in your sample.
- If the crop has already been planted, find areas of the field where there are gaps in the stand or wilting seedlings. Go to the next nearest surviving plant in the row and dig the roots of that seedling to look for any pests present.

Digging for soil insects

Scouting for grubs in soybeans

INJURY/DAMAGE ASSESSMENTS

Plant stand assessment

For row crops, plant population can be calculated by counting the number of plants in a thousandth of an acre (1/1000), then multiplying the count by 1,000 to obtain the number of plants per acre. First measure the row width to determine what length of row needs to be measured for the assessment.

Plant populations at various row widths

ROW WIDTH		LENGTH OF ROW EQUAL TO 1/1,000 ACRE[1,2]	
CENTIMETRES	INCHES	METRES	FEET
38	15	10.6	34 ft. 10 in.
51	20	8.0	26 ft. 1 in.
56	22	7.3	23 ft. 10 in.
71	28	5.7	18 ft. 8 in.
76	30	5.3	17 ft. 5 in.
81	32	5.0	16 ft. 4 in.
86	34	4.7	15 ft. 5 in.
91	36	4.4	14 ft. 6 in.
97	38	4.2	13 ft. 9 in.

[1] *To obtain the number of plants per one-thousanth hectare, multiply the number of plants in the length of row by 2.47.*

[2] *Multiply the number of plants counted in the length of row above by 1,000 to determine the number of plants/acre.*

Source: OMAFRA Publication 811, *Agronomy Guide for Field Crops*

To determine plant population in narrow-row crops or weed/insect infestation levels, a sampling frame with a known area can be placed on the ground. Count all pests or weeds within the area of the frame. This can be accomplished using a square frame (e.g. 50 cm x 50 cm = 0.25 m^2) or a circular frame (e.g. a hula hoop).

Hula hoop method for determining plant and pest populations

INSIDE DIAMETER OF HOOP	AREA	FACTOR BY WHICH TO MULTIPLY THE NO. OF PLANTS WITHIN THE HOOP TO EQUAL:	
CM (IN.)	M^2 (FT^2)	PLANTS PER HECTARE	PLANTS PER ACRE
91 (36)	0.65 (7.0)	15,385	6,165
84 (33)	0.55 (6.0)	18,182	7,334
76 (30)	0.45 (4.9)	22,222	8,874
69 (27)	0.37 (4.0)	27,027	10,956
61 (24)	0.29 (3.2)	34,483	13,865
INSIDE DIMENSIONS OF A SQUARE FRAME IN CENTIMETRES (IN.)			
50 x 50 (20 x 20)	0.25 (2.7)	40,000	16,133
100 x 100 (40 x 40)	1.00 (11.1)	10,000	3,924

Count the number of plants that are found within the hoop or square and multiply that number by the pre-determined factor listed above to determine plant population per hectare or acre.

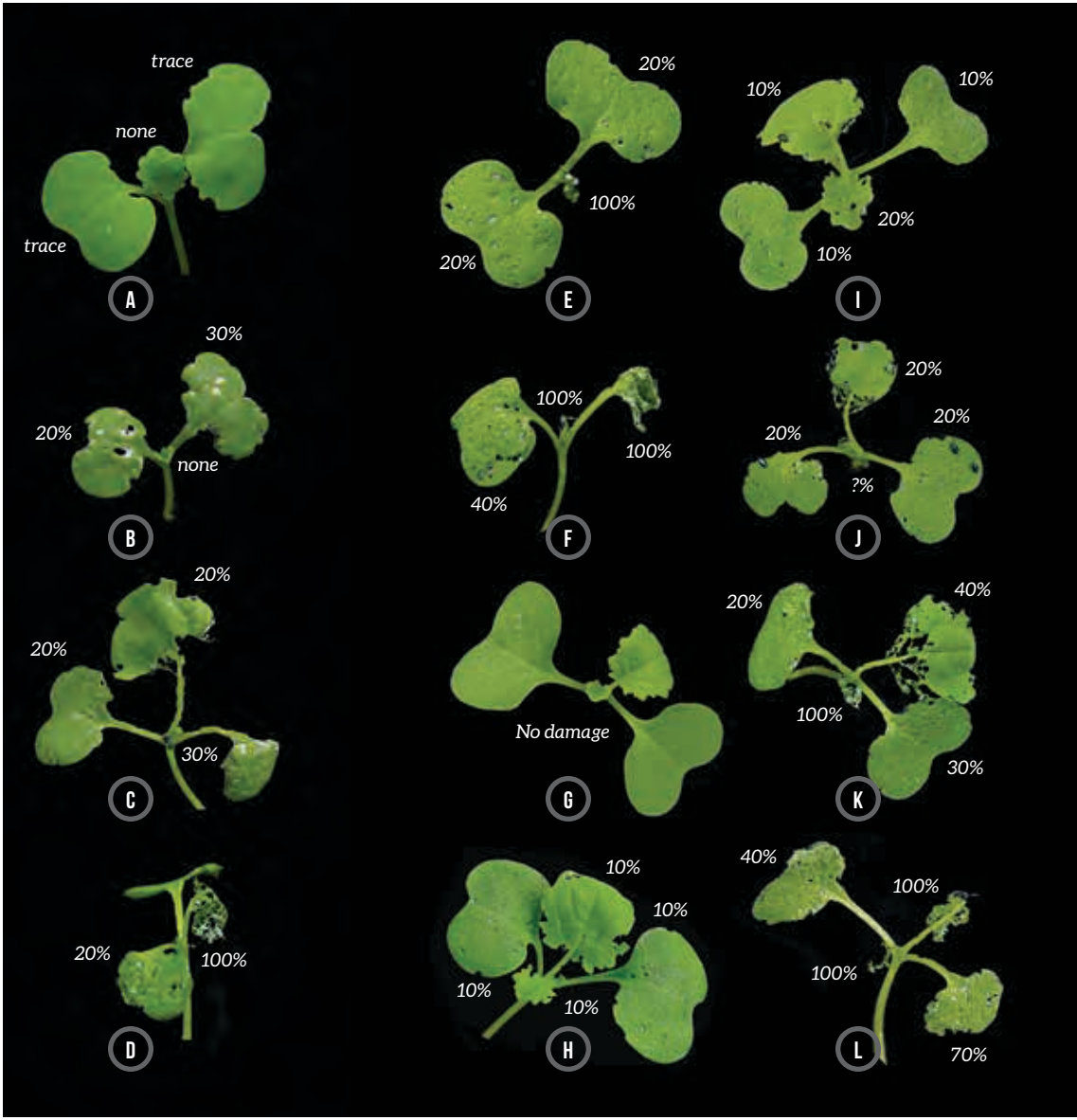
Source: OMAFRA Publication 811, *Agronomy Guide for Field Crops*

Corn rootworm root injury ratings

- Mid-late July is the best time to dig up roots and assess feeding injury.
- Do not wait until late August or September to inspect the roots because they may outgrow the injury or start to breakdown, making it difficult to confirm the presence of rootworm feeding.
- Cut the stalk of the corn plant approximately 30 cm (12 in.) from the ground level.
- Use a shovel to dig up the entire root mass 20 to 25 cm (8 to 10 in.) in diameter and 15 to 20 cm (6 to 8 in.) deep.
- Shake the loose soil from the root mass, taking care not to break off roots.
- Soak the root mass in water, then wash the root system with a hose nozzle or high pressure power washer with water to remove as much soil as possible.
- Use the Iowa State Node-Injury Scale to rate rootworm feeding injury www.ent.iastate.edu/pest/rootworm/nodeinjury/nodeinjury.html

NIS	DESCRIPTION
NODE-INJURY SCORE	NOTE: "EATEN" IS DEFINED AS THE ROOT BEING EATEN BACK TO WITHIN 3.75 CM (1.5 IN.) OF THE STALK
0.00	No feeding damage
1.00	One node, or the equivalent of one node eaten
2.00	Two complete nodes eaten
3.00	Three or more nodes eaten

Canola seedlings with varying levels of flea beetle damage: A to F – first leaf stage; G to L – two leaf stage. Control of flea beetles would be warranted on seedling plants D, E, F, K and L.
R. Underwood



Canola seedling defoliation assessment

Flea beetles

Scouting in the fall for flea beetles can help predict problems in the spring and implement cultural management strategies, though spring scouting is still required to determine if chemical control is needed.

Once the crop emerges, scout every two to three days. Select three or four plants in 10 areas of the field to assess the percent defoliation on the cotelydons and newly emerging leaves until the plants are at the 4-leaf stage and can compensate for the damage.

Control is warranted if 25% of the canopy is defoliated between the cotyledon stage and the 4-leaf stage and adults are still actively feeding. If adults are feeding on the seedling stems under cool conditions, action may need to be taken before 25% defoliation on leaves. If the growing point has been clipped, consider this 100% defoliation during the assessment.

Assessing defoliation in soybeans

- Sample trifoliate leaves located in mid-canopy of five plants, in 10 areas of the field, avoiding the field's edge.
- Discard the least and worst damaged leaflet for each trifoliate sampled (there will then be only one leaflet left).
- Establish the percent defoliation on the 50 plants sampled by comparing them to the photos below.

