Protecting pollinators from pesticides

CUCURBIT CROPS

POLLINATOR PARTNERSHIP CANADA

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POLLINATOR PARTNERSHIP CANADA

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FOREWORD

Insect pollinators, especially bees, play a crucial role in the pollination of field grown cucurbits, such as pumpkin, squash, gourds, cucumbers, melons, and watermelons. Pollinator health is important to the long-term sustainability of cucurbit production as well as to the broader environment, especially as pollinator populations are known to be in decline globally. Keeping managed bees and other pollinators such as wild bees healthy requires involvement from all participating in cucurbit production, from beekeepers to growers, agronomists, crop consultants, and pesticide applicators.

The focus of this guide is to minimize the impacts of pesticides on pollinators, and it is meant for all those involved in cucurbit production. There are many factors that impact pollinator health in addition to pesticide exposure, including habitat loss, insects and diseases, and climate change. By reducing pollinators' exposure to pesticides, stakeholders can help pollinator populations to be more robust and healthier in the face of multiple stressors.

This guide can be used as a quick reference on individual topics or can be read in its entirety for a deeper dive into the subject. It provides guidance on how to minimize the impacts of pesticides on the pollinators (primarily bees) found in cucurbit crops through informed decision-making, best management practices, and by maintaining good communication between growers, applicators, and beekeepers.

The **first section** of this guide covers the relationship between managed and wild pollinators, and cucurbit crops. The **second section** covers four important practices that help minimize the impacts of pesticides on pollinators: integrated pest management, communication, habitat, and pesticide product selection and use. The **third section** distills the information contained in sections 1 and 2 into action-oriented recommendations for growers, applicators, and beekeepers. The **resource section** includes more detailed information on the impacts of pesticides on bees and how to identify and report suspected bee poisoning.

In addition to this guide, readers can consult the **supplemental document** for pollinator precaution levels for products registered for use in cucurbit production and for additional information on the pesticide risk characterization framework used by the Pest Management Regulatory Agency (PMRA) to designate precaution levels.

This guide focuses on field grown cucurbits that require insect pollination. We hope this guide will help everyone involved in field cucurbit production learn more about the pollinators that pollinate this important crop group and how we can maintain productive and healthy cucurbit growing systems while protecting pollinators within those systems.

1 CUCURBIT POLLINATION

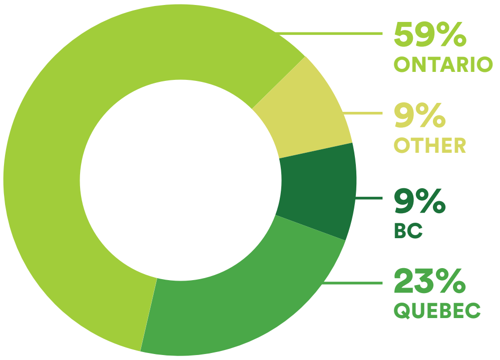
CUCURBIT PRODUCTION IN CANADA

In Canada, cultivated cucurbits are comprised of three main production groups including (1) pumpkin, squash, and gourds (*Cucurbita* species), (2) cucumber and melons (*Cucumis sativus* and *Cucumis melo*, respectively), and (3) watermelon (*Citrullus lanatus*). Cucurbits are global crops: Pumpkins, squash, and gourds are native to Mesoamerica (central Mexico south though Nicaragua and northern Costa Rica), cucumbers to India, watermelons to Africa, and melons to India and Australia[1].

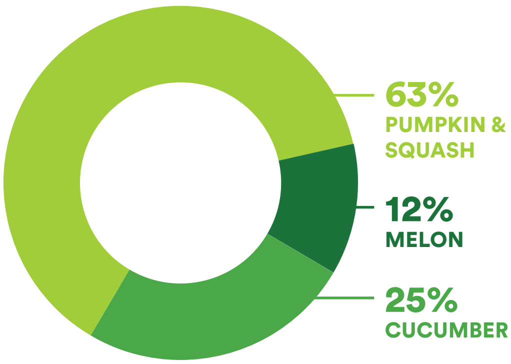
In Canada in 2019, cucurbit crops had a farm-gate value of approximately $134 million CAD, with most crops being consumed fresh or used for cultural expression associated with Thanksgiving and Halloween[2,3]. The pollination services of bees, wild and managed, contribute to this value significantly.

Most cucurbit production in Canada occurs in Ontario (59%), followed by Quebec (23%) and British Columbia (9%), with all other provinces combined producing the remaining 9%[3]. Among the cucurbit crops, pumpkin and squash occupy the most area (63%) followed by cucumbers (25%), and melons and watermelons (12%)[3]. The value of pumpkin and squash crops in Ontario alone has increased from about $7 million to $31 million over the last twenty years[4]. It is important that growers can produce a marketable product which requires consideration of both pest control, pollination requirements, as well as other factors.

% OF TOTAL AREA BY PROVINCE PLANTED CUCURBIT CROPS IN CANADA



PRODUCTION AREA BY CROP TYPE



CUCURBIT POLLINATION SYSTEMS

All cucurbits have separate male and female flowers on the same plant, and each flower lasts only a single day[5]. Pollen must be moved by insects (mostly bees) from the male flowers to the female flowers to produce fruit, except in parthenocarpic cucumber varieties[6] and some zucchini varieties which develop without pollination. Some varieties of melon and watermelon have hermaphroditic flowers (both sexes on the same flower) as well as separate male and female flowers (e.g., Hale's Jumbo cantaloupe cultivar)[5]. Male flowers usually appear first, are more numerous, and produce more nectar than female flowers. Production of nectar and attractiveness to pollinators varies among cucurbit types, with pumpkins and squash being the most attractive[5].

Production systems are substantially different among the cucurbit crops. For example, seedless watermelon is grown from triploid varieties that must be pollinated with pollen from pollen donor diploid varieties[7]. Some cucumber varieties produce only female flowers and must be interplanted with another pollen donor variety, and some parthenocarpic cucumber varieties require no pollination[6]. This guide focuses on field grown cucurbits that require insect pollination.

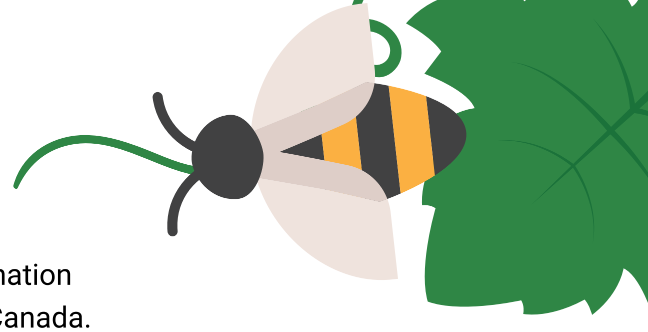


Table 1. Flower types, flower duration, production systems, and pollination requirements for the main groups of cucurbit crop groups grown in Canada.

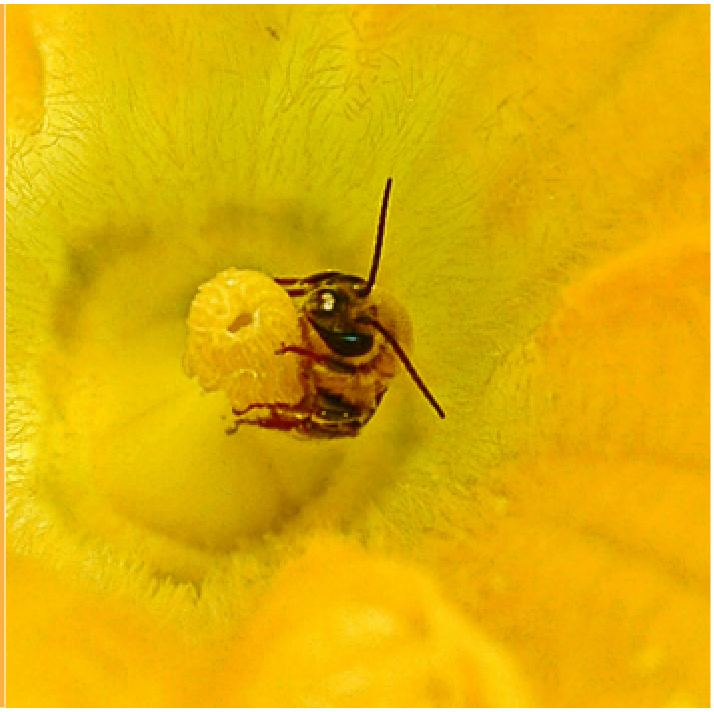
CUCURBIT CROP GROUP	FLOWER TYPES	FLOWER DURATION	FIELD PRODUCTION SYSTEMS	RECOMMENDED STOCKING RATES FOR MANAGED POLLINATORS[8]
PUMPKIN, SQUASH, GOURDS (*CUCURBITA SPECIES*)	Separate male and female	6 hours, dawn to noon; new flowers every day	Fresh market, processing market, small scale greenhouse specialty cucurbit market	Requires insect pollination Honey bees: 0.04-3 hives/acre Commercial bumble bees: 0.5-3 colonies/acre, spaced in field. Where there are 7 total bees/25 flowers, stocking managed bees is unnecessary[9].
CUCUMBER *(CUCUMIS SATIVA)*	Separate male and female; Some hybrid varieties produce only female flowers and must be interplanted with pollen donor varieties	All day for 1 day, fertility declines over the day; new flowers every day	Fresh market, processing market, greenhouse market	Requires insect pollination except for parthenocarpic varieties Honey bees: 0.1-4 hives/acre Commercial bumble bees: 0.5-3 colonies/acre, spaced in field
MELON *(CUCUMIS MELO)*	Separate male and female or hermaphrodite	All day for 1 day, fertility declines over the day; new flowers every day	No special systems	Requires insect pollination Honey bees: 0.2-5 hives/acre Commercial bumble bees: 0.5-3 colonies/acre, spaced in field
WATERMELON *(CITRULLUS LANATUS)*	Separate male and female or male and hermaphrodite	All day for 1 day, fertility declines over day; new flowers every day	Seedless watermelon varieties are triploid and must be interplanted with diploid pollen donor varieties	Requires insect pollination Honey bees: 0.04-3 hives/acre Commercial bumble bees: 0.5-3 colonies/acre, spaced in field Where wild bees are abundant, stocking managed bees is unnecessary[10]

POLLINATION REQUIREMENTS OF CUCURBITS

Because of their pollination systems, and large, oily pollen, all non-parthenocarpic cucurbit crops in Canada are completely dependent on insect pollination to produce fruit[5,11]. A lack of pollination, on its own or in combination with other factors, can lead to crop failure. Furthermore, the size of cucurbit fruit is related to the amount of pollen deposited by bees on female flowers, with less pollen resulting in smaller or misshapen fruit[11-13].

Both honey bees and wild bee species visit cucumber[11,14], watermelon[15], and pumpkin and squash[9] flowers. Research shows that wild bees may be more abundant and/or more efficient at pollinating these crops than honey bees[15-18].

