The Pollination System of Pumpkin, Squash, Summer Squash, and Zucchini

By Susan Chan, M.Sc.

Overview:

This factsheet is divided into three sections that explain the pollination system of the crop. The first section explains the plant part of the system, the second section explains the behaviour of the pollinator, and the third section describes best management practices on the farm that will support a stable pollination system.

The Plant Part of the System:

Pumpkins, squash, summer squash, and zucchini are all members of the genus Cucurbita. These crops share a common pollination system in which a single plant has separate male flowers and female flowers that bloom for a single day before wilting. Both male and female Cucurbita flowers produce large amounts of nectar with a high sugar content (about 40% sugar) in nectaries located at the base of the flower. Unlike the closed nectaries in male flowers, the female nectaries are open and shaped like a circular yellow trough. (Figure 1)

Male Cucurbita flowers provide pollen on an organ known as the synandrium. The pollen is large, bright yellow, sticky, and particularly spiny (Figure 2). During pollination, female Cucurbita flowers receive the pollen on an organ known as the gynecium, which has a sticky surface to trap the pollen (Figure 3).

Only female Cucurbita flowers produce a fruit and can be easily distinguished from the male flowers by the small undeveloped fruit-like ovary under the flower (Figure 4). This ovary resembles the fruit it will become after pollination and fertilization are complete. For example, an ovary on a pumpkin plant will look like a small pumpkin in shape; on a zucchini plant, the ovary will look like a tiny zucchini. Without pollination, these ovaries will never develop into marketable products.
Generally, Cucurbita crops produce many more male flowers than female flowers. For example, Connecticut Field Pumpkins produce about twenty times as many male flowers as female flowers. At the beginning of the flowering season, if you examine the Cucurbita crops that you grow, you will notice that most of the flowers produced are actually male flowers rather than female flowers. This is normal and may be understood as a strategy to attract pollinating bees to the crop before their pollination services are actually needed. Many bees will stay with a crop once they have begun foraging on it as long as it still provides the nectar and pollen that they need.

All Cucurbita flowers last only about 5-6 hours on a single day. They open at sunrise, providing nectar and pollen immediately upon opening. Over the course of the morning, the supply of nectar and pollen is used up as bees visit the flowers. By about noon, or earlier if the day is hot, all the flowers wilt and close, and the window of opportunity for pollination of that flower is over. The next day will bring a new crop of flowers to supply pollen and nectar and to be pollinated to set fruit.

Pollination is the first step in a series of events in the plant that produce a marketable fruit. In Cucurbita pollination, pollen is typically transferred from male flowers to female flowers by bees, including squash bees, bumble bees, and honey bees. Bees are attracted to the Cucurbita flowers by the abundant, high