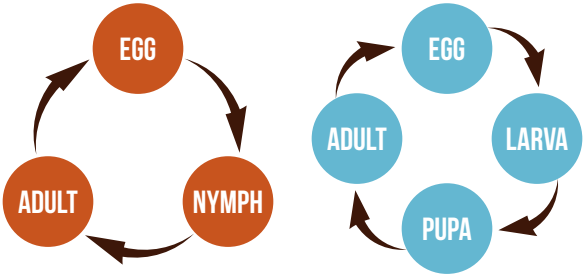
Thresholds in soybeans (% of defoliation)

- Pre-bloom (vegetative stages) 30%
- From bloom (R1) to pod-fill (R4) 15%
- From pod-fill to maturity (R5-R6) (unless pods are being clipped off plant) 25%

INSECT METAMORPHOSIS

Insects and some pests transform through metamorphosis. Some go through **Incomplete Metamorphosis** where there are three distinct stages of development; egg, nymph and adult, and no pupal stage. Nymphs and adults in this group often look similar, though the nymphs are smaller and will lack wings. Examples of insects that belong in this group include grasshoppers, aphids, stink bugs. Both nymphs and adults of plant feeders can do damage.

Other insects go through **Complete Metamorphosis** where there are four distinct stages of development; egg, larva, pupa and adult. Each stage can look very different from one another and only the larval or adult or less often, both stages of the plant feeding insects can damage crops. Examples of insects that belong in this group include beetles, ants, wasps, butterflies and moths, and flies.



Incomplete metamorphosis

Complete metamorphosis

Knowing which category the pest of concern fits in can help with scouting, identification and understanding when to expect crop injury or when to expect natural enemies to play a role in control. Applying a control strategy against the incorrect stage of the insect pest may not effectively mitigate the problem.

BELOW GROUND PESTS

T. Cowan

WIREWORMS

Coleoptera | Elateridae

Agriotes spp., *Hemicrepidius* spp., *Limonius* spp., *Melanotus* spp. and others

R.S. Bernard

Description

Adults

- 8 to 20 mm depending on the species
- Dark body (brown, charcoal, black), tapering at the base of the thorax
- Able to turnover when put on its back, while producing a popping sound that earned its name "click beetle"

Larvae

- 2 to 40 mm
- Hard body, cylindrical, slightly shiny, copper in colour, with a distinctive flat head
- Newly hatched larvae are white for approximately one month before turning hard and coppery in colour
- Only three pairs of legs near the front of the body

Newly molted wireworm
T. Baute

Adult click beetle
T. Baute

Life cycle

Complete metamorphosis

One generation every one to six years depending on the species

- All growth stages (larvae and adults) can be found in a field at the same time
- Adults lay their eggs in the soil during the summer months
- Larvae are the damaging stage and grow over a period that can be as long as six years, depending on the species
- Overwinter as larvae or adults in the soil below the frost line (as deep as 1.5 m underground)
- Larvae move vertically in the soil profile once soil temperatures reach 10 °C and move downward again when the temperatures reach 26 °C or higher
- Most actively feeding on seeds and roots from April to June but can also be present near the soil surface in the fall

Targeted crops

Primary crops at risk

- Corn
- Cereals (mainly oats, wheat, winter rye)

Secondary crops

- Soybeans
- Dry beans
- Forage crops (rare)
- Canola

Increased risk

- Sandy and silty soils, especially knolls
- Early planting along with a cool, wet spring

Corn damage
T. Baute

Root clipping
T. Baute

Damage

- Roots and seeds: perforations and tunnels
- Seedlings: stunting, wilting, yellowing and sometimes death of the plant
- Leaves: small notches (rare), purplish tips
- Field: uneven plant height or stand thinning/gaps

Favourable conditions and risk factors

- Sandy and silty soils, especially knolls
- Fields in rotation with grass crops (cereals, mixed forages and especially following sod), canola or vegetable crops (carrots, potatoes)
- Fields with grassy weeds or following summer fallow
- More crop injury in early planted fields during cool wet springs due to slowed crop emergence

Scouting

Larvae

When? April to the end of June (as soon as the soil temperature reaches 10 °C); September to mid-October (before the first frost)

How? Bait trap (see page 36 for instructions)

Take note: Note the number of larvae per bait trap

Thresholds

- An average of one larva per bait trap

The number of individuals per trap depends on the conditions of the year, on the soil temperature and humidity and also on the presence/absence of other sources of CO_2 close to the trap (e.g. manure or other decomposing material).

Pest management strategies

Preventive and cultural control options

- Crop rotation: avoid planting a cereal or corn crop following sod, or pasture. Non-host crops (alfalfa, pulse crops, lettuce, sunflower, buckwheat) decrease wireworm populations
- Weed management: mainly grassy weeds (quackgrass and volunteer cereals)
- Increase the planting rate up to 10% to compensate for potential losses
- Plant in warm, moist soil conditions. Dry conditions can delay germination and increase risk.

Biological control and natural enemies

- Tend to have limited impact on wireworm populations
- Predators: beetles, birds
- Pathogens: nematodes, fungi

Chemical control options

- Soil insecticide: granular soil insecticides for corn are available for planters equipped with insecticide boxes
- Insecticide seed treatment: use if the threshold is reached or in fields with a history of wireworm injury
- Foliar insecticide treatment: none available and are not an accepted management strategy

MILLIPEDES

Diplopoda | various species

Description

Incomplete metamorphosis

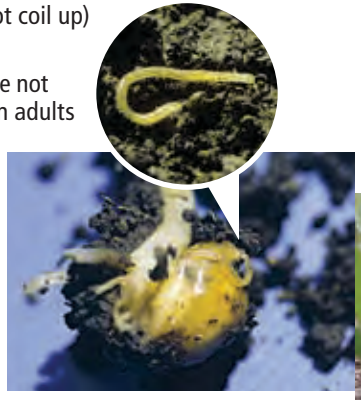
Adults

- 2.5 to 5 cm long
- Hard-shelled, cylindrical dark reddish brown to grey-black
- Millipedes are not insects but arthropods – they get their name (milli: thousands, pedes: legs) from having many legs; two short pairs of legs per body segment in the adult stage
- Coil up tight when disturbed (unlike wireworm which do not coil up)

Mature millipede
T. Baute

Immatures

- Whitish yellow bodies that have not hardened, with fewer legs than adults
- Coil up tight when disturbed



Damage on seedling
A. Schaafsma

Risk factors

- Typically beneficial but when planting too early in cool, wet conditions that allow seeds to sit for an extended period causes millipedes to feed on the swollen seeds
- No-till fields with significant crop residue and organic matter are at higher risk, though damage has also been experienced in conventional fields
- Deep planting can also promotes favourable conditions for injury

No control measures are available for millipedes.

GARDEN SYMPHYLANS

Scutigerella immaculata Newport

Description

Incomplete metamorphosis

Adults

- 6 mm
- Small, white centipede-like with 12 pairs of legs

Immatures

- Look similar to adults, but have fewer legs

Damage

- Feeds on roots, gaps in stand

Risk factors

- High organic matter soils or heavily manured soils
- Rarely economic

Corn damage
E. Cullen

GRUBS

EUROPEAN CHAFER, JAPANESE BEETLE AND JUNE BEETLE (A.K.A WHITE GRUB)

Coleoptera | Scarabaeidae

Rhizotrogus majalis, *Popillia japonica*, *Phyllophaga* spp.

European chafer
R.S. Bernard

Japanese beetle
H. Bohner

Description

Adults

EUROPEAN CHAFER

- ~ 13 mm
- The wings are brownish beige with a darker brown line at the junction of the wings

JAPANESE BEETLE

- ~ 13 mm
- The head and the thorax are metallic green with reddish coppery wing and a series of 12 white tufts of hair along the margin of the abdomen

June beetle
R.S. Bernard

JUNE BEETLE

- ~ 20 to 25 mm
- Maroon colour
- Larger than European chafer and Japanese beetles

Larvae

- White C-shaped larvae with an orange-brown head and dark posterior – when walking, they drag their posterior along the ground
- Larvae can be distinguished by their raster (anal bristles) patterns at the anterior abdominal segment

EUROPEAN CHAFER

- 4 mm (1st instar) to 25 to 30 mm (full grown)
- "Y" shaped pattern of anal bristles (rasters)

JAPANESE BEETLE

- 4 mm (1st instar) to 20 to 25 mm (full grown)
- Wide, shallow "V" shape pattern of anal bristles (rasters)

JUNE BEETLE

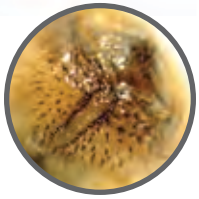
- 4 mm (1st instar) to 40 mm (full grown)
- Oval shaped raster pattern with two parallel rows of anal bristles (rasters)

Larvae can be distinguished by their raster (anal bristles) patterns at the anterior abdominal segment

R.S. Bernard

European chafer
A. Schaafsma

Japanese beetle
H. Russell



June beetle
A. Schaafsma

Life cycle

Complete metamorphosis

- European chafer and June beetle adults are nocturnal while Japanese beetles are active during the day
- European chafer and Japanese beetle are annual grubs (one-year cycle) while June beetle grubs have a three-year cycle
- European chafer larvae are more cold tolerant and can be at the soil surface as soon as the ground thaws
- June beetle larvae (three-year cycle) do the most damage during their second year and are at the soil surface once the ground warms up
- Japanese beetle larvae come to the soil surface once the soil is 15 °C – adults can also cause economic damage to soybean leaves later in the season

Life cycles and feeding periods for common grubs (European chafer, June beetle, Japanese beetle).
Damaging stages are shaded