Pumpkin, squash, and some gourds (genus *Cucurbita*) have evolved in close relationship with squash bees (*Eucera* species). These bees collect only pumpkin and squash pollen to feed their larvae. In Ontario, the daily and seasonal flowering period of pumpkin or squash flowers corresponds with the daily and seasonal foraging activity period of hoary squash bees (*Eucera pruinosa*)[9]. In fact, hoary squash bees are "early birds", reaching peak numbers on the crop flowers as soon as the flowers open at dawn. Where they are present, hoary squash bees complete crop pollination well before honey bees begin foraging on the crop in large numbers[9,16].



THE POLLINATORS OF CUCURBIT CROPS

Cucurbit flowers are visited by many insects including wasps, ants, moths, and beetles, but the most important pollinators are bees. This guide uses the terms 'wild' bees to mean bee species that live without human intervention, and "managed" bees, which in Canada includes honey bees, and commercialized common eastern bumble bees, the alfalfa leafcutter bees, and blue orchard bees. While most people are familiar with managed honey bees, the valuable pollination services provided by wild bees to many crops, including cucurbits, are less well-known. The health of all bees is important as many bee species are known to be in decline globally[19-21].

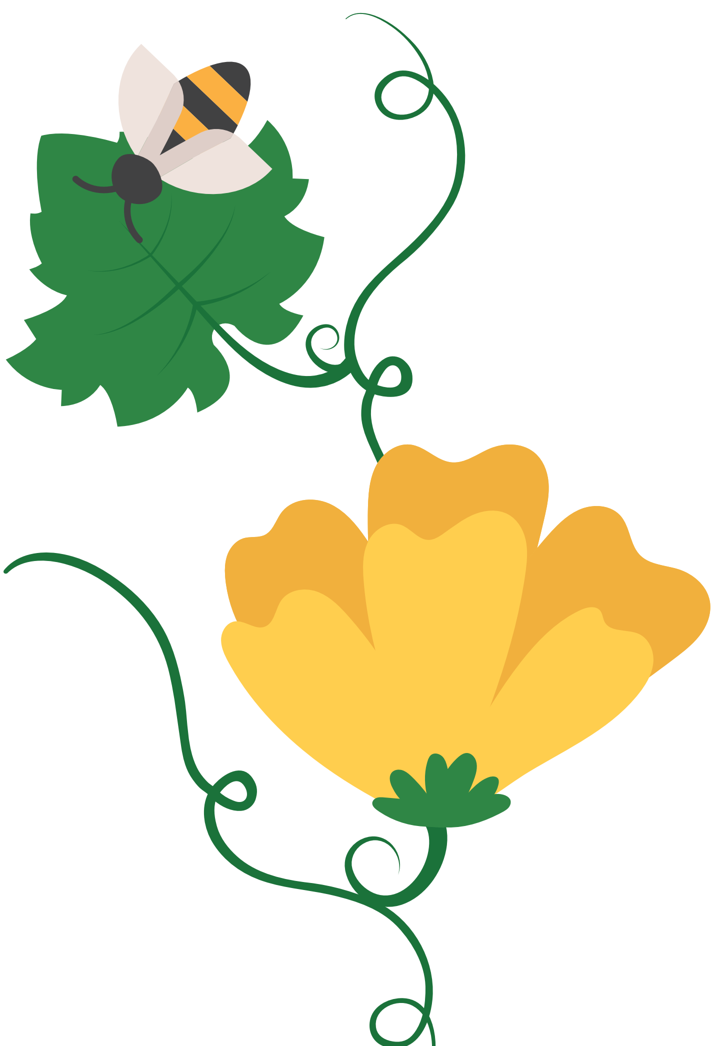
CASE STUDY
HOWE FAMILY FARM, AYLMER, ONTARIO

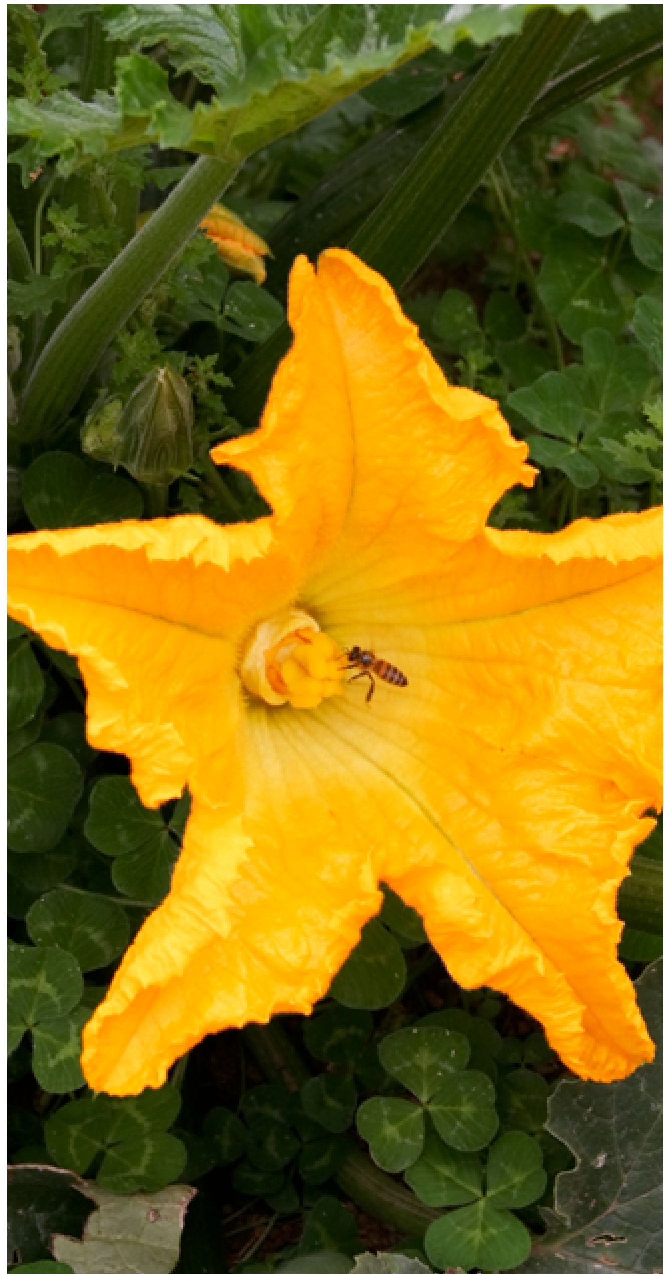
The Howe Family have been growing watermelon and cantaloupes on their farm near Aylmer, Ontario since the early 1940s, with a present production of 80 acres of melons and 220 acres of pumpkins. They use a no-till system with a rye cover crop that controls weeds, reduces the need for irrigation, prevents erosion, improves the soil on the farm by adding organic matter, and does not disrupt the ground nests of hoary squash bees. To pollinate their seedless watermelon crop, the Howes interplant diploid and triploid varieties and have a long-standing relationship with a commercial beekeeper who supplies 150 hives annually to the farm. Kevin Howe is also interested in learning how to use other managed bees such as leafcutter bees to improve pollination services to his watermelon crop. "Our farm's pumpkin crop is pollinated almost exclusively by hoary squash bees that build their nests on the edges of the sandy laneways that crisscross our farm. To attract other beneficial insects such as wild bees, predators, and parasitoids, I have intercropped wild flowers with our farm's one-acre vegetable plot that supplies fresh vegetables to visitors to our farm store. Attracting wild bees and using them together with managed honey bees assures a successful harvest for all our farm's cucurbit crops while the other beneficial insects help to reduce pest insect populations".

MANAGED BEES

Managed bees are sometimes rented (honey bees) or purchased (bumble bees) for cucurbit pollination (Table 1). While honey bees may be less efficient pollinators of some cucurbits than wild bees, they are easy to manage and transport, and can provide a large pollinating force, especially when field sizes are large. Variation in honey bee stocking recommendations is related to planting density in the field, with higher stocking rates needed with higher planting densities. Not all cucumber and melon varieties have been tested for their pollination needs, therefore these recommendations provide guidelines only.

Managed bumble bees (*Bombus impatiens*) can be purchased in Canada to provide pollination services to crops and have their own stocking rate recommendations (Table 1). Bumble bee colonies should be placed throughout the field instead of just on the field edges[8].





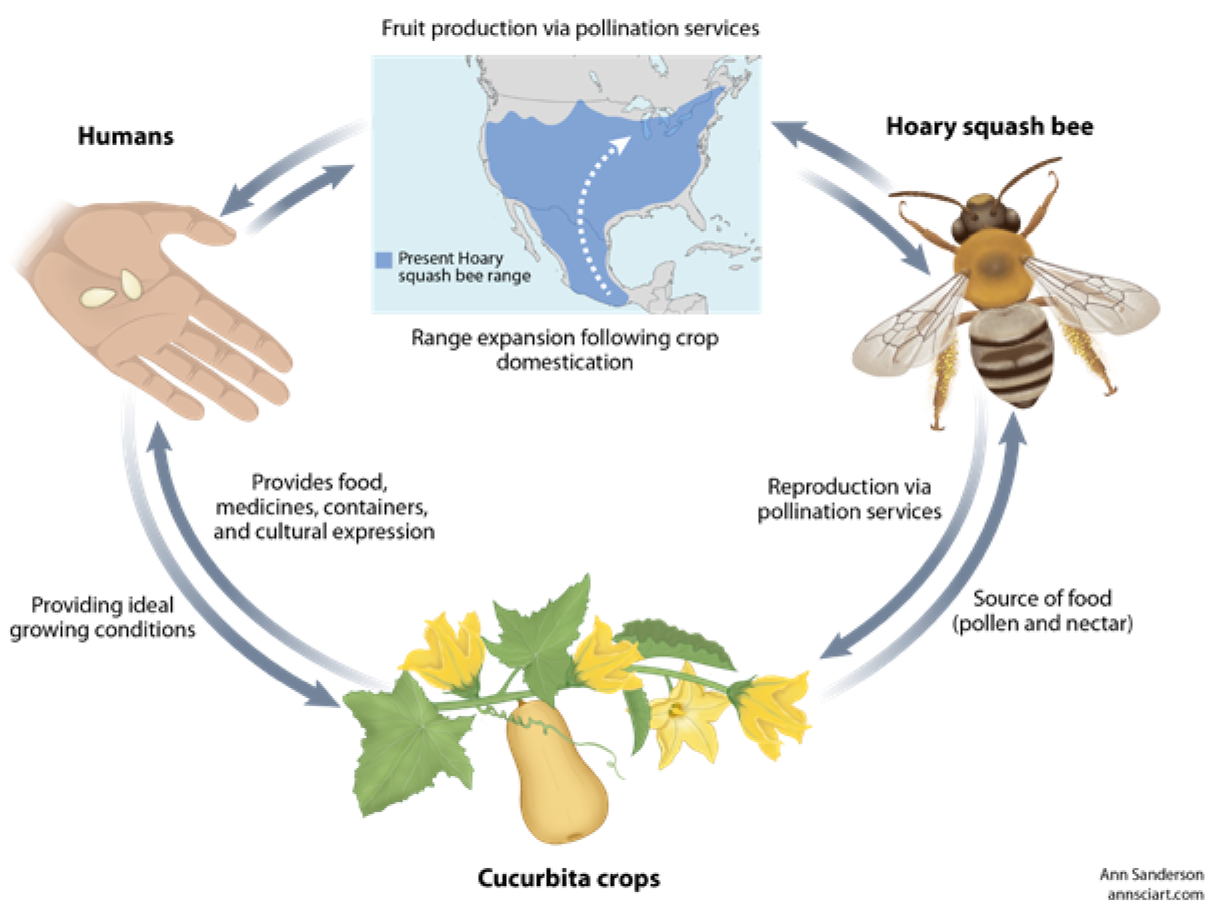
Although they readily visit cucurbit flowers to collect nectar and can carry pollen from flower to flower, both honey bees and bumble bees are known to avoid harvesting pollen from pumpkin and squash[22,23]. This is likely because the pollen is so large, spiney, and oily, or may not meet the bees' nutritional needs[23]. In fact, honey bees and bumble bees will often groom pumpkin pollen off themselves to avoid taking it back to their nests or hives.

WILD BEES

There are over 800 species of wild bees in Canada, ranging in size from a few millimeters up to 25 mm in length. Wild pollinators are on-site natural allies that are known to support cucurbit production. Even in the presence of high densities of honey bees, having more wild bees will improve crop pollination[10,24]. Wild bees are present in and around fields all year, either as adults that can be seen foraging or as eggs, larvae, or pupae that are less visible but nonetheless are present in nests in the ground, in twigs, or in cavities. In fact, many ground-nesting bees such as squash bees, long-horned bees, mining bees, and sweat bees construct their nests on crop edges or in fields.

Cucurbits, especially pumpkins and squash, have a special relationship with a group of wild solitary bees known as the squash bees (*Eucera* species). Squash bees only harvest pollen from plants in the genus *Cucurbita*, including pumpkin and squash[25]. Although these wild bees are native to Mexico, they have spread across North America into south central Canada and most of the United States following the expansion of pumpkin and squash cultivation by humans[25].

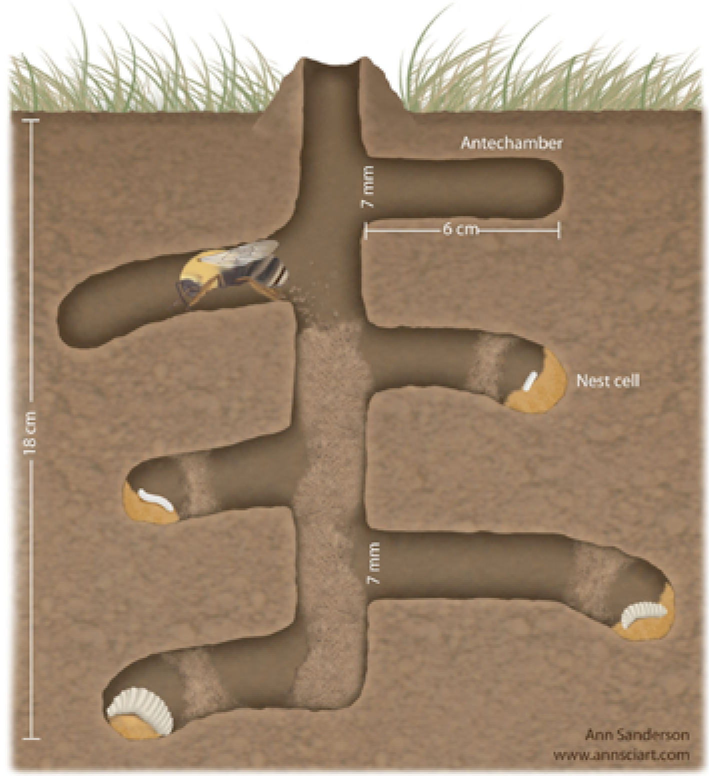
THE RECIPROCAL RELATIONSHIP BETWEEN HUMANS, CUCURBITA CROPS, AND THE HOARY SQUASH BEE



The only species of squash bee currently present in Canada is the hoary squash bee (*Eucera pruinosa*, formerly known as *Peponapis pruinosa*). It is found in both Ontario and Quebec but has not been found in the other Canadian provinces yet. In Ontario, the hoary squash bee is found on most farms growing pumpkin or squash, is the most abundant visitor to the crop flowers and is a highly efficient pollinator of the crop[9,16,18,26,27].

Hoary squash bees nest in aggregations close to pumpkin or squash fields. Although they are solitary, their populations can increase greatly over time if their nesting aggregations are protected from exposure to insecticide residues in soil or tillage[28] (see Case Study pg 24). Their seasonal and daily foraging activity period coincides closely to flowering in those crops and they complete pollination of the crop within 2 hours of flower opening[9].

Wild bumble bees (*Bombus* spp.) are social insects, but they live in smaller colonies than honey bees, numbering anywhere from 40 to 400 bees. They are more abundant on cucurbit farms that have natural areas or grassland nearby[29,30]. Bumble bees forage in cooler weather and lower light levels than honey bees and most other wild bees, and deposit more pollen grains on cucurbit flowers per trip than either honey bees or squash bees, making them excellent pollinators of cucurbits[29].



The ground nest of a hoary squash bee showing the female excavating a lateral shaft and various stages of offspring in nest cells.

Cucurbit crops are also visited by other types of wild solitary bees, including sweat bees, mining bees, long horned bees, and leafcutter bees[9,14,15,17]. Night-blooming bottle or birdhouse gourds (*Lageneria siceraria*) are also pollinated by hawkmoths[31]. See 'Wild pollinators of cucurbits' on page 14 for more information and photos of common wild cucurbit pollinators.

In 90% of watermelon farms surveyed in New Jersey and Pennsylvania, sufficient pollination services were provided by wild bees alone[10,32]. Yield in large watermelon fields is often better along field edges, likely because wild solitary bees are contributing more to pollination there than in the middle of the fields[7]. Growers can improve pollination by creating wild pollinator habitat along field margins or within large fields as well as using managed pollinators[33,34].

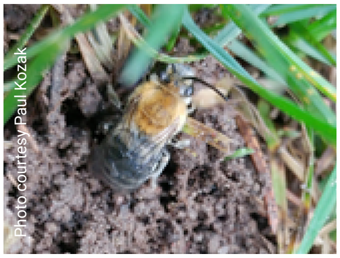
Pollination of cucurbit crops by wild bees can be encouraged by:

- Creating or leaving adjacent habitat which can provide nesting and floral resources for wild bees and can also support honey bee health (p. 22)
- Identifying and protecting squash bee nesting aggregations within or near production areas (p. 24)
- Having smaller field sizes or fields that incorporate habitats as strips or patches at least every 500m. Field edges and marginal lands can be used for habitat. (p. 24)
- Reducing exposure to pesticides by following label recommendations and practicing integrated pest management (p. 17)

Where wild bees are present in abundance, honey bee pollination services may not be needed on pumpkins and squash and other cucurbit crops such as watermelon[9,10,16,18,19].

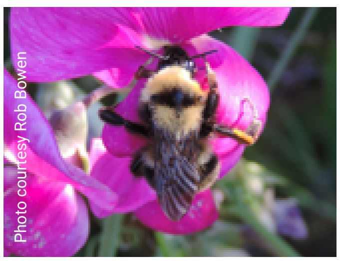
WILD POLLINATORS OF CUCURBITS

These are some native bees that you may see in or around cucurbit fields. They are docile and rarely sting people. All those shown here are known to pollinate cucurbits. Use the iNaturalist App to help identify bees.



SQUASH BEES

(genus *Eucera*) The hoary squash bee is the most abundant visitor to pumpkin and squash crops in Ontario and it also visits other cucurbit crops. Squash bees are solitary ground nesters. Hoary squash bees are relatively large with long antennae and grey and black stripped abdomen. They mate in pumpkin flowers and male bees sleep in the flowers after the flowers have wilted whereas the female bees sleep in the ground.

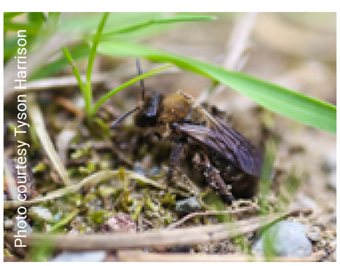


BUMBLE BEES

(genus *Bombus*) Bumble bees are excellent pollinators of cucurbits. They live in small colonies (~40-400 individuals) in the ground or above ground in cavities. They can fly in cool and inclement weather. There are about 40 different types of bumble bees across Canada. The most common bumble bee species found on cucurbits in eastern Canada is the common eastern bumble bee (*Bombus impatiens*)

SWEAT BEES

(family Halictidae) Sweat bees can be as tiny as 4 mm, like the one on the left, or up to about 11 mm. Some are metallic, others bright green, and some have stripes.They often visit cucurbits and may provide pollination services. They are solitary and nest in the ground. The little ones might land on you and lick your sweat in the summer. The most common group to visit cucurbits are small sweat bees in the genus *Lasioglossum*.



MINER BEES

(family Andrenidae) Like the sweat bees, mining or miner bees nest in the soil. They all are solitary bees but sometimes will nest in large numbers in one area. They range in size from 7 mm to 18 mm. They are common pollinators of cucurbit crops, especially watermelon and cucumbers. Look for them nesting within fields or on banks or flat areas beside fields. Like all solitary bees, they are very docile and rarely sting people.

RESEARCH HIGHLIGHT

TAKING AN IPM APPROACH REDUCES PESTICIDE USE AND INCREASES PROFITS

New published research done in Indiana, where watermelon is an important crop, compared standard insecticide use practices with an integrated pest management (IPM) approach on a seedless watermelon crop[35]. The study was conducted over four years, at five sites, and measured pest pressure, the amount of insecticide used, the insecticide residue concentrations in nectar and pollen, yield, pollinator abundance, and profitability.

Under standard practices in the watermelon system in the study region, prophylactic neonicotinoid insecticide treatments are followed by other foliar sprayed insecticides on a schedule. IPM avoids prophylactic use of insecticides and uses pest scouting methods and established economic thresholds to trigger insecticide application to the crop (see Table 2).

The study found that pest pressure was higher in the watermelon crop in the IPM system but that pests rarely reached the pre-established economic threshold. As a result, the IPM system used 95% fewer insecticide treatments than the standard system, resulting in lower neonicotinoid residues in the nectar and pollen of the IPM system crop, and a 129% increase in the number of pollinators visiting the watermelon flowers. The greater wild pollinator populations resulted in a 26% increase in yield in the IPM system.

Because of the enhanced pollinator populations, higher yield, and lower insecticide input, the IPM system produced a $4,512.69 per hectare increase in profit over the standard pest management system. Remarkably, the benefits of enhanced pollinator populations were realized within the first year of transition to an IPM strategy. Clearly, using an IPM approach in seedless watermelon in this study promoted pollinator health and was profitable.

2 PRACTICES TO PROTECT POLLINATORS

Growing crops in a productive and cost-effective manner is crucial, as is keeping pollinators healthy. Pollinators and agriculture are intimately tied together because about 75% of crops require or benefit from insect pollination[37]. Balancing the need for crop protection with pollinator health calls for employing several practices that together result in resilient and productive agricultural systems.

This guide covers four important practices that can help all stakeholders protect pollinators while maintaining production:

- Integrated pest management
- Communication between beekeepers and farmers
- Supporting pollinators through habitat
- Selecting and using pesticide products

INTEGRATED PEST MANAGEMENT (IPM)

Using integrated pest management (IPM) and an IPM consultant can help you save money and time, reduce pesticide use, reduce impacts to wild pollinators, and enhance crop pollination. IPM is a pest management strategy based on ecosystem function and long-term prevention of pest damage. It combines techniques such as habitat manipulation, use of pest-resistant plant varieties, a range of cultural practices, biological control, and as a last step, pesticides to keep pest populations below an economic threshold.