INSECT		JAN-MAR	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV-DEC
EUROPEAN CHAFER		3rd instar larvae – overwintering		3rd instar larvae – feeding and pupation	Adults emerge, mate and lay eggs – no feeding		1st instar larvae – feeding	2nd instar larvae – feeding	3rd instar larvae – feeding	3rd instar larvae – over-wintering
JUNE BEETLE	Yr 1	Adults overwintering in soil			Adults emerge, mate and lay eggs	Eggs hatch – 1st instar larvae – feeding	3rd instar larvae – feeding		2nd instar larvae – feeding	2nd instar larvae – overwintering
	Yr 2	2nd instar larvae – overwintering		2nd instar larvae – feeding						3rd instar larvae – overwintering
	Yr 3	3rd instar larvae – overwintering		3rd instar larvae – feeding					Pupation and adults remain in soil to hibernate and overwinter	
JAPANESE BEETLE		3rd instar larvae – overwintering		3rd instar larvae – feeding		Adults emerge, mate and lay eggs	1st instar larvae – feeding	2nd and 3rd instar larvae – feeding		3rd instar larvae – overwintering

Targeted crops

EUROPEAN CHAFER
- Corn
- Cereals

JAPANESE BEETLES
- Soybeans
- Mixed forages

JUNE BEETLE
- Corn
- Soybeans
- Mixed forages
- Cereals

Damage

- Damage is dependent on the timing of planting/crop stage relative to the presence of actively feeding larvae
- Roots: fibrous roots chewed and pruned
- Plants: less vigorous, yellow, wilted, stunted and dying
- Flowers and seeds: reduced seed production
- Field: thin plant population, uneven growth, sometimes in circular patches

ADULT JAPANESE BEETLE
- Leaves: soybean leaves are skeletonized, leaving only veins (similar to lacing) or irregular shape holes

European chafer damage in corn
C. DiFonzo | Inset: A. Schaafsma

June beetle grub damage in soybeans
T. Cowan

Favourable conditions and risk factors

- Fields with sandy or silty knolls and in areas close to tree lines
- Fields following soybeans, alfalfa, sod, pasture, corn, cereals, potatoes and canola
- Fields grown adjacent to pastures, sod farms, park land and golf courses
- Fields with a history of grub infestations Increased damage in cool, wet springs due to slower crop emergence

Scouting

Adults

EUROPEAN CHAFER AND JUNE BEETLE

When? May to July

June beetle adults only present in year 1 of the cycle: if a high population of adults is observed, there could be significant grub damage the following year (April to September).

ADULT JAPANESE BEETLE

When? End of June to mid-August

Where? The adults feed on the leaves, flowers and soybean pods

How? Evaluate the percent defoliation (see page 46)

Japanese beetle damage in soybeans
H. Bohner

Larvae (all species)

When? Fall scouting can help predict populations for the following spring

EUROPEAN CHAFER GRUB

When? Early to mid-April until end of May; end of July to early November

JAPANESE BEETLE GRUB

When? May; end of August to mid-September

JUNE BEETLE GRUB

When? End of April to mid-June; mid-August to end of October

Where? Scout in high risk areas of the field

How? With a shovel, dig a hole about 30 cm x 30 cm, 7 to 10 cm deep, in five different areas in the field and count the number of larvae in each sample. High risk areas of the field include areas near tree lines and in sandy knolls.

Thresholds

- Two or more larvae per square foot (30 cm^2) warrant control. If grub populations are high (i.e. four or more grubs per square foot), use the higher rate of an insecticide seed treatment

ADULT JAPANESE BEETLE

- Consult page 46 for defoliation thresholds in soybeans

Pest management strategies

Preventive and cultural control options

- Avoid planting in cool wet conditions which delay crop emergence
- Avoid planting susceptible crops that have no insecticide seed treatment available in fields with a known history of damage
- Delay soybean planting in years 1 and 3 of the June beetle's life cycle to avoid grub feeding
- Plant forages with a good mix of legumes and grasses and over-seed to compensate for some feeding damage
- Adults prefer to lay eggs on shorter plants so avoid cutting forages shorter than 7.5 cm
- If European chafer population is extreme, avoid planting corn and plant soybeans instead but adjust planting date to late May to avoid feeding larvae

Biological control and natural enemies

- Parasitoids: flies (e.g. Tachinidae), wasp parasitoid (e.g. Tiphiidae, Pelecinidae), rove beetles
- Predators: beetles, birds (e.g. starling, blackbird, thrush), mammals (e.g. skunks, racoons)
- Pathogens: nematodes, fungi, bacteria

Chemical control options

- Physical control: tillage can kill some of the larvae and expose them to predators
- Soil insecticides: granular insecticides applied in furrow if planter is equipped with insecticide boxes
- Insecticide seed treatment: use in fields that reach threshold or have a history of damage
- Insecticide treatment: foliar treatment for Japanese beetle adults when defoliation thresholds are reached (not for grub control)

EUROPEAN CRANE FLY

Diptera | Tipulidae

Tipula paludosa Meigen

D. Cappaert

T. Baute

Description

Complete metamorphosis

Adults

- 20 to 25 mm
- Fly with long legs and threadlike antennae (looks like a big mosquito)
- Dark in colour

Larvae

- 5 to 40 mm
- a.k.a Leatherjackets
- Light grey-brown colour, legless, with tough looking skin
- Can be confused for cutworms but cutworms have a distinct head
- Head capsule may contract into the body when disturbed
- Two spiracular plates surrounded by six fleshy anal lobes at the posterior end
- Wiggles when disturbed (Cutworms roll up rather than wiggle)

Damage

- Similar to grub damage

SEEDCORN MAGGOT

Diptera | Anthomyiidae

Delia platura (Meigen)

R.S. Bernard

Pest and Diseases Image Library, Bugwood.org

Description

Adults

- 5 to 6 mm
- Pale grey to yellowish colour
- Looks like a small elongated housefly

Larvae

- 6 to 10 mm
- Yellowish-white, headless, legless larva (maggot)
- Body tapers to the front with two small protracting mouth hooks

Life cycle

Complete metamorphosis

Two to four generations per year

- The pupal stage overwinters (at a depth of 7 to 13 cm in the ground)
- The adults are active at temperatures between 16 and 29 °C
- The eggs are laid in the crevices of wet soils that emit a decomposing organic matter odour (e.g. freshly incorporated crop residues, areas where manure has

been applied or newly worked land) and on weeds or weedy areas
- The young larvae penetrate germinating seeds to feed on internal tissues (can also finish their growth on decomposing organic matter)
- The larvae enter summer diapause when temperatures are warmer than 29 °C
- Peak adult activity in early spring and again in the fall

Targeted crops

Primary crops
- Soybeans
- Dry edible beans

Secondary crops
- Corn (rare)

Increased risk
- Where manure is applied or green plant material is buried prior to planting

Field damage
H. Bohner

Damage
- Seeds: tunnels on the surface or inside of seed
- Roots: brown scars on the surface
- Seedlings: feeding tunnels on cotyledon, embryo and hypocotyl – can mine into the stem of seedlings
- Field: slow emergence and/or reduction in plant stand; damage occurs early in spring

Favourable conditions and risk factors
- Cool, wet springs when emergence is delayed
- Heavy textured soil that retains moisture
- Soil with recently applied manure, or freshly buried green residues just prior to planting
- Deep planting depth

Scouting
When? April to mid-June

Where? 10 areas of the field

How? Look for symptoms of poor emergence and dig up seed and seedlings. Look for tunneling and scarring.

Thresholds
- No rescue treatments are available; assess plant stand to determine if replanting is required

Soybean damage
J. Gavloski

Pest management strategies

Preventive and cultural control options
- Planting date: Plant later in good soil conditions to ensure rapid seedling emergence. If manure or green residues are incorporated, wait at least two weeks before planting.

Biological control and natural enemies
- Parasitoids: wasp parasitoid, rove beetles (e.g. *Aleochara bilineata* Gyllenhal)
- Predators: ground beetles
- Pathogens: fungi

Chemical control options
- Insecticide seed treatment or in-furrow soil applied insecticides in high risk fields
- There is no treatment to rescue a crop other than replant as soon as possible

ALFALFA SNOUT BEETLE

Coleoptera | Curculionidae

Otiorhynchus ligustici

G. Quesnel

Description

Adults

- 12 mm in length
- The adult is a flightless, dark-grey weevil
- All the adults are female capable of laying fertile eggs

Larvae

- Up to 12 mm
- Larvae are small, white and legless with a light-reddish-brown head and can be found in the soil, feeding on or in the alfalfa roots

Life cycle

Complete metamorphosis

Two year life cycle

- Year 1, adults emerge from their overwintering sites in April, feed on alfalfa shoots and migrate to new sites to lay eggs
- The eggs hatch soon after laying and the young larvae begin feeding on the side roots and eventually on the main/tap root of the host plant
- In November the larvae burrow deep into the soil (40 to 60 cm) where they remain as non-feeding grubs until late summer the following year
- In late summer of year 2, the larvae pupates and then become inactive adults by late fall
- In April to May of year 3, adults emerge from the soil to start feeding and late migrate to new sites to lay eggs

Targeted crops

Primary crops

- Alfalfa

Secondary crops

- Clovers and trefoil to a lesser extent

Areas at risk

- Alfalfa in coarser soils

Damage

- Primarily a below ground pest
- The larvae start feeding on lateral roots and then move to the taproot to gouge its surface.
- The larvae girdle the taproot, leaving deep spiral grooves, often completely severing the root
- Severely injured plants may appear yellow and leafless in the fall
- Damage is most evident in late summer and early fall
- Adults feed on leaves and stems, causing only marginal damage