Pesticides should be selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment[39]. For example, pesticides are used only when field monitoring indicates that pest insect populations are exceeding pre-established economic thresholds[39,40]. Treatments are made with the goal of reducing populations of the target pests without harming other organisms. IPM plans help farmers meet their production and crop protection goals and protect pollinators, while minimizing impacts to the environment. See Table 2 for guidance on crop scouting and economic thresholds for cucurbit crops. See Research Highlight for an example of how IPM benefits cucurbit growers.

IPM PRINCIPLES:

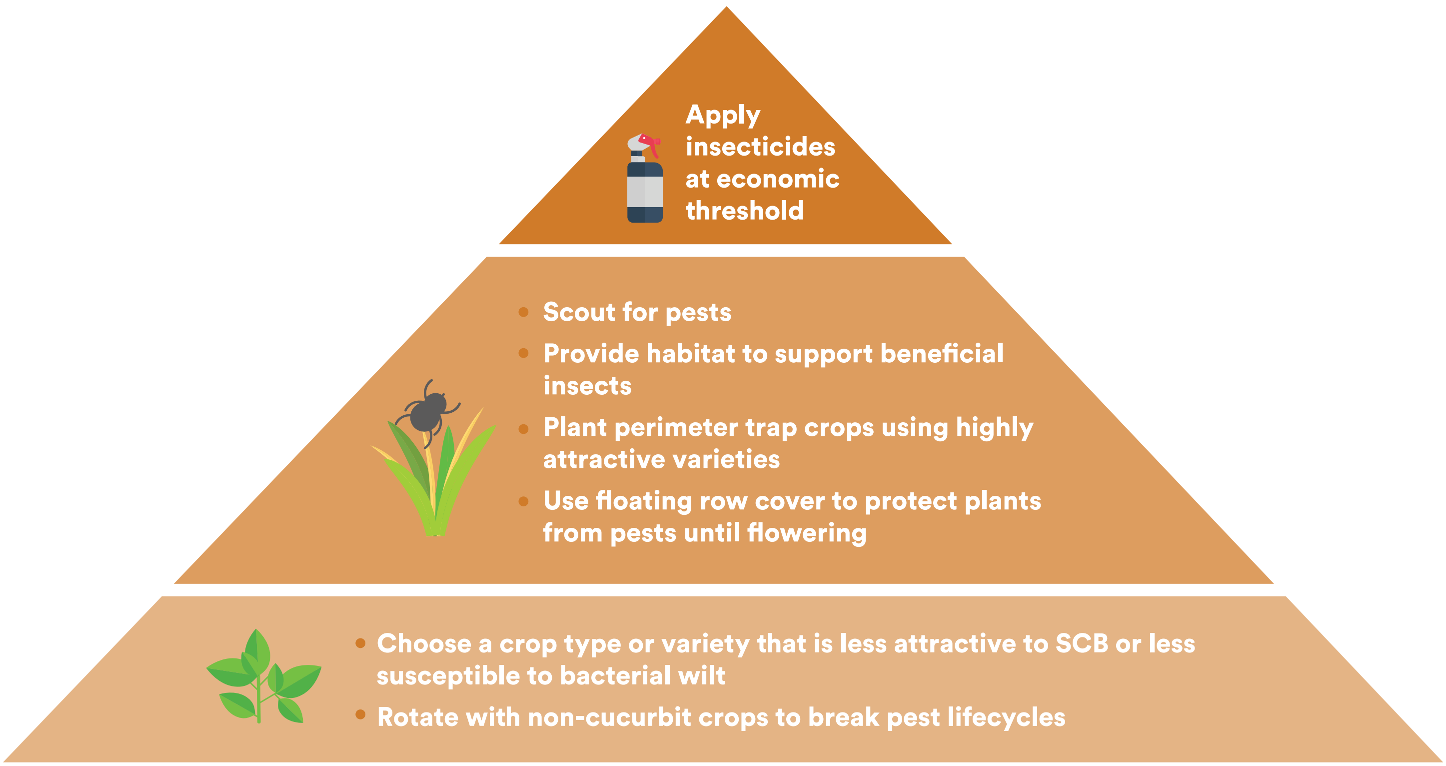
- A multi-faceted approach that combines chemical, physical, biological, and cultural pest control methods.
- Prevention of infestations.
- Monitoring and identifying pests at frequent intervals throughout the growing season.
- Decision-making based on monitoring and thresholds.
- Selection of pest control products that are the least toxic to non-target, beneficial insects.
- On-going evaluation and improvement of management strategies.

Careful consideration of pollinator health should be taken in each of these steps to support pollinators without limiting the effectiveness of pest management.

AN IPM CONSULTANT CAN HELP YOU SAVE MONEY AND TIME, REDUCE PESTICIDE USE, REDUCE IMPACTS TO WILD POLLINATORS, AND ENHANCE CROP POLLINATION.

Unless economic pest thresholds have been reached the previous year, planting neonicotinoid-treated seed is not in line with IPM strategies because the treated seed is not applied in response to a pest population threshold but rather as a form of insurance without regard to existing pest pressure.

IPM strategies sometimes require more initial thought and investment, but they have large and long-term payoffs that include cost savings from using fewer inputs and better yields from stronger pollinator and beneficial insect populations. You can learn about and implement IPM strategies yourself (see resource list on pg. 38) or contact local IPM specialists.



Management tools available within integrated pest management (IPM) systems to manage striped cucumber beetle (SCB), the most economically damaging pest in cucurbit crops, and bacterial wilt, a disease spread by SCB in these crops. Begin at the bottom, for foundational activities that should be the basis of pest control, and proceed with options until you reach the economic threshold, after which insecticide application may be warranted.

Table 2. Striped cucumber beetle (SCB) scouting guidelines and intergrated crop management economic thresholds for cucurbit crops.

CROP	SCOUTING GUIDELINES	ECONOMIC THRESHOLD	NOTES
PUMPKIN, SQUASH, MELON, CUCUMBER	Carefully inspect 10 groups of 10 plants across the field. Count the number of SCB feeding on the plants and divide by 100 to determine the number of SCB per plant. Be sure to monitor field borders and other potential overwintering sites[40] Start scouting immediately after transplanting or when seedlings emerge. Scout fields at least two times a week while plants are emerging. Scout until harvest[41].	0.5–1 SCB per plant at the seedling to 4-inch tall stage[40].	Use the lower threshold on bacterial wilt–susceptible varieties. A follow-up application may be necessary, as SCB emergence is often staggered[40] SCB will often take shelter in leaf axils and in cracks in the soil when the plants are small. Once blossoms are present, SCB are usually found inside older (spent) flowers[40] Turk's Turban variety is particularly susceptible to SCB and can be used as a trap crop[40] See instructions for using perimeter trap crops to manage SCB and bacterial wilt
WATERMELON	Count the number of SCB on 8 randomly selected plants throughout the field as well as on the soil surface just below the plant[42]	5 SCB/SCB per plant[42]	SCB tend to clump in the field. Scouting as described will take clumping into account[42]. Higher economic thresholds reflect watermelon's lack of susceptibility to bacterial wilt vectoring by SCB[42].

CASE STUDY

LEARNING IPM STRATEGIES AND CHOOSING PESTICIDES TO PROTECT POLLINATORS, STELLMAR FARM, LITTLE BRITAIN, ONTARIO

"At Stellmar Farm, we grow many varieties of pumpkins, squash, and decorative gourds, including giant pumpkins, which we sell at our annual pumpkin festival. During our pumpkin festival we educate the visitors to our farm about hoary squash bees and pumpkin pollination. Learning from research done on our farm by the University of Guelph, we have stopped applying neonicotinoids to our crops and have adopted IPM strategies. For example, we consulted the Ontario Ministry of Agriculture, Food, and Rural Affairs online IPM page and learned to scout 10 groups of 10 plants within our fields, looking for cucumber beetles feeding on the young plants. If we find an average of more than 1 cucumber beetle per plant in our crop at the seedling to 4-inch stage, we apply chlorantraniliprole as a foliar spray to those plants and this gives us effective control. This way we avoid neonicotinoids and we apply an insecticide only if pest pressure warrants it. We have also begun to protect a small aggregation of squash bees on the lawn right beside the giant pumpkin patch on our farm. This means we don't till and we don't apply any pesticides to that area. In four years, we have seen our nesting aggregation grow from a couple of nests to over 100 nests in a relatively small area. Although we have honey bees on the farm, most of our pumpkin pollination is carried out by hoary squash bees so they are really important to production."

DAVID MARTIN & JOSEPH STELLPFLUG,
STELLMAR FARM

MAINTAINING CLEAR COMMUNICATIONS

The need for communication and cooperation between beekeepers and growers cannot be overstated and is the most effective way to reduce honey bee pesticide exposure risk. Both beekeepers and growers benefit from developing positive working relationships and familiarizing themselves with each other's management practices. However, communication between beekeepers and growers does not overcome exposure issues for wild bees. See the Selecting and Using Pesticides section (p. 26) for more information on how to protect wild bee.

DISCUSSIONS AND CONTRACTS BETWEEN GROWERS AND BEEKEEPERS SHOULD INCLUDE:

- Coordination of crop timing with dates of apiary arrival and departure.
- Details of the beekeeper's responsibility to provide strong and effective colonies for crop pollination.
- Details of the grower's responsibility to safeguard bees from poisoning.
- A clear designation of responsibility for providing supplemental water and feed.
- A description of pest management practices in the cropping system before colonies are delivered.
- A description of pesticides to be used on a crop while bee colonies are present.
- A description of buffers to be placed between treated areas and apiaries.
- A communication plan for informing neighbouring growers and applicators of apiary locations.
- A description of possible pesticide use in adjacent crops.
- A diagram showing the location of honey bee colonies.
- Reference to provincial and regional information on crop pests and spraying schedule where available.

SUPPORTING POLLINATORS THROUGH HABITAT

Maintaining or creating habitat on your farm can go a long way toward supporting healthy honey bees, increasing the abundance and variety of wild bees, and improving their resilience to other stressors[43-46]. There is an abundance of evidence showing that leaving non-invasive weeds, wildflowers, and other habitat patches around pollinator dependent crops increases pollination and crop production[44-48].

Ideal habitat for bees includes the following elements. Keep in mind that creating habitat with just some of these elements can significantly improve bee health and abundance:

- Flowering plants (native plants, cover crops, non-invasive weeds, shrubs, trees, or ornamental plants) that, in combination, bloom from early spring to fall to support honey bees and wild bees such as bumble bees that need forage all season. Although squash bees depend on cucurbits for pollen, they can visit other flowers for nectar.
- Undisturbed soil, including lawns[29], piles of debris such as sticks, dead leaves or compost, standing plant material, or old logs that provide nesting sites for ground nesting, twig (tunnel) nesting, and cavity nesting bees and overwintering sites for bumble bee queens.
- Protection from pesticide application and drift through pesticide-free buffers and thoughtful management, especially around native bee nesting aggregations.

There can be concern that non-crop floral resources will 'pull' honey bees or other bees away from the crop. However, research shows that non-crop floral resources can help honey bees by providing a diversity of pollen sources that they need to maintain health. Additionally, these areas attract and enhance wild bee populations rather than taking them away from the crops[45,47,48].


Photo courtesy Paul Kozak


Photo courtesy Rufus Isaac

ENHANCING AGRICULTURAL HABITAT FOR POLLINATORS

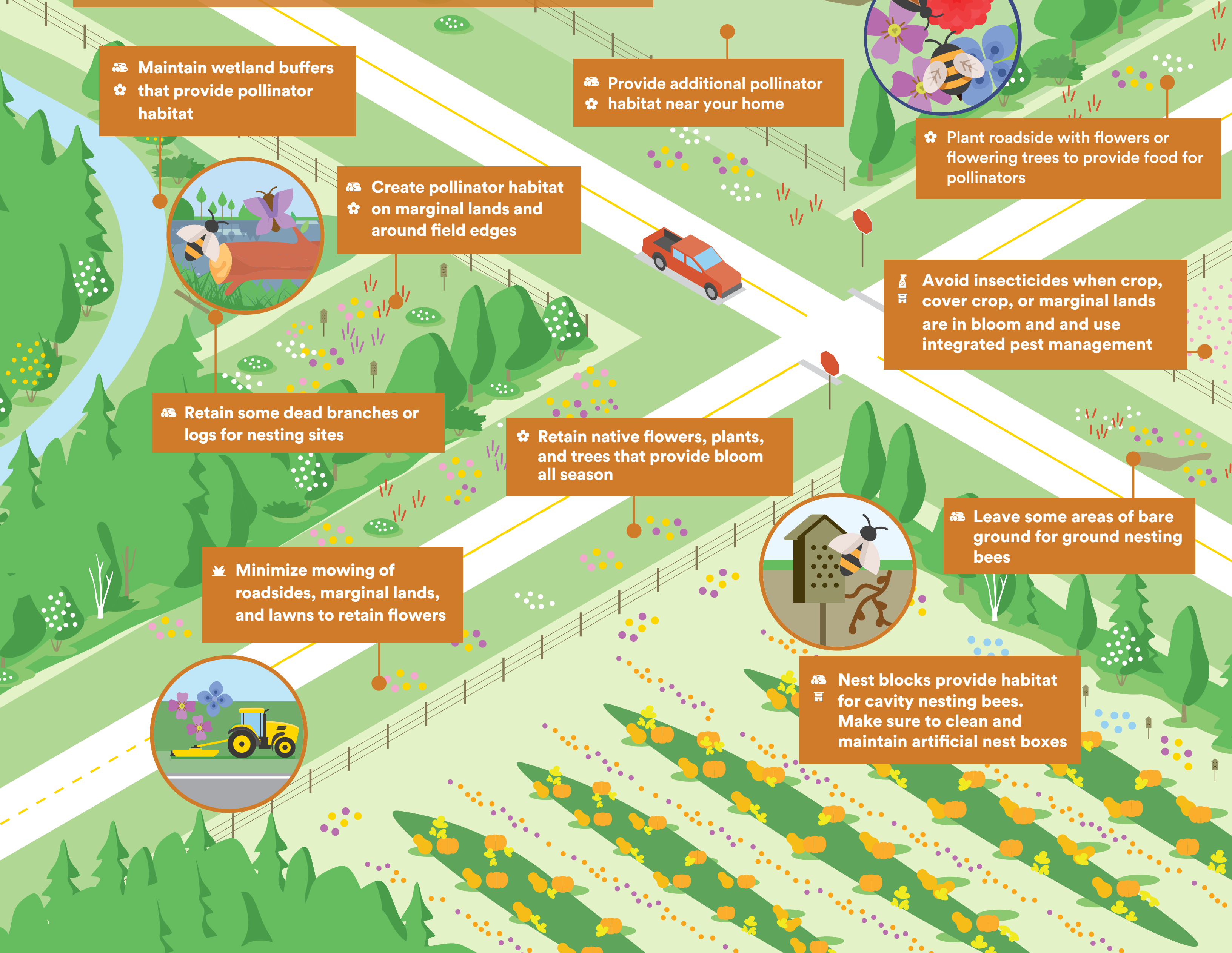
Loss of habitat in agricultural lands threatens pollination in crops such as cucurbits. Actions taken to increase habitat, large and small, can make a significant impact on pollinator populations.

Key actions that a farmer can take

- Increase flower diversity
- Reduce impact of mowing
- Provide nest sites
- Communicate with beekeepers about pesticide applications
- Reduce pesticides

Consider incorporating some of these actions on your farm. Keep an eye out for wild bees to see the positive impact you are having.

Providing buffer strips or habitat near the farms can improve crop yield in pollinator-dependent crops



CASE STUDY
PROTECTING NESTING HABITAT FOR HOARY SQUASH BEES- STROM'S FARM AND BAKERY, GUELPH, ONTARIO

"We have been growing pumpkins on our farm near Guelph, Ontario for the last 30 years and for every one of those years, the hoary squash bee has been our primary pollinator. At first, our hoary squash bees nested in a small vegetable garden that we had in our backyard and from there they flew to our surrounding pumpkin fields to pollinate the crop and collect pollen for themselves. Over time, we covered the vegetable garden with sod and allowed the bees to continue nesting in the lawn where they are protected from tillage and from exposure to the insecticides we use to manage our insect pests. From a small nesting aggregation, our hoary squash bee population has expanded to fill almost our whole back lawn with over 3000 nests. Although the nesting area is busy with bees during the months of July and August, we never get stung as squash bees are very gentle. The rest of the year we don't notice them at all as they are developing below ground in their nests."

AMY STROM, STROM'S FARM & BAKERY,
WELLINGTON COUNTY, ONTARIO

Having habitat to support pollinators can be as simple as reducing unnecessary vegetation control. As such, it can involve no extra work and can even create some labour savings:

- Use selective weed control to increase pollinator friendly species.
- Identify areas that are less productive, scrubby, or marginal. Keep these as habitat for beneficial insects rather than cultivating these sections. This can save money and make the farm more efficient by intensifying production.

Proactively enhancing and creating pollinator habitat can also help attract and sustain pollinator populations on your farm and help enhance your crop yield or quality through improved pollination.

- In buffer plantings around waterways, use plants that also provide foraging and/or nesting habitat for bees.
- Intentionally create floral strips or hedgerows, which can take little or no land out of production, on field edges and other areas of your farm[46-48].

Preserving and creating habitat for bees is an achievable goal for large- and small-scale cucurbit growers. Small actions taken by many growers and landowners can add up to large benefits for the whole agricultural community.

There can be many other beneficial insects, including predators and parasitoids, in and around cucurbit fields. Minimizing use of pesticides and providing habitat will also help protect these biocontrol insects, possibly reducing future pest outbreaks. See Managing Cucumber Beetles in Organic Farming Systems, 2019 for other ways of encouraging beneficial insects on the farm.

SELECTING AND USING PESTICIDE PRODUCTS

Pesticides have become an integral part of some farm management systems. However, there are risks to pollinators associated with their use. Exposure to pesticides can kill bees or it can cause effects that do not kill them but negatively impact foraging, learning, reproduction, or the long-term health of populations[49].

The Ecological Farmers Association of Ontario (EFAO) offers farmer-led education, research and community building for farmers wanting to learn and employ ecologically friendly ways of managing crop pests, including those found in cucurbit crops. The Atlantic Canadian Organic Regional Network (ACORN) provides similar information and support in the Canadian Maritime provinces.

Health Canada's Pest Management Regulatory Agency (PMRA) uses a risk assessment framework to help eliminate unacceptable risks from pesticides. To learn more about this framework, see the supplemental document.

POTENTIAL PESTICIDE IMPACTS ON BEES

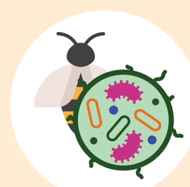
Bees can be impacted lethally or sublethally by pesticides. For more information, see Recognizing and Reporting a Bee Poisoning in the Resources section on p.38

Lethal

increased bee death

Sublethal

increased susceptibility to pests and diseases



alteration of gut microbiome

decreased reproduction

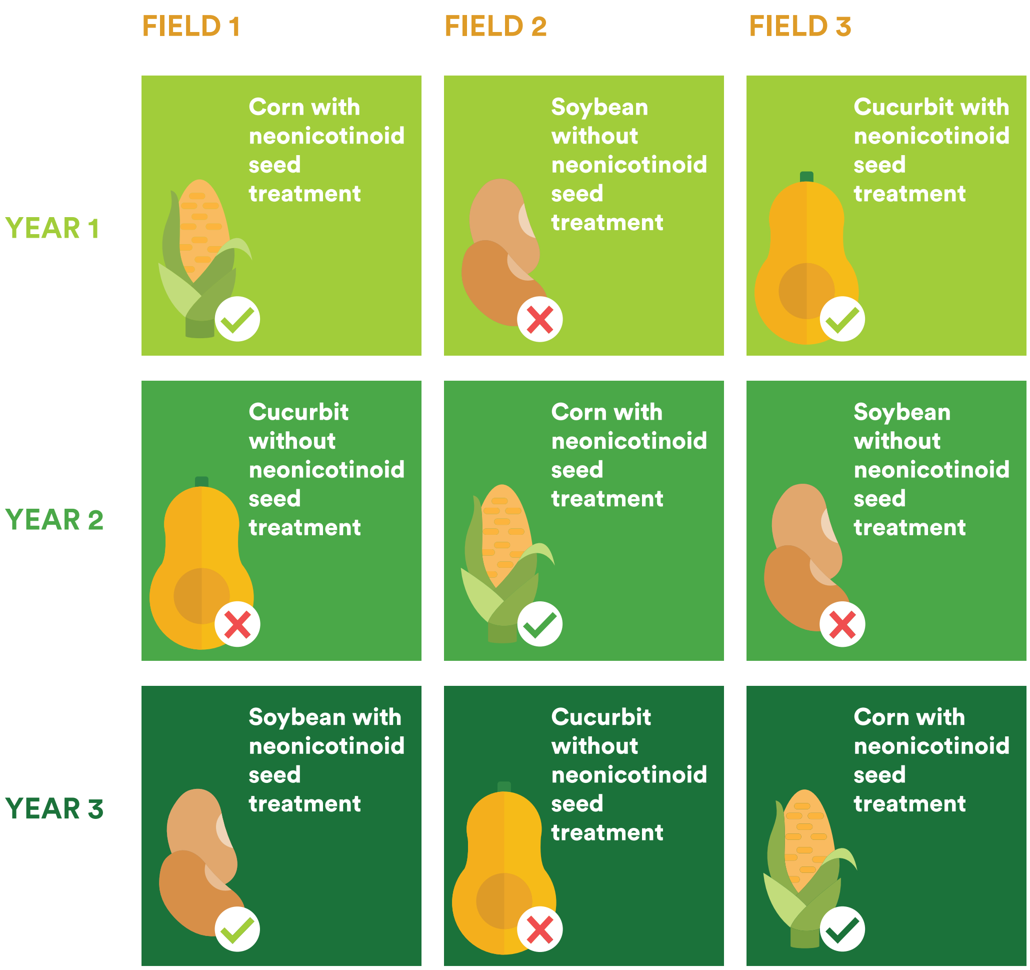
learning and memory impairment

impaired orientation

reduced foraging

By using pesticides within an integrated pest management (IPM) framework, following label directions, and selecting products that have low toxicity to bees, healthy bee populations can be maintained that will contribute to cucurbit pollination, pollination of other crops, and pollination in natural ecosystems

If insecticide treatments are needed to control insect pests in cucurbit crops, growers should rotate between pesticide classes (a) from year to year in the same crop to avoid the development of pest resistance and (b) in the same location, even if a different crop is grown, to avoid accumulation of pesticide residues in the soil[50].