Percentage of acres at risk: alfalfa in coarser soils (sandy loam, sand, gravel)

Favourable conditions and risk factors

- Alfalfa fields on lighter soils (sandy loam, sand, gravel) in infested areas
- Alfalfa snout beetles have been detected in eastern Ontario on Wolfe Island, in the Prescott/Brockville area, in Kemptville and at the Central Experimental Farm at Agriculture and Agri-Food Canada in Ottawa

Root damage
G. Quesnel

Scouting

Adults

When? Late April to late May

Where? In alfalfa field where adults are feeding or on the edge of fields/roads when the beetles migrate to new sites

How? Using a sweep net, visually inspecting edges of fields and side of roads, and checking haying equipment

Larvae

When? September to mid-October

Where? Alfalfa fields

How? Using a shovel, dig up wilted alfalfa plants and surrounding soil, looking for root feeding injury and larvae

Thresholds

- No threshold established

Pest management strategies

Preventive and cultural control options

- Machinery should be thoroughly cleaned of any soil and plant debris before being moved out of an infested field
- If adults are present during harvest, they may end up in the bales and survive for some time. First cut hay from infested fields should be stored at least two months before being shipped out.
- Alfalfa snout beetle will not survive long without a host crop to feed on. A tight alfalfa rotation of two or three years (seedling year + one or two production years) should be followed by two or more years of non-host crops which include corn, small grain cereals and soybeans.

Biological control and natural enemies

- Alfalfa snout beetle has no known predators, parasites or pathogens In Ontario

Chemical control options

- Current insecticides are not effective at controlling this pest

Yellowing alfalfa due to alfalfa snout beetle root feeding
G. Quesnel

NORTHERN CORN ROOTWORM
WESTERN CORN ROOTWORM

Coleoptera | Chrysomelidae

Diabrotica barberi (Smith & Lawrence) and
D. virgifera virgifera (LeConte)

Northern corn rootworm
R.S. Bernard

Western corn rootworm
R.S. Bernard

Description

NORTHERN CORN ROOTWORM (NCR)

Adults

- 4 to 7 mm
- Green or yellow body without stripes or markings on the wings

WESTERN CORN ROOTWORM (WCR)

Adults

- 4 to 7 mm
- Yellow to green with three wavy black stripes on the wings – stripes may blend together
- The abdomen of Western corn rootworm is yellow

Note: Do not mistake the Western corn rootworm for the striped cucumber beetle. Striped cucumber beetles have a very black abdomen and three distinct, well defined parallel stripes on the wings.

Do not mistake for look-alike Striped cucumber beetle
E. Roddy

Larvae (all species)

- 10 to 18 mm
- White with a brown head and a dark and distinctive plate at the tip of the abdomen

Life cycle

Complete metamorphosis

One generation per year

- The eggs overwinter in the soil
- When soil temperatures reach 10 °C, the eggs hatch and the larvae begin feeding on root hairs. This typically takes place around mid to late June.
- The larvae go through three instars over a three week period. The 1st instars feed on small root hairs; the 2nd and 3rd instars feed on the main roots and the oldest larvae may also feed on the brace roots.
- Pupation occurs in the soil, followed by adult emergence typically in mid-July
- Adults prefer to feed on tassels, pollen and silk but will also feed on leaves in late planted corn if reproductive structures are not yet available
- Mating and egg laying typically occurs in the natal corn field, but adults will eventually move to later flowering fields as food sources deteriorate
- Most eggs are laid starting in mid-August, their number can reach 300 eggs/female for the Northern corn rootworm (NCR) and as many as 1,000 eggs for the Western corn rootworm (WCR)

Lodging from root clipping
C. DiFonzo

Targeted crops

- Corn

Damage

Larvae

- Primarily a below ground pest
- Roots: brown scars on root surface, small holes and tunnels along roots, onset of fungal diseases. Root ends will be pruned and appear ragged.

Corn root damage
J. Smith

- Stem: bending of stems, known as "goose-necking"; lodging from the base of the plants

Adults

- Silk clipping by adult feeding may lead to reduced pollination. Once pollination is complete, adult feeding is no longer a threat to yield.
- Adults may feed on leaf tissue, leaving window-paned strips parallel with the leaf veins. Leaf feeding rarely causes economic injury.

Favourable conditions and risk factors

- Corn planted after corn on heavy textured soils is at greatest risk – crop rotation eliminates this risk
- Heavy adult populations in the previous year's corn crop
- Presence of alternate host plants such as reed canary grass, barnyard grass, green foxtail
- Volunteer corn in soybean fields negates crop rotation out of corn

Scouting

Adults

When? Mid-July to end of August. Scout before 70% of the plants reach the R1 (silking) growth stage.

How? Inspect 20 plants in five different areas of the field weekly from adult emergence to the end of August. Look for silk clipping and count the number of adults per plant at ear height.

It is also possible to scout the adults emerging directly from the ground by using emergence traps.

Larvae

It is not recommended to look for the presence of larvae as they are difficult to see due to their small size and may be hidden within roots, therefore, feeding injury is assessed on roots using the Iowa State Node-Injury Scale: www.ent.iastate.edu/pest/rootworm/nodeinjury/nodeinjury.html

When? Mid-July to early August

How? See page 40 for detailed description of root digging method

Do not wait until late August or September to inspect the roots because they may outgrow the injury or start to breakdown making it difficult to confirm the presence of rootworm feeding.

Rootworm larvae on roots
J. Smith

Thresholds

Adults

- Field corn can withstand heavy adult activity, usually requiring at least 10 adults per ear before control is recommended, however, seed corn may require control if adult populations are causing extensive silk clipping

Silk clipping (R1 stage)

- If fresh silks are being clipped to within 1.25 cm of the ear tip control is recommended

Clipped silks
A. Hitchon

To determine if control is recommended in the following corn crop, monitor adult numbers during the month of August. Count the number of beetles per plant at ear height.

- One Western corn rootworm adult/plant
- Two Northern corn rootworm adults/plant

Pest management strategies

Preventive and cultural control options

- Crop rotation is the most effective method of corn rootworm control. Rotate after corn to a non-host crop such as soybean, forages, sugar beets or wheat.
- Early planting may reduce crop susceptibility to larval feeding

Biological control and natural enemies

- Predators: beetles
- Pathogens: nematodes, fungi

Chemical control options

- If crop rotation is not an option and adult populations were high in the previous crop, effective control may be achieved using Bt corn rootworm hybrids (preferred method), high rate insecticide seed treatment, or soil insecticides
- For long-term management of corn rootworm it is recommended to rotate control options. In order to prevent resistance development, do not use the same method of chemical or transgenic control year after year
- Follow insect resistance management requirements (IRM) for Bt corn which includes:
  - Plant a non-Bt refuge
  - Rotate Bt events from year to year
  - Use pyramided Bt events rather than single traits
  - See www.cornpest.ca for the table of currently registered Bt products in Canada and IRM requirements

ABOVE GROUND PESTS

T. Baute

BLACK CUTWORM

Lepidoptera | Noctuidae

Agrotis ipsilon (Hufnagel)

Black cutworm adult
T. Baute

Description

Adults

- 40 to 55 mm wingspan
- Greyish brown moth with a small black triangle (dagger-like) running through a kidney-shaped spot on the forward wing

T. Baute

Larvae

- 3.5 to 50 mm
- Brown-black greyish back with lighter underbelly
- Two pairs of black spots on each body segment, the outside pair is twice as large as the inside one
- Curls up when disturbed

J. Smith

Life cycle

Complete metamorphosis

Two to three generations per year

- Adults do not overwinter in Ontario but instead migrate in the spring from the southern U.S. states
- Heaviest immigration of adults occurs in April to May but can be as early as March
- Adults lay eggs on dense green vegetation present in fields in early spring before spring cultivation or weed control
- The larvae hatch after five to 10 days and feed on the leaves until about the 4th instar. Larvae then migrate below the soil surface and can cut plants at or below the ground level.
- There are six larval instars in total and larvae are nocturnal, only feeding at night
- During their development (20 to 40 days), **on average, one larva will cut five corn plants**

Targeted crops

Primary crop

- Corn

Secondary crop

- Occasionally soybeans but rare

Increased risk

- Where weeds or green residues are present prior to planting

High risk field
T. Baute

Foliar damage
T. Baute

Cut plant
A. Schaafsma

Damage

- Leaves: small pinholes or notches (young larvae), holes with irregular edges or chewed leaf margins looking as if they were shredded (larger larvae)
- Plants: sudden wilting, cut or hollowed out stems at ground level or just below soil surface (final larval stages)
- Field: spotty plant population/uneven growth

Favorable conditions

- Fields with pre-plant weeds (e.g. mouse-eared chickweed, mustards, volunteer wheat and volunteer oat, lamb's-quarters, curled dock, yellow rocket, velvetleaf, alfalfa, stinkweed), cover crops or crop residues
- No-till fields or late spring plowed with annual weeds
- Fields planted into sod or legume forages
- Late planting
- Fields with a history of black cutworm infestation

Fields located along Lake Erie tend to experience frequent black cutworm infestations.

Scouting

Adults

When? April to end of June using pheromone traps

Larvae

When? Early May to mid-June; as soon as crop emerges until 5-leaf stage

Where? In the areas of the field that show favourable conditions

How? Inspect 20 plants in five areas of the field once or twice per week from emergence to the 5-leaf stage. Look for leaves with pinholes, wilted or cut plants; dig the ground surrounding the plant to a depth of 5 cm to find the larvae.