An example of an insecticide and crop rotation system that avoids buildup of pesticide residues in soil

It is important to remember that wild bees may be visiting the cucurbit crop flowers even if honey bees have been moved during pesticide application. Hoary squash bees and bumble bees are early morning foragers on cucurbit crops[9] so pesticides should not be applied during that time. Furthermore, in pumpkin and squash crops, male hoary squash bees rest inside the wilted flowers during the afternoon and evening, making pesticide application any time during bloom unadvisable. Foliar sprays of neonicotinoids are not permitted during bloom for any cucurbit crop[36]. The following practices outline ways to control exposure to pesticides, so the risk is acceptable to pollinators while maintaining crop production and quality.

SELECTING LEAST TOXIC PESTICIDE PRODUCTS: UNDERSTANDING PESTICIDE RISKS

Bee poisonings are related to exposure amount, exposure time, and the toxicity of a pesticide. The term, 'pesticide' refers to all substances that are meant to control pests, including insecticides, fungicides, nematicides, miticides, and herbicides. The highest risk to bees is from pesticide products that are highly toxic, have residual toxicity longer than 8 hours, can be found as residues in pollen, nectar, or soil where bees can be exposed to them, or are sprayed on the crop during bloom when the bees are present. **Risks are reduced by following pesticide labels closely and paying attention to changes in use restrictions.** Insecticides are generally more toxic to non-target insects than other types of pesticides because they are formulated to kill insects. Though herbicides and fungicides are generally less toxic than insecticides, they too can present risks. However, herbicides can also be useful and necessary for the creation and management of pollinator habitat, and fungicides often are necessary components of commercial cucurbit production.

Some of the active ingredients in the following chemical families used in cucurbit crops have residual toxicity longer than 8 hours. None can be applied to the crop during bloom. Read labels carefully.

- Organophosphates such as malathion.
- N-methyl carbamates such as carbaryl.
- Neonicotinoids such as imidacloprid, clothianidin, thiamethoxam.

Growers can compare the toxicity of pesticides by using the tables in the supplemental document to choose those that are least toxic to bees while still being effective against target pests. Use Supplemental Table 2: Pesticide Toxicity to help you choose the lowest risk products. However, it is also important to use pesticides with different modes of action to avoid developing chemical resistance in pest insects or pathogens. This means that only using the lowest toxicity product may not always be recommended. See p.38 for resources on mode of action.

Direct application of neonicotinoids to soil and chemigation in field crops are not permitted in Canada[36]. Because neonicotinoids are systemic, residues can travel from the point of application to other parts of the plant, including cucurbit nectar and pollen where foraging bees can be exposed[57-58]. In soil, neonicotinoid residues can persist for long periods of time[50].

FUNGICIDES

Fungicides are often necessary for cucurbit production to prevent the development of powdery or downy mildew, or angular leaf spot. However, there is evidence that some fungicides can negatively impact bees on their own[54] and in synergy with insecticides[48-53]. Following label directions, avoiding applying fungicides directly on or near honey bee colonies, and applying them when wild bees are not active, can help safeguard bee health.

INSECTICIDES

Insecticides are designed to kill insects and therefore present a higher risk to managed and wild bees than other pesticides. Insecticides are considered a major factor contributing to agricultural productivity, yet if they are used incorrectly, they can be toxic to humans and/or animals. If they are used repeatedly in the same location, some insecticides can accumulate in the environment[36]. Use of insecticides within an Integrated Pest Management framework (see p. 17) and following label directions for application to cucurbits will help minimize risk to bees and other beneficial insects.

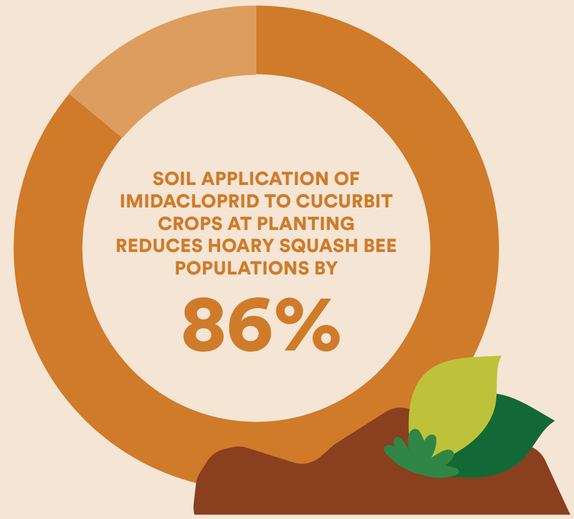
SYNERGIES

Some products can have synergistic effects in the field, that is, they are more toxic in combination than individually. For example, the fungicides myclobutanil and propiconazole have each been found to synergize with some pyrethroids and neonicotinoids[49-53]. Follow label instructions.

FOLLOW LABEL DIRECTIONS

Pesticide labels are legal documents. Product registration, toxicity testing, and product regulation are in place to protect honey bees and other pollinators from the negative effects of pesticides. **It is illegal to use a pesticide in any way other than for the purpose and in the manner stated on the label.** In addition, properly following pesticide labels is important from an economic perspective for the cucurbit grower, from a human health perspective for the user, by-standers, and consumer, as well as from an environmental perspective for bees and other beneficial insects. Applying too much of one pesticide, applying it repeatedly in the same place, or applying it outside of label use because of inattention to label details could cost the grower more money and could increase the risk of the product to visiting bees. For the most current information on label restrictions, use the PMRA online label search or download the PMRA pesticide label app.

- Review the entire label for precautionary and advisory statements such as "toxic to bees".
- Crop-specific precautions may also be listed on the label.
- Although the bee precautions are mainly based on toxicity to honey bees, they are also relevant to other species of bees. Where differences in toxicity to other bee species are known, they are noted in Table 2 in the supplemental document.
- Residual toxicity to bees can vary greatly between insecticides. When using insecticides with extended residual toxicity, it is imperative that applicators carefully consider potential exposures to wild and managed bees and avoid applying insecticides to blooming plants (crops or weeds)[60,61].
- More PMRA information on pollinator protection can be found at: www.canada.ca/pollinators



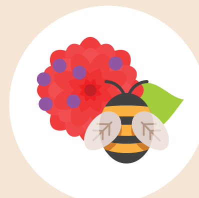
Although the negative impacts of neonicotinoids on honey bees and bumble bees are well understood[28], research recently done at the University of Guelph in Ontario illustrates how important it is to understand the effects pesticides can have on other important wild bee species. The research showed that soil application of imidacloprid to cucurbit crops at planting reduces hoary squash bee populations by 86% over 3 years. In 2019, the Canadian Pest Management Regulatory Agency (PMRA) deregistered the application of neonicotinoids directly to soil, reduced the number of allowable foliar applications of the neonicotinoid clothianidin to one per season pre-bloom but maintained registration of neonicotinoid seed treatments. These 2019 decisions were confirmed in the PMRA's proposed special review of neonicotinoid use on cucurbit crops and are summarized in Table 1 of that document[36]. As regulations change in response to scientific evidence, it is important to read pesticide labels and stay up to date on use restrictions.

Bee exposure to pesticides can occur when:

- Beekeepers and growers do not adequately communicate.
- Pesticides are applied when bees are actively foraging.
- Pesticides are applied to cucurbit crops, weeds in the field or field margins during bloom, or to neighbouring fields.
- Pesticides drift onto blooming plants adjacent to the cucurbit crop.
- Systemic insecticides (like neonicotinoids) are translocated into the nectar and pollen of crop and non-crop flowering plants because of their movement through soil and water[60].
- Bees collect insecticide-contaminated nesting materials, such as leaf pieces collected by alfalfa leafcutter bees or are exposed to soil contaminated with pesticide residues as they build their ground nests[61,62].
- Honey bees collect insecticide-contaminated water in or near treated fields.
- Wild bees develop or overwinter in soil contaminated with pesticide[61,62].

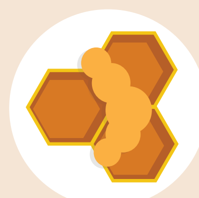
ROUTES OF PESTICIDE EXPOSURE TO BEES

Directly sprayed on or through contact with recently sprayed leaves and flowers



Consumption of contaminated pollen and nectar

Contact with contaminated nesting materials



Effects on larvae through contaminated nectar, pollen, and cell materials

Contact with contaminated soil

Ways bees can be exposed to pesticide contaminants. Diagram adapted from Iris Kormann, Oregon State University.

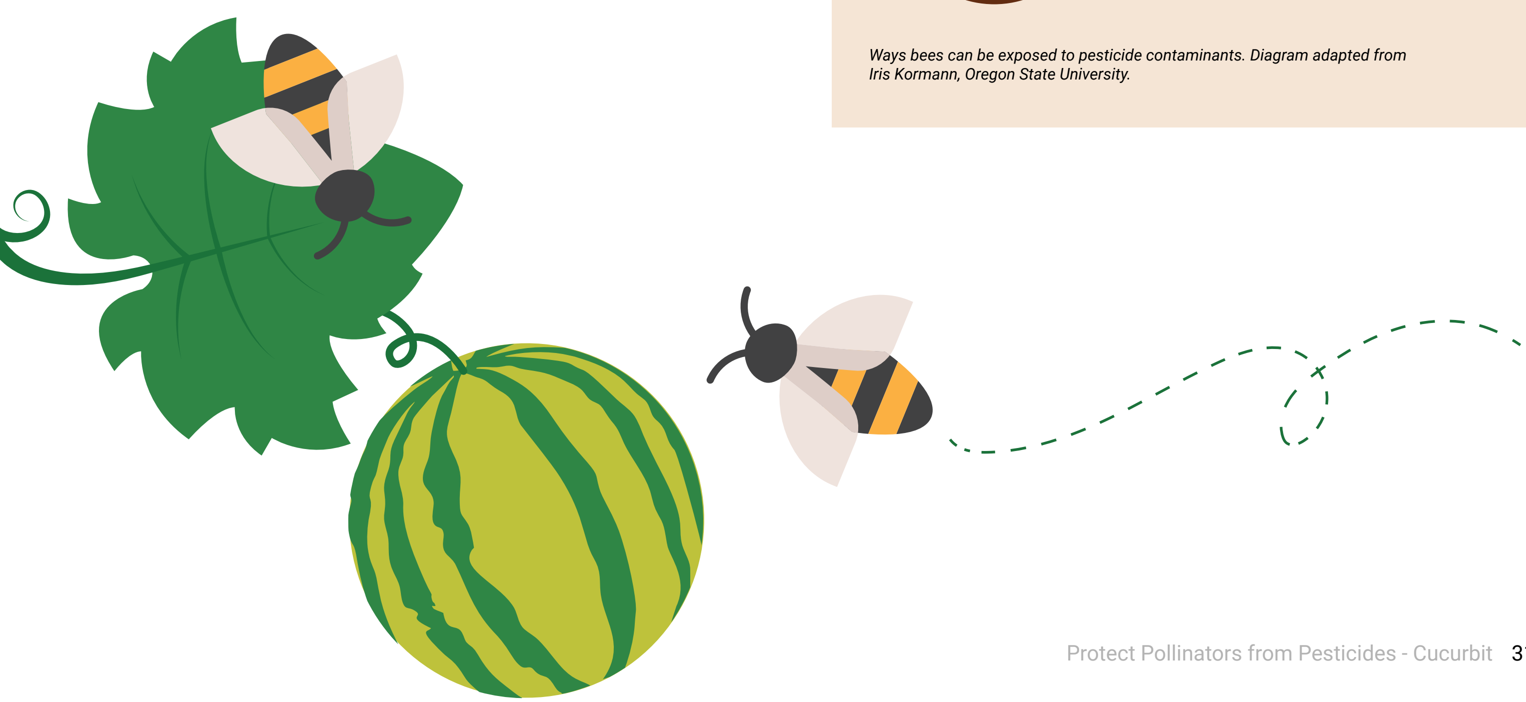


Photo courtesy Terena O'Hara

REDUCING BEE EXPOSURE TO PESTICIDES

When using pesticides, in addition to following label directions and maintaining clear communications with beekeepers and other stakeholders (see p. 36), other ways of minimizing managed and wild bee exposure include:

- Ensuring that pesticide drift is minimized to reduce contact with adjacent habitat.
- Avoiding applying pesticides during warm evenings when honey bees are clustered on the outside of their hives.
- Avoiding applying pesticides (especially insecticides that have toxicity to bees) to any blooming flowers, even weeds; bees may be using these resources.
- Being aware that pesticides can be absorbed in soil, potentially impacting ground nesting bees or taken up by non-crop plants that bees forage on[62].
- Looking for bees on crops, and for ground nests of solitary bees like hoary squash bees, long-horned bees, sweat bees, and mining bees within fields. Protect nesting areas from any exposure to insecticides wherever possible. If you identify a hoary squash bee nesting area on your farm, mark it and avoid applying pesticides in that area.
- Remembering that some bees, including the important hoary squash bee and bumble bees, forage in the early morning on cucurbit flowers and that hoary squash bees sleep in wilted pumpkin and squash flowers.
- Notes may be found in Table 2 of the supplemental document if it is currently known that greater precautions are needed for bumble bees or solitary bees than for honey bees.

3 ACTION GUIDE

GROWERS AND PESTICIDE APPLICATORS

COMMUNICATION

- Write and agree to a contract that defines expectations and responsibilities between beekeeper and grower/applicator, including protocol for suspected pesticide incidents involving pollinators.
- Establish a chain of communication between all parties, including crop consultants and applicators.
- Outline a pest management plan that specifies which systemic products have been applied, which contact pesticides may be used during bloom, and methods to protect bees during application.
- Give 48 hours' notice to beekeepers when applications are necessary so that safety measures to protect the hives can be taken.

HIVE LOCATION

- When hosting hives on your property, provide a safe location that is out of the range of pesticide applications, including no-spray buffers.
- Be aware that there likely are more honey bee colonies than you are currently aware of in any area because honey bees have a foraging range of a few kilometers. Check with your Provincial Ministry/Department of Agriculture for hives that might be located in your area and use the BeeConnected app.

PRODUCT SELECTION AND USE

- Always read and follow pesticide label directions carefully. Check for new use restrictions on the label.
- Select pesticides that have the lowest pollinator precaution levels using the Table in the supplemental document.
- Follow best management practices (BMPs) for pesticide applications. Be careful to only apply pesticides to target crops and avoid spray drift onto hives, other blooming crops, or flowering weeds nearby, whether or not the pesticide has a bee caution on the label.
- Since fine droplets tend to drift farther, apply spray at lower pressures or choose low-drift nozzles that produce medium to coarse droplet size. Turn off sprayers near water sources (ponds, irrigation ditches, or leaking irrigation pipes), when making turns, and at the ends of fields.
- To minimize drift, do not spray in windy conditions or during temperature inversions.
- Never spray crop products onto hives, including low toxicity products such as herbicides and fungicides.
- Apply insecticides with residual toxicity when bees are inactive or not present. Bees generally forage during daylight hours and when temperatures exceed 13°C for some wild bees and 17°C for honey bees. When abnormally high temperatures result in foraging activity earlier or later in the day, adjust application times accordingly to avoid bee exposure. Note: Some important pollinator species such as squash bees and bumble bees forage at much lower temperatures and light levels and may be present on cucurbit crop flowers in the early morning[9].
- Inspect chemigation systems to verify that bees cannot access chemigation water. Remember that systemic insecticides can get into nectar and pollen from chemigation water[57,58].
- Avoid applying insecticides with long residual toxicity directly to soil as many bees nest in soil within cropping areas. **Direct applications of neonicotinoids to soil in cucurbits are no longer permitted in Canada.**

PLANNING AND SCHEDULING

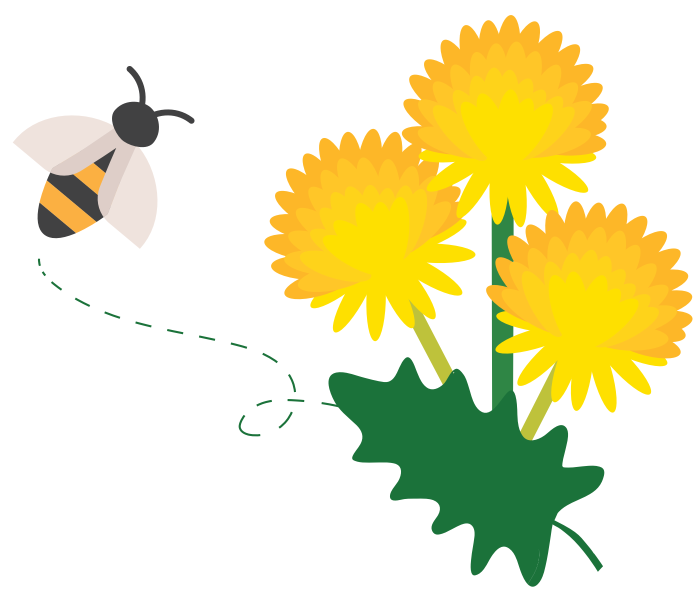
- Learn the pollination requirements of your specific cucurbit crop and when they are attractive to bees.
- Plan your pesticide applications to occur well before or after bloom, when hives are not on location, and managed and wild bees are not active on the crop. Wild bees such as squash bees and bumble bees are active on the crop at dawn[9]. **Spraying neonicotinoids onto blooming cucurbit crops is no longer permitted in Canada**[36].
- Keep track of weather patterns, including wind, precipitation, humidity, and daily temperatures to avoid any unintentional pesticide drift to nearby bee foraging areas.

PEST AND WEED CONTROL

- Scout for pest insects and use economic thresholds for treatment decisions; you can learn the pests and beneficial insects and treatment thresholds yourself (see Table 2 and additional resources provided at the end of this document) or hire an integrated pest management (IPM) consultant that can help save you time and money by reducing unnecessary pesticide application (see Research Highlight).
- If necessary, control blooming weeds such as dandelions within fields before applying insecticides that have a long residual toxicity to bees. This is especially important in early spring when bees will fly several kilometers to obtain pollen and nectar from even a few blooms of dandelions or wild mustard.

CONSIDERATIONS

- Consider non-chemical pest control, such as the use of crop rotation, row covers, trap crops, resistant varieties, transplanting instead of direct seeding, straw mulch, and intercropping to support beneficial insects such as the tachinid fly *Celatoris diabrotica* for long-term suppression of cucumber beetles[63]. E-organic, an organization that provides science, experience, and regulation-based information on organic farming and research, provides useful research-based suggestions for non-chemical management of cucumber beetles.
- The University of California IPM website describes integrated pest management (IPM) practices for cucurbits in the west and Ontario Crop IPM provides scouting calendars and information about pest thresholds for Ontario cucurbit producers
- Explore programs such as Operation Pollinator or Bees Matter that support planting habitat areas on your farm for honey bees, other pollinators, and other beneficial insects, or build your own bee habitat using Pollinator Partnership's Ecoregional Planting Guides or the Canadian Honey Bee Forage Guide.



BEEKEEPERS

COMMUNICATION AND REGISTRATION

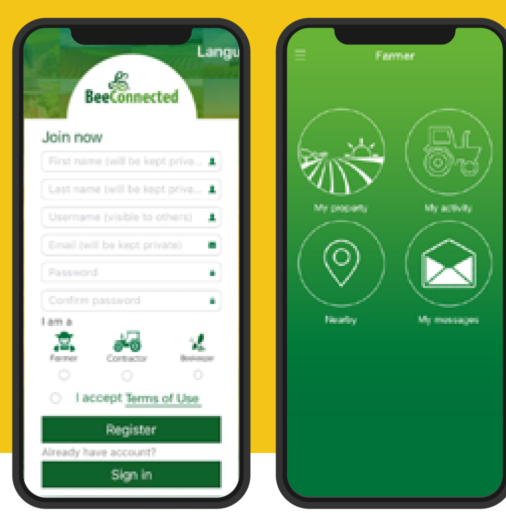
- Write and agree to a contract that defines expectations and responsibilities between beekeeper and grower, including protocol for suspected pesticide incidents involving pollinators.
- Do not leave unmarked colonies near fields. Post the beekeeper's name, address, and phone number on apiaries, large enough to be read at a distance.
- Register your colonies with your Provincial Ministry/Department of Agriculture. You can notify pesticide applicators of the location of your apiaries using the BeeConnected app.
- Communicate clearly to the grower and/or applicator where your colonies are located, when they will arrive, and when you will remove them.
- Ask the grower what pesticides, if any, will be applied while bees are in the field, when they will be applied, and whether the label includes precautionary statements for bees. Ask them to contact you if they decide on any new applications.
- Request 48 hours' notice from growers when applications are necessary so that safety measures to protect the hives can be taken.

PEST MANAGEMENT

- Learn about pest problems and management programs to develop mutually beneficial agreements with growers concerning pollination services and prudent use of insecticides. Seek information on major crop pests and treatment options for your region (see resource section for provincial links).
- Miticides, such as those used in hives for varroa control, are pesticides too. Use care when managing pests in and around bee hives, apiaries, and beekeeping storage facilities. Use pesticides for their intended use and follow all label directions carefully. Regularly replace brood comb to reduce exposure to residual miticides.

The BeeConnected app is an open platform between growers, beekeepers, and applicators for discussion and planning for bee protection in farmlands.

http://www.beeconnected.ca/



PROTECTING HONEY BEES FROM EXPOSURE

Place hives at least 6 m away from the crop with a no spray buffer, rather than directly adjacent to the crop, if possible.