Note: The size and number of larvae and the leaf stage of the crop

The risk of damage has passed if the corn has reached the 5-leaf stage and/or larvae are over 2.5 cm in size (mature and almost done feeding).

Thresholds

Corn

- 10% of plants in the 1st to 4th leaf stage with damaged leaves/pinholes or 3% or more plants are cut and larvae found are smaller than 2.5 cm

Five leaf corn collar method
T. Baute

Black cutworm larva
J. Smith

Black cutworm pupa
T. Baute

Pest management strategies

Preventive and cultural control options

- Weed and crop residue management: ground must be bare two to three weeks before planting
- Rotation: avoid planting in forages or sod if high populations have been observed in previous years
- Planting date: avoid late planting
- Choose agronomic practices that favor the presence of natural enemies (e.g. set up grassy or woody areas around the field, reduce systemic insecticide applications)

Biological control and natural enemies

- Parasitoids: flies (e.g. Tachinidae), wasp parasitoids (e.g. Braconidae; Ichneumonidae), rove beetles (e.g. Staphylinidae)
- Predators: birds, ground beetles
- Pathogens: nematodes (e.g. Steinernematidae, Heterorhabditidae), fungi

Chemical control options

- The preferred method for fields with a history of infestations is to use Bt hybrids containing Cry1F
- Insecticide seed treatment available: only appropriate for fields with a history of black cutworm infestations, most efficient against young larvae
- Foliar insecticide treatment available (can be restricted to infested areas): not effective if larvae are more than 2.5 cm

DINGY CUTWORM

Lepidoptera | Noctuidae

Feltia jaculifera (Guenée)

J. Gavloski

Description

Complete metamorphosis

Adults

- Easily confused with western bean cutworm; dingy cutworm lack the distinct "full moon" marking on wings

Larvae

- Gray to reddish-brown larvae, with subtle dark "V" shape pattern on the top of each abdominal segment
- Two pairs of spots on the side of each abdominal segment, both pairs being of equal size

Target crops

- Corn
- Canola

Damage

- Usually causes less damage than black cutworm since it primarily feeds on leaves and rarely cuts the plant

REDBACKED CUTWORM

Lepidoptera | Noctuidae

Euxoa ochrogaster (Guenée)

J. Gavloski

Description

Complete metamorphosis

Adults

- Have four colour forms varying from dark red to pale clay colour

Larvae

- Reddish-brown larvae with two dull red stripes running along the length of their back
- More likely found in Northern Ontario

Target crops

- Canola (primarily)
- Cereals (rare)

Damage

- Early instars feed on leaves while older larvae cut plants at the base
- Threshold for canola: 25 to 30% stand reduction and larvae are 2.5 cm or smaller

VARIEGATED CUTWORM

Lepidoptera | Noctuidae

Peridroma saucia (Hübner)

T. Cowan

Description

Complete metamorphosis

Larvae

- Gray, mottled, with distinctive yellow dots at the top of the front abdominal segments
- Occasionally there is a yellow-orange stripe along the body

Target Crops

- Soybeans (occasionally)
- Corn (rarely)

Damage

- Larvae feed on the leaves and have caused economic injury in soybeans in Ontario
- Follow defoliation thresholds for soybeans on page 46
- Rarely causes economic damage in corn

SLUGS

Gastropoda | Agriolomacidae, Arionidae

Many species including:
Arion fasciatus (Nilsson) – Banded slug
Arion subfuscus (Draparnaud) – Dusky slug
Deroceras laeve (Müller) – Marsh slug
Deroceras reticulatum (Müller) – Grey garden slug

J. Smith

Description

Adults

- 25 to 50 mm
- Soft body, no legs, brownish-grey to beige, with or without markings
- The head has two pairs of tentacles, one of which holds the eyes
- "Snails without their shell" and are covered in a slimy mucous to keep from dehydrating

Larvae

- 4 to 5 mm
- Similar to the adults, but more bluish or purplish

Slugs on soybeans
B. Hall

Life cycle

Complete metamorphosis

One generation per year

- Hermaphrodite, that is they can self-breed and/or breed with each other
- There is one generation per year but two populations, one maturing as adults in spring and one maturing as adults in fall
- The eggs and the adults survive during the winter, and the eggs hatch in the spring when the temperature reaches 5 °C
- They can eat as much as 50% of their weight per day and travel 3 m per day
- Most active during cool and wet periods in spring and fall and prefer environments with high humidity and relatively cool temperatures

Targeted crops

Primary crops

- Soybeans
- Canola

Secondary crops

- Corn
- Forages
- Cereals

Damage

- Seeds: chewed or hollow
- Seedlings: partially or completely chewed
- Leaves: in corn, strips are scraped off, causing the leaf to shred, resembling hail damage. Growing point in corn rarely impacted. In soybeans and other broadleaf plants, leaves are skeletonized and growing point can be killed.
- Traces of slime trails on leaf surface
- Field: gaps in plant stand, uneven growth

Corn plant injury
T. Baute

Cotlyden damage
R. Hammond

Percentage of acres at risk: Occasional pest of soybeans, dry beans and canola. Growing point of corn is rarely impacted.

Favourable conditions and risk factors

- Fields with a history of slug problems
- Poor drainage fields and fields with loam or clay soil
- Dense canopy
- No-till corn, soys and canola with considerable crop residues
- Wheat fields underseeded with red clover
- Newly seeded alfalfa
- Fields following mixed forages
- Open seed furrows
- Cool, wet, cloudy spring or fall conditions
- Mild winter with a thick cover of snow

Scouting

Fall monitoring can predict problem fields for next spring since the same population of slugs are present in the fall and spring.

When? End of April to the end of June and September to mid-October. At night or early in the morning.

How? Visual observation of the symptoms (traces of slime trails, defoliation). Shelter traps (see page 38 for details).

Note: The presence of slugs underneath the shelter trap every five days or so

When scouting, look for traces of slime and defoliation
T. Baute

Thresholds

- No economic thresholds are available but finding the presence of slugs under shelter traps can help guide preventive and cultural practices to reduce the risk

High risk field
T. Baute

Pest management strategies

Preventive and cultural control options

- Plant early, before eggs hatch and the slugs become active, if the conditions are favourable to rapid plant growth
- Ensure seed slots are closed
- Tillage to eliminate significant residue, exposing the slugs to dehydration and predation. Zone tillage or row sweepers can help speed up the drying of the row area, thus deterring slug feeding. Moving trash away from seedlings may help reduce damage.

Biological control and natural enemies

- Parasitoids: nematodes
- Predators: ground beetles, rove beetles, vertebrates (e.g. birds and small rodents)
- Pathogens: likely but not well known

Chemical control options

- Baits: Some products are available (iron phosphate pellets) but are not cost effective for field crops though small hot spot areas can be treated effectively. Apply baits shortly after May 24 to achieve the highest potential for success.
- Experiments with 28% nitrogen/water mixtures or foliar potash applications have proven to be inconsistent and are not encouraged
- Insecticides (seed, soil applied or foliar) do not control slugs

CORN FLEA BEETLE

Coleoptera | Chrysomelidae

Chaetocnema pulicaria Melsheimer

F. Peairs

Description

Adults

- ~ 2 mm
- Black and oval shiny body with enlarged, jumping hind legs

Life cycle

Complete metamorphosis

Three to four generations per year

- The adults overwinter within the first 5 cm of soil or in residues and are active at temperatures above 18 °C
- Eggs are laid on the soil, plants and crop debris in May to July
- One generation takes approximately one month with early generations considered the most problematic
- Larvae hatch and feed on roots in the soil (rarely seen), though it is the adults that cause economic damage
- Adults carry *Erwinia stewartii* (bacterium that causes Stewart's wilt) in their gut and transmit the disease when feeding

Targeted crops

Primary crop

- Corn; seed corn being the most vulnerable due to Stewart's wilt

Damage

- Feeding damage is rarely economic; transmission of Stewart's wilt is the main concern
- Leaves: long feeding scratches or window-paning on the leaves, usually running parallel with the leaf veins. Only susceptible varieties, and seed corn inbreds, show yield loss unless extreme drought conditions exist.
- The risk of transmission of Stewart's wilt disease is higher from the seedling stage to the 5-leaf stage, though some transmission can occur during reproductive stages of corn
- Often mistaken with the damage caused by slugs

Percentage of acres at risk: 100% of seed and sweet corn acres, particularly following mild winters. Rarely a concern in field corn except for hybrids susceptible to Stewart's wilt.

Stewart's wilt field

A. Tenuta

Favourable conditions and risk factors

- Presence of grasses in the field or on the edge of the field in the fall
- Mild winters, especially during the months of December, January and February
- Planting hybrids and inbreds susceptible to Stewart's wilt
- Drought conditions can worsen impact from feeding injury and Stewart's wilt, even for non-susceptible varieties

Scouting

Adults

When? Every five days after crop emergence until the 5-leaf stage

Where? Examine at least 10 plants in 10 areas of the field

Areas at risk

- 100% of seed and sweet corn acres

How? Inspect leaves for feeding scars and presence of adults. Sticky traps at field's edge can be used to detect adult emergence and presence but visual scouting still required.

Look for: Observe closely the corn hybrids or inbreds that are susceptible to the Stewart's wilt disease, taking note of the number of beetles and leaf stage of the crop

Thresholds

- For susceptible hybrids and inbreds, six beetles per 100 plants prior to the 5-leaf stage warrant control. For tolerant varieties, an average of five or more beetles per plant prior to the 4-leaf stage may warrant control, particularly in drought conditions where impact of injury and disease can be aggravated.
- Prediction models are available in some neighbouring US states that help predict the risk of high adult activity each year based on winter temperatures and adult survival – risk is higher after milder winters

Early symptoms of Stewart's wilt
A. Tenuta

Pest management strategies

Preventive and cultural control options

- Plant tolerant hybrids, especially following a mild winter
- Avoid early planting dates for susceptible hybrids particularly following a mild winter
- Weed management: especially grasses in the beginning of the season because they attract flea beetles

Biological control and natural enemies

- Pathogens: nematodes

Chemical control options

- Insecticide seed treatment: for susceptible hybrids and seed corn inbreds planted in fields with a history of flea beetle infestations
- Foliar insecticides: additional foliar sprays may be necessary for seed corn and susceptible varieties if populations are very high. It is not economical to spray corn with insecticides to protect against the flea beetles transmission of Stewart's wilt except for highly susceptible inbreds and hybrids.

CRUCIFER FLEA BEETLE
STRIPED FLEA BEETLE

Coleoptera | Chrysomelidae

Phyllotreta cruciferae (Goeze), *P. striolata* (Fab.)

R. Underwood

B. Hall

Description

CRUCIFER FLEA BEETLE

Adults

- 1.5 mm
- Black and oval body with metallic blue-green highlights and enlarged, jumping hind legs

STRIPED FLEA BEETLE

Adults

- 1.5 mm
- Black and oval body with cream to yellow coloured dorsal stripes and enlarged, jumping hind legs

Flea beetles jump when they are disturbed.

Life cycle

Complete metamorphosis

One generation per year

- The adult phase overwinters in sheltered areas such as woodlots or under leaf litter on the soil surface
- The adults emerge at the beginning of late April (soil T: 10 to 15 °C). The striped flea beetle emerges 1 to 4 weeks before the crucifer flea beetle.
- Eggs are laid on the soil surface close to the base of host plants in May and June
- Larvae hatch and feed on roots for approximately one month from June to late July; then pupate
- First generation adults emerge in early August and feed on host plants until late October before locating overwintering sites
- Flea beetles can fly as far as 1 km away to find their preferred host plants when winds are calm

Targeted crops

Primary crop

- Canola and other crucifers (e.g. mustard)

Areas at risk

- 60 to 100% of canola acres

Damage

Greatest damage is done by adults and most severe during the first three weeks following crop emergence.

Larvae

- Roots: chewed though greatest extent of damage is by adults

Adults

- Leaves and stems: small pale green spots or small pinholes on the cotyledons, stems and leaves
- Pods: surface with small perforations or scars, especially in hot and dry years resulting in shriveled seed and pod diseases
- Field: plant stand thinned, stunted plants

Percentage of acres at risk: 60 to 100% of canola acres at risk, greatest following mild winters

Favourable conditions and risk factors

- Previous warm, open fall that allowed for good adult fall feeding and overwintering preparation
- Mild winters with good snow cover
- Warm springs that increase adult mobility and activity
- Light and crusty soils
- Excess nitrogen (a lush canopy is more sensitive to flea beetles)
- Very hot and dry weather can increase pod injury

Scouting

Adults

When? Mid-May to end of June and mid-August to mid-September

Where? Edge of field will have greatest activity though scout throughout the field to know average level of defoliation. Sticky traps at field's edge can be used to detect adult emergence and presence but visual scouting still required.

How? Inspection of three plants in 10 areas of the field to determine the percent defoliation

When? From the cotyledon stage to the 4-leaf stage. Observe every two days.

Note: The presence of adults, % defoliation on new leaves and the leaf stage of the plant

Thresholds

- 25% of the canopy is defoliated between the cotyledon stage and the 4-leaf stage and adults are still actively feeding. If adults are feeding on the seedling stems under cool conditions, action may need to be taken before 25% defoliation on leaves.
- Once the plants have reached the 4-leaf stage, they are usually well established and can compensate for the damage incurred
- In hot dry summers, 50 or more adults per plant, actively feeding on pods, may warrant control

Pest management strategies

Preventive and cultural control options

- Weed management: control weeds, especially crucifers before planting (e.g. wild mustard, volunteer canola, flixweed, pennygrass, field pennycress, stinkweed)
- Planting into good soil conditions that promotes rapid plant growth and good stand establishment
- Planting rate: overseeding can compensate for some stand loss
- Proper fertilization: avoid excess nitrogen which could produce a lush canopy more sensitive to the attacks of flea beetles
- No-till or minimum tillage to create a cooler soil microclimate that is less ideal for flea beetles

Biological control and natural enemies

- Parasitoids: hymenoptera (Braconidae)
- Predators: lacewings, fall field crickets, plant bugs, birds, toads
- Pathogens: nematodes

Chemical control options

- Insecticide seed treatment is recommended
- Foliar insecticide treatment: Once the threshold has been reached before 4-leaf stage. It is possible to treat only the edge of the field (if the damage is concentrated in that area).

25% defoliation = threshold

R. Underwood

BEAN LEAF BEETLE

Coleoptera | Chrysomelidae

Cerotoma trifurcata (Forster)

H. Bohner

J. Smith

Description

Adults

- 4 to 9 mm
- Vary in colour but are most often yellow, orange, tan or red
- May or may not have four black square shaped spots on their wings
- All have a small black triangle at the start of the wings
- Often mistaken for the spotted cucumber beetle (*Diabrotica undecimpunctata howardi* Barber) or ladybeetle adults

Larvae

- Up to 10 mm
- Below ground and rarely seen
- White with a brown colouration at each extremity of their body
- Brown head and three pairs of well sclerotized legs
- Looks very similar to corn rootworm larvae (*Diabrotica* spp.)

Life cycle

Complete metamorphosis

One generation per year

H. Bohner

- The adults overwinter in the grassy edges of fields, underneath piles of dead leaves and in woodlots (no survival if the soil T ≤-9 ˚C during winter) and emerge around the end of April (T ~ 10 to 13 °C)
- Overwintering adults may feed on early emerging soybeans or forages and live until approx. late June
- Adults lay lemon shaped, orange coloured eggs at the base of soybean and legume plants
- Larvae feed on soybean roots and nodules but are not of economic concern
- Pupation occurs in the soil
- First generation adults emerge in July and feed into fall before moving to their overwintering habitat

Targeted crops

Primary crops

- Soybeans

Secondary crops

- Dry beans
- Forages (rarely causes economic injury)

Damage

Overwintering generation (April to mid-June)

- Leaf feeding: circular holes between the main veins
- Seedling plants may be cut at the base or missing cotyledons under heavy populations

First generation damage (July to September)

- Leaf feeding: circular holes between the main veins
- Pod feeding: circular holes on the surface of the pod, leaving only a thin film of tissue to protect the seeds

within the pod. Pod lesions increase susceptibility to secondary seed diseases such as Alternaria.

- Pods may also be clipped off the plant, but this is not the primary cause of yield loss
- Vector of bean pod mottle virus which causes the plant and seed to become wrinkled and mottled, reducing seed quality

Percentage of acres at risk: 15 to 25%, higher risk in the most southerly counties of Ontario where soybeans are planted early and overwintering is most successful

Favourable conditions and risk factors

- Soybean fields neighbouring alfalfa and other legumes
- Earliest soybean fields planted in the area

Scouting (soybeans)

Adults

Seedling stage

When? End of April to mid-June

Where? On the seedling plants or along the soil surface

Pod damage
T. Baute

Soybean defoliation
T. Baute

Cotyledon damage
R. Hammond

Seedling stage (VE-V1)

How? Randomly pick five areas of the field to sample and count the beetles on 5 to 6 m of row at each location.

Beetles may quickly drop off the plants as you approach and hide in soil cracks. Try to create little disturbance or cast a shadow over the plant while scouting.

Note: The average number of beetles per metre of row

Beyond the seedling stage

How? Establish the percent defoliation on 20 plants in five areas of the field and confirm the presence of adults. See defoliation scouting techniques and thresholds on page 46.

At the R4-R6 stages

How? Visual observation of percent defoliation (page 46) and damaged or clipped pods on 20 plants in five areas of the field (avoid the edges of the field) and confirm the presence of adults

Thresholds

Soybeans

- Seedling stages (VC-V2): 16 adult beetles per 30 cm of row. If plants are clipped off at the stem, control is warranted.
- Vegetative stages to R4 stage: see defoliation thresholds on page 46
- From pod fill to maturity (R4-R6): 25% defoliation or if 10% of the pods on the plants have feeding injury and the beetles are still active in the field, a spray is warranted. Consider days-to-harvest intervals. Consult page 46 for the evaluation of the percent defoliation.

Bean pod mottle virus
A. Tenuta

Pest management strategies

Preventive and cultural control options

T. Baute

- In areas with a history of injury, delay planting to the end of May/ beginning of June, after the emergence of the overwintering generation. Later planted fields however may be susceptible to pod feeding from first generation adults in July and August.
- Avoid being the first field to emerge in the area, if there is a history of seedling injury
- In fields with a history of pod feeding damage (rather than seedling damage), plant early to be less attractive to 1st generation adults that prefer less mature soybean plants in July and August

Biological control and natural enemies

- Parasitoids: flies (Tachinidae)
- Predators: mites
- Pathogens: entomopathogens (fungi)

Chemical control options

- Insecticide seed treatment: use if the field has a history of early season bean leaf beetle feeding damage or when planting food grade soybeans to reduce bean pod mottle virus incidence by reducing vector abundance
- Foliar insecticide treatment: is available when defoliation thresholds have been reached

Bees may forage soybeans during flowering. If spray is warranted, select an insecticide that poses less risk to bees, and spray in the evening once temperatures are cooler so that bees are less active. Notify nearby beekeepers a day prior to application so that they can take extra precautions to protect their hives.