- Work with growers to find a location for beehives that is at least 6 m away from the crop, including no-spray buffers.
- Do not return colonies to fields treated with insecticides that are highly toxic to bees until at least 48 to 72 hours after application. Bee deaths are most likely to occur during the first 24 hours following application.
- If practical, isolate apiaries from intensive insecticide applications and protect them from chemical drift. Establish holding yards at least 4 km from crops so that honey bee colonies can be moved to those yards when crops are being treated with insecticides that are highly toxic to bees.
- Place colonies on ridge tops rather than in depressions. Insecticides drift down into low-lying areas and flow with morning wind currents. Inversion conditions are particularly hazardous.
- Verify that a clean source of water is available for bees, and if there is not one available, provide one.
- Feed bees when nectar is scarce to prevent long-distance foraging to treated crops.
- In pesticide risk-prone areas, inspect bees often to recognize problems early.

RESOURCES

RECOGNIZING AND REPORTING BEE POISONING

Because of guidelines and regulation on product use, large-scale honey bee deaths are uncommon in developed countries, especially in recent years. Nevertheless, incidents where large quantities of bees are killed by pesticides do occur and suggest a misuse of a product, system, or management protocol, or a possible result of a lack of communication.

Bee poisonings can be either lethal or sublethal. An example of lethal poisoning is when pesticide drift comes into direct contact with foraging honey bees, leading to large numbers of dead workers within or around the crop, or outside the hive entrance. In contrast, sublethal exposure does not kill bees outright but rather can lead to poor bee and hive health; reduced capacity to forage, orient, and learn; and many other symptoms[49].

Lethal and sublethal poisonings are harder to casually observe in wild bees than in managed honey bees but are nevertheless a risk. Without a marked hive or nesting site, they can easily go unobserved. Known sublethal impacts on wild bees include reduced longevity, development, body mass, learning, colony size, reproduction, navigation, and increased

susceptibility to pest and pathogens [49, 64-70]. If you see more than one dead bumble bee in a location, this may be an indication that there has been lethal exposure to a toxic substance.

The signs and symptoms listed below can be the result of pesticide exposure, but some can also be a result of viruses or other diseases. Careful observation of individual honey bee and colony behaviour, as well as preserving samples for testing (see instructions on p.41), can help determine the underlying causes. In some cases, pesticide poisoning can be exacerbated when hive health is initially poor, emphasizing the importance of nutrition, water supply, and proper management practices by beekeepers to maintain the health of their colonies.

HONEY BEE POISONING

- Excessive numbers of dead and dying honey bees in front of hives.
- Severe colony imbalance, large brood size with few bees.
- Lack of foraging bees on normally attractive blooming crops.
- Stupefaction, paralysis, and abnormal jerky, wobbly, or rapid movements; spinning on the back.
- Forager disorientation and reduced foraging efficiency.
- Immobile, lethargic bees unable to leave flowers.
- Regurgitation of honey stomach contents and tongue extension.
- The appearance of “crawlers” (bees unable to fly). Bees move slowly as though they have been chilled.
- Dead brood, dead newly emerged workers, or abnormal queen behaviour, such as egg laying in a poor pattern.
- Queenless hives.
- Poor queen development in colonies used to produce queens, with adult worker bees unaffected.

HONEY BEE RECOVERY FROM PESTICIDE POISONING

If a honey bee colony has lost many of its foragers but has sufficient brood and adequate stores of uncontaminated pollen and honey, it may recover without any intervention. Best practices include moving bees to a pesticide-free foraging area, if possible. If sufficient forage is unavailable, feed them with sugar syrup and pollen substitute, and provide clean water to aid their recovery. Protect them from extremes of heat and cold, and if needed combine weak colonies.

If pollen or nectar stores are contaminated, brood and workers may continue to die until the colony is lost. Additionally, pesticides applied by beekeepers can accumulate in colonies. If there is a possibility that pesticides have transferred into the hive beeswax, consider replacing the comb with a new foundation, using comb from unaffected colonies, or shaking the bees into a new hive and destroying the old comb and woodenware. Replacing brood comb on a regular schedule (typically 2 to 5 years) may prevent pesticide accumulation in brood comb wax and is also good practice for managing disease accumulation in comb.

PESTICIDE POISONING IS NOT ALWAYS OBVIOUS AND MAY BE CONFUSED WITH OTHER FACTORS:

- Delayed and chronic effects, such as poor brood development, are difficult to link to specific agrochemicals, but are possible when stored pollen, nectar, or wax comb become contaminated with pesticides. Severely weakened or queenless colonies may not survive the winter.
- Poisonous plants, such as death camas (*Zigadenus venenosus*), cornlily (*Veratrum viride*), and spotted locoweed (*Astragalus lentiginosus*), can injure and occasionally kill bee colonies.
- Viral paralysis disease, starvation, winter kill, and chilled brood can cause symptoms that may be confused with bee poisoning. Beekeepers may request a laboratory analysis of dead bees to determine the cause of an incident. Health Canada and provincial Departments of Agriculture or of the Environment (depending on the province) investigate suspected bee poisoning incidents (see p. 43 for contact information).

HOW TO REPORT A SUSPECTED BEE POISONING

If you suspect a bee poisoning incident, or have a question or concern regarding an incident, contact the appropriate federal or provincial authority (see contact information on page 42). Describe why you suspect the bees may have been exposed. Provide photos or videos of the incident, list pesticide treatments you have applied to the hives and notes describing the previous health of the colony, prevailing winds, registrant name on the product label, product name, or active ingredients (from the pesticide label or PMRA's pesticide label search app), and any other pertinent details. Growers and beekeepers should work together to compile this information.

Preserve at least 56 grams (1/4 cup) of adult bees, brood, pollen, honey/nectar, or wax by immediately freezing in clearly labelled, clean containers, and ensure the samples stay dry and protected from light which can lead to the degradation of pesticides. This may be helpful if the incident is later determined to warrant laboratory analysis. It is also a good idea to have a sample of the affected bees as well as a sample from an unaffected apiary. In the event of enforcement action, some provinces will need to collect their own samples. Do not disturb the hives or site until the representative from your province's lead office has finished collecting information.

It also is important that, if you suspect a bee poisoning incident, you communicate with nearby growers and/or beekeepers, and act quickly so that the cause can be determined and prevented in the future.

PROVINCIAL RULES AND RESOURCES TO PROTECT POLLINATORS

The federal government is responsible for the registration of pest control products, and all three levels of government (federal, provincial/territorial, and municipal) play a role in regulating their sale and use. Ministries of certain provinces provide rules intended to reduce the hazard of pesticide application to bees, as well as guidance on bee management.

ALBERTA (MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT)

https://open.alberta.ca/dataset/b8f74b45-3867-456d-8c85-db6413eeb801/resource/d911d5f2-6fbb-48b1-a304-3ab3fdabaeaf/download/how-to-reduce-bee-poisonings-pesticides.pdf

780-415-2314

NOVA SCOTIA (DEPARTMENT OF AGRICULTURE)

https://novascotia.ca/agri/programs-and-services/industry-protection/#bees

902-679-8998

MINISTRY OF AGRICULTURE, FOOD AND FISHERIES

https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/animal-production/bees/beekeeping-bulletins

604-556-3129

ONTARIO (ONTARIO MINISTRY OF FOOD AND RURAL AFFAIRS)

http://www.omafra.gov.on.ca/english/food/inspection/bees/apicultu.html

1-877-424-1300

MANITOBA (MINISTRY OF AGRICULTURE)

http://web2.gov.mb.ca/laws/statutes/ccsm/b015e.php

604-556-3129

SASKATCHEWAN (MINISTRY OF AGRICULTURE)

http://www.agriculture.gov.sk.ca/

306-953-2304

NEW BRUNSWICK (DEPARTMENT OF AGRICULTURE, AQUACULTURE AND FISHERIES)

https://www2.gnb.ca/content/gnb/en/departments/10/agriculture/content/bees.html

506-453-2108

PRINCE EDWARD ISLAND (DEPARTMENT OF AGRICULTURE AND FORESTRY)

https://www.princeedwardisland.ca/sites/default/files/legislation/A%2611-1-2-Animal%20Health%20and%20Protection%20Act%20Bee%20Health%20Regulations.pdf

902-314-0816

NEWFOUNDLAND AND LABRADOR (DEPARTMENT OF NATURAL RESOURCES)

http://www.nlbeekeeping.ca/beekeepers-corner/research/

709-637-2662

QUÉBEC (MINISTÈRE DE L'AGRICULTURE, DES PÊCHERIES ET DE L'ALIMENTATION)

http://legisquebec.gouv.qc.ca/en/ShowDoc/cs/A-1

(1-844-264-6289) 1-844-ANIMAUX

REPORT A BEE INCIDENT TO HEALTH CANADA

Bee incidents can also be reported by contacting Health Canada's PMRA at 1-800-267-6315. If you know which product may have caused the bee poisoning, you can also notify the pesticide company, which is required by law to report adverse effects to Health Canada. See the Useful Links section below (pg. 43) for a link to report a bee incident to Health Canada.

USEFUL LINKS

BEECONNECTED APP
http://www.beeconnected.ca/

RESOURCES FOR POLLINATOR FRIENDLY FARMERS AND GARDENERS
https://seeds.ca/pollination/resources/

BRITISH COLUMBIA CUCURBIT PRODUCTION GUIDE
https://www2.gov.bc.ca/gov/content/industry/agriservice-bc/production-guides/vegetables/cucurbits

DALHOUSIE UNIVERSITY ORGANIC CUCURBIT PRODUCTION GUIDE
https://www.dal.ca/faculty/agriculture/oacc/en-home/resources/horticulture/vegetables/cucurbit.html

E-ORGANIC, ORGANIC VEGETABLE PRODUCTION SYSTEMS, INSECT MANAGEMENT IN ORGANIC FARMING SYSTEMS
https://eorganic.org/menu/879,878

INATURALIST APP
https://www.inaturalist.org/

GOVERNMENT OF ONTARIO CROP IPM
http://www.omafra.gov.on.ca/IPM/english/cucurbits/index.html

POLLINATOR PARTNERSHIP CANADA: POLLINATOR GUIDES
https://pollinatorpartnership.ca/en/ecoregional-planting-guides

HEALTH CANADA'S PEST MANAGEMENT REGULATORY AGENCY (PMRA) PESTICIDE LABEL SEARCH
https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php

PROPOSED SPECIAL REVIEW DECISION ON NEONICOTINOID USE IN CUCURBITS-2021
https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/consultations/proposed-special-review-decision/2021/environmental-risk-related-to-squash-bee/document.html

INSECTICIDE RESISTANCE ACTION COMMITTEE: THE IRAC MODE OF ACTION CLASSIFICATION
https://irac-online.org/mode-of-action/

UNDERSTANDING THE FLOWERING HABITS OF CUCUMBERS
https://www.seminis-us.com/resources/agronomic-spotlights/understanding-flowering-habits-cucumbers/

POLLINATOR PARTNERSHIP: TECHNICAL GUIDE FOR PRESERVING AND CREATING HABITAT FOR POLLINATORS ON ONTARIO'S FARMS
https://pollinatorpartnership.ca/en/ag-guides

UNIVERSITY OF CALIFORNIA, INTEGRATED PEST MANAGEMENT
http://ipm.ucanr.edu/

REPORT A BEE INCIDENT TO HEALTH CANADA
https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management/public/protecting-your-health-environment/report-pesticide-incident.html

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