SOYBEAN APHID

Hemiptera | Aphididae

Aphis glycines (Matsumura)

T. Baute

Description

- Wingless adults and nymphs look similar in appearance though nymphs are smaller

Adults

- Approx 1.5 mm
- Pale greenish-yellow with black cornicles ("tailpipes") and a pale yellow "tail"
- Adults may be winged or wingless

Nymphs

- Look like adults but are smaller and wingless

Life cycle

Incomplete metamorphosis

Several generations per year

- All females throughout the spring and summer months
- Overwinters as eggs on twigs of European buckthorn
- Nymphs hatch from eggs in the spring and molt into adults
- Two generations live on buckthorn before the third generation develop wings and fly to colonize on soybeans

- The aphids then continue to produce wingless generations until the soybean aphids become crowded. Winged adults are then produced in the next generation to disperse to other plants or fields.
- Aphids can migrate into fields throughout the summer from nearby fields or from far distances (i.e. U.S. states) via storm fronts
- Adults are born pregnant and give birth to live young so populations build up quickly
- As fall approaches, females start to produce winged males and females which fly to buckthorn to mate and produce eggs

Soybean aphids on buckthorn
T. Baute

Mosaic virus symptoms
T. Baute

Targeted crops

Primary host

- Buckthorn (*Rhamnus cathartica* and other R. species)

Primary crop

- Soybeans

Damage

- Piercing-sucking mouthparts suck juices and nutrients from the plant
- Once populations reach threshold levels, aphids can cause the plants to abort flowers, become stunted, reducing pod and seed production and quality
- Yield loss is greatest when soybeans are in the early R stages (R1-R2), when flowers can abort and impact pod establishment
- Peak infestations during the pod fill stage (R3) and beyond can result in smaller seed size and a reduction in seed quality
- Injury is exacerbated in dry years when plants are stressed
- Vector of soybean mosaic virus which causes leaves to mottle and seed hilum to stain the seed coat

Percentage of acres at risk: Any field in Ontario is at risk, with risk of higher levels once every 3 or 4 years. Fields in Eastern Ontario tend to experience early infestations (before R1) that require management as soon as the soybeans reach the early R stages.

Favourable conditions and risk factors

- Early planted fields are prone to early season infestations from aphids moving from buckthorn in the spring though this risk is lower in fields in southern Ontario where buckthorn is scarce
- Late planted fields are prone to summer migration of adults coming from other soybean fields
- Fields under drought stress or potassium deficiency can be more prone to injury

Scouting

When? Scout each field every seven to 10 days during R1 until the crop is well into the R6 stage. Scout fields more frequently (every three to four days) as aphid populations approach the threshold.

Where? Look at 20 random plants across the field, avoiding field edges

Aphids on young plant
T. Baute

Heavy infestation
T. Baute

How? Turn leaves over on each trifoliate of the plant to count the number of aphids on the leaves and stems

Estimate the number of aphids per plants and note the crop stage. A minimum of two field visits is required to confirm that aphid populations are increasing. Note the presence of natural enemies.

Thresholds

- 250 aphids per plant and actively increasing on 80% of the plants from the R1 up to and including the R5 stage
- This threshold gives an approximate seven to 10 day lead time before the aphids would reach the economic injury level, where cost of control is equal to yield loss
- When soybean aphid populations are not actively increasing above 250 aphids per plant, natural enemies are keeping up with the aphid population
- More aphids per plant are needed once soybeans are in the R6 stage

To assist in scouting and making management decisions, use the free Aphid Advisor app: www.aphidapp.com to determine if control is necessary or if natural enemies are abundant enough to keep aphid populations below threshold.

Pest management strategies

Preventive and cultural control options

- Removal of buckthorn can eliminate the overwintering host
- Resistant varieties are available but some aphid biotypes exist that can overcome the mechanism of host plant resistance

Biological control and natural enemies

Natural enemies play a large role in soybean aphid management.

- Predators: ladybeetles, lacewing larvae, minute pirate bugs, syrphid fly larvae
- Parasitoids: *Aphelinus certus*, and others
- Pathogens: entomopathogenic fungi

Ladybeetle larvae eating aphids
T. Baute

Chemical control options

- Insecticide seed treatments: Seed treatments are no longer present in the plants once they enter the R1 stage of soybeans and require foliar applications if thresholds are reached
- Foliar insecticides: Apply once threshold has been reached. Scout fields after application to ensure that aphid populations do not rebound or secondary pests, particularly spider mite populations do not flare up.

Bees forage soybeans during flowering. If spray is warranted, select an insecticide that poses less risk to bees and other beneficials, and spray in the evening once temperatures are cooler so that bees are less active. Notify nearby beekeepers a day prior to application so that they can take extra precautions to protect their hives.

POTATO LEAFHOPPER

Hemiptera | Cicadellidae

Empoasca fabae (Harris)

T. Baute

Description

Adults

- 3 mm
- Pale yellow-green, wedge-shaped, winged insect with a row of six rounded, white spots behind the head

Nymphs

- Smaller than adults and are wingless

Life cycle

Incomplete metamorphosis

Three to four generations per year

- Do not over-winter in Ontario but migrate north every spring via weather fronts from states along the Gulf of Mexico
- Adults can arrive as early as late April, early May
- Females lay their eggs in the tissue of main veins and petioles of leaves
- Development from egg to adult takes approximately four weeks
- Generations may overlap

Targeted crops

Primary crops

- Alfalfa
- Dry beans

Secondary crops

- Non-pubescent soybeans (rare)

Areas at risk

- 100% of alfalfa and dry bean acres

Damage

- Both adults and nymphs can cause injury
- Their piercing-sucking mouthparts suck juices and nutrients from the plant, injecting protein into the leaves to block veins causing V-shaped yellowing at leaf tips which is called "hopperburn"
- Border areas are usually affected first
- Symptoms are sometimes confused with nutrient deficiency or herbicide injury, and are often dismissed as "drought damage"
- Because yield is lost before hopperburn is evident, do not use the presence of hopperburn as a management guide

Hopper burn

G. Quesnel

Stunted alfalfa
G. Quesnel

Alfalfa

- Damage is most severe in new seedlings and young regrowth
- Potato leafhopper feeding causes reduced stem elongation, reduced root development, leaf cupping and stunting
- Yields can be lowered by as much as 50% with a severe infestation, accompanied by a reduction in protein levels of 2 to 3%
- Decreased stand vigour results in slow regrowth following cutting and increased winterkill
- Most of the damage occurs from June to mid-August

Dry edible beans

- Tend to move onto edible beans and non-pubescent soybeans after neighbouring alfalfa fields are cut
- Leaf tips turn yellow and curl downward from feeding injury
- In heavy infestions plants are stunted, have reduced number of pods, seeds and seed weight

Percentage of acres at risk: 100% of alfalfa and dry bean acres are at risk each year. Infestations are very frequent along Lake Erie counties.

Favourable conditions and risk factors

- Hot, drier-than-normal conditions
- Fields neighbouring other alfalfa fields

Scouting

Alfalfa

When? Every five to seven days beginning late June or after first cut

Where? 20 sweeps from five areas of the field, avoiding field edges

How? Use a sweep net (see page 39) to determine the number of nymphs and adults per sweep. Measure 20 random alfalfa stems to determine the average height.

Dry Beans

When? Every five to seven days as soon as crop emerges

Where? 10 areas of the field

How? Walk an X pattern through the field and pick 10 trifoliate leaves that are newly and fully expanding from the centre of the plant canopy. Determine the average growth stage of the plant.

Note: The number of leafhopper adults flying/jumping off the leaves and count the number of nymphs present on each leaf

Thresholds

Action thresholds

ALFALFA		DRY EDIBLE BEANS	
STEM HEIGHT	NUMBER OF PLH PER SWEEP[1]	BEAN GROWTH STAGE	PLH THRESHOLD PER TRIFOLIATE[2]
9 cm (3.5 in.)	0.2 adults	Unifoliate	0.25
15 cm (6 in.)	0.5 adults	2nd trifoliate	0.5
25 cm (10 in.)	1.0 adults or nymph	4th trifoliate	1.0
36 cm (14 in.)	2.0 adults or nymph	First bloom	2.0

[1] *1 Sweep = 180° arc*

[2] *Adults and nymphs*

[3] *The taller the alfalfa, the more leafhoppers it takes before control is necessary.*

Nymph
T. Baute

Pest management strategies

Preventive and cultural control options

- Resistant alfalfa varieties are available that use glandular hairs as the resistance factor but these hairs are not fully expressed on first year plants
- Cutting alfalfa early is the preferred recommendation and will potentially reduce egg, nymph and adult populations

Biological control and natural enemies

- Predators and parasites play a minor role in controlling this pest
- Pathogens: entomopathogenic fungi during cool, moist conditions

Chemical control options

- Insecticide seed treatments are recommended for dry bean fields with a history of leafhopper infestations and provide up to six weeks of protection
- Foliar insecticides only if thresholds are reached in alfalfa or dry beans, though cutting is the preferred method of control of alfalfa since spraying will kill any natural enemies of alfalfa weevil

Forages are frequently visited by bees. Spray in the evening when bees are less active and contact local beekeepers so they can protect their hives.

NATURAL ENEMIES

J. Smith

HELPING TO PROMOTE 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. Research indicates that 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 nearby fields. However, plant selection is important to not encourage pest populations that may be equally attractive to these plant species. Also, these buffer strips shouldn't be encouraged in a food grade cropping system where plant viruses carried by these bordering plants can be vectored by aphids, etc. to the crop and 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 depending on soil type and crop rotation.

A big component of natural enemy conservation is selective use of pesticides. Only applying pesticides when pests have reached threshold can help reduce harm to the natural enemies, and 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. Even frequent use of foliar fungicides has been shown to reduce the presence of entomopathogens (fungi) that control insects and should be used only when necessary. Some research indicates that the use of systemic insecticide seed treatments can have a negative impact on natural enemies; 1) indirectly by suppressing the pest population year after year so that the fields are not able to sustain a natural enemy population, and 2) directly by the natural enemy feeding on prey that contains the insecticide which then kills the natural enemy.

Unfortunately we have little control over weather which 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 and 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 crops susceptibility to stress incurred by pests.

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

GROUND BEETLES

Coleoptera | Carabidae

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

R.S. Bernard

Description

Complete metamorphosis

Adults

- 25 mm maximum
- Typically dark black or brown but some with bi or tricolour highlights
- Their body is slightly flattened and oblong
- The head is narrower than the thorax and they have very visible mandibles

Larvae

- The larvae are beige to black
- Their head has powerful and very visible mandibles
- They have a pair of cerci at the end of the abdomen

In general, they attack almost everything in their way, larvae or adults. Because they travel mainly by walking, they can usually be seen on the ground. They are favoured by soil conservation practices.

Key pests they feed on

- Slugs, caterpillars like armyworm and cutworm, grubs, wireworms to name a few

ROVE BEETLES

Coleoptera | Staphylinidae

Aleochara bilineata Gyllenhal, *Philonthus fuscipennis* Mannerheim and other species

R.S. Bernard

Description

Complete metamorphosis

Adults and Larvae

- Adults: 1 to 35 mm
- Larvae: 0.5 to 25 mm
- Elongated bodies that are in a variety of colours
- Adults have wings that are short, exposing much of their abdomen which is very flexible
- When disturbed or running, they curl up the tip of their abdomen like a scorpion

Both larvae and adults are predators. They can be found in almost all types of habitats. They are mainly predators or scavengers. Some species are ectoparasites to the fly pupae (e.g. *Aleochara bilineata* Gyllenhal).

LADY BEETLES

Coleoptera | Coccinellidae

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

J. Smith

Description

Adults

- 1 to 10 mm
- Various shades of red, pink, yellow, orange or black with most having some markings on the wings
- Most are round or oval shaped though a few are slightly oblong

Larvae

- Vary in colour but usually black to blackish grey with some orange, red or yellow markings
- Look like tiny alligators, some with spines along their back

Both adults and larvae are predators and can be found on plants where pests are present. Important natural enemies of soybean aphids but feed on many other pest species.

SOLDIER BEETLES

Coleoptera | Cantharidae

Cantharis rufa Linné, *Ancistronycha bilineata* Say and other species

R.S. Bernard

Description

Adults

- 17 mm maximum
- Long, straight and slightly flattened body
- The wings are often shorter than the abdomen
- Some adults are predators, others feed on pollen. They can be found mainly on the edges of fields.

Larvae

- They are dark in colour
- Their body is stubby and generally hairy
- Their head has powerful and highly visible mandibles
- The tip of the abdomen doesn't have any circus
- Looks like the rove beetle larva
- Predators only, the larvae feed on slugs and on the larvae of seed borne insects
- They can be found in the soil and bedding

PIRATE BUGS

Hemiptera | Anthocoridae

Description

Incomplete metamorphosis

OMAFRA

Adults

- 1 to 5 mm
- Somewhat oval to teardrop shaped
- Black and white cross pattern on their backs (like a pirate flag)

Nymphs

- Similar size and shape to adults but lack wings and are yellow-orange to red in colour

Commonly feed on field crop pests including aphids, mites, small caterpillars.

Can also be found in flowers feeding on nectar.

VERTEBRATES

Some birds (ravens, crows, thrashers, thrushes, blackbirds, starlings) as well as some mammals (skunks, racoons, small rodents), love to eat soil borne pests. For example: the holes the skunks dig searching for "white grubs".

Evidence of a skunk searching for grubs.
T. Baute

PARASITOIDS

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

DIPTERA (FLIES)

Diptera | Tachinidae

Winthemia rufopicta (Bigot) and other species

D. Cappaert

Description

Complete metamorphosis

TACHINID FLIES

Adults

- ~10 mm
- The adults look like the domestic fly, or sometimes like bees or wasps with only one pair of visible wings

Parasitoid of many pests including: armyworm, black cutworm, potato stem borer.

Most tachinidae stick their eggs directly on the body of their host. Once the parasitic larva emerges out of the egg, it migrates inside their host's body to feed on the internal organs.

Parasitized armyworm
R. Bauernfeind

HYMENOPTERA (WASPS)

Hymenoptera | Aphelinidae | Braconidae | Campopleginae | Ichneumonidae and others

Soybean aphid and parasitoid wasp
T. Baute

Braconid wasp parasitizing larva
S. Bauer

Description

Complete metamorphosis

Adults

- Rarely bigger than 15 mm
- Attack many different pests though often are very specific to only being adapted to parasitize one particular stage of one species of insect pest
- Parasitoids play a key role in the biocontrol of some caterpillars, soybean aphids and alfalfa weevil for example
- These wasps lay their eggs on or inside their hosts resulting in the eventual death of the host. Depending on the species, one or more stages of growth of the host (eggs, larvae, pupae and/or adults) may be parasitized.

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

Entomophthorales | Eurotiales | Hypocreales

Entomophthora muscae (E. Cohn) Fresenius, *Beauveria bassiana* (Balsamo-Crivelli) Vuillemin and other species

Soybean aphid killed by pathogen
T. Baute

Pathogenic fungi

The fungal pathogens attack many insects, such as caterpillars, flies and beetles. High density populations of insect pests favour the proliferation and the dissemination of spores (infectious agent), resulting in a fast drop of the populations of insect pests when the temperature and humidity conditions are adequate.

BACTERIA

Bacillales | Burkholderiales

Bacillus thuringiensis, *B. cereus*, *Burkholderia cepacia* and other species

Pathogenic bacteria

The bacteria that attack insects naturally occurs in the soil and are specific to a group of insects. The best known one is *Bacillus thuringiensis* (Bt). When ingested by an insect, the crystals produced by the bacteria are modified into toxic molecules of protein that destroy the host's stomach wall. The insects sensitive to that toxin usually stop feeding within hours after exposure and usually die two to five days later.

VIRUSES

Naturally occurring insect killing viruses are present on the soil and plant surfaces. Once ingested, the insect usually climbs to the tops 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 killed by a virus
A. Schaafsma

NEMATODES

Rhabditida | Heterorhabditidae, Steinernematidae

Steinernema feltiae Filipjev and other species

Beneficial nematodes

Parasitic nematodes are naturally occurring, microscopic worms that enter into a host through its natural orifices, produce offspring and rapidly kill their host. Nematodes need special conditions to proliferate and travel, which complicates their use. For example, they are not very efficient in compacted or cold soils (the optimal temperature is usually between 14 and 30 °C). They infect the larval forms of lepidoptera, coleoptera and diptera as well as adult crickets and adult grasshoppers.

PROTECTING INSECT POLLINATORS AND BENEFICIAL INSECTS

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 and use insecticides only when necessary. This approach can include implementing cultural practices 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 insecticide 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

P. Porter

T. Baute

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 pm allows the spray to dry before the bees are exposed to it the next day
  - Early morning is the next best time, but spraying should be completed well before 7 am
  - 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, including seed treatments on windy days
- 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 it or planting seeds treated with an insecticide.
- Take measures to reduce movement of dust from insecticide seed treatments onto flowering plants and trees that are in or adjacent to the target field. 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/or surface water.
- Research indicates that use of vacuum (i.e. negative pressure) planters poses a significant risk of pollinator exposure from drift of insecticide containing dust exhausted from these planters during planting. All growers should 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

P. Porter

Communication and cooperation among growers, 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 growers as to where hives are in relation to their fields so they can properly inform the beekeeper when an application is being made. Contact information for the local beekeepers' association in your area can be found on the Ontario Beekeepers' Association website at www.ontariobee.com/community/local-beekeepers-associations. Other ways to find your local beekeepers are to contact the Provincial Apiarist at 1-888-466-2372, ext. 63595 or see www.ontario.ca/crops and click "Apiculture" and then "Bee Inspectors" for a list of provincial bee inspectors who know the local beekeepers.

Related information

Additional information and Best Management Practices can be found at Health Canada's pollinator protection web page: www.healthcanada.gc.ca/pollinators

The following site provides IPM information

Ontario Ministry of Agriculture, Food and Rural Affairs: www.ontario.ca/crops

Grain Farmers of Ontario
679 Southgate Drive
Guelph, Ontario Canada N1G 4S2

www.gfo.ca
Phone: 519-767-9713 or 1-800-265-0550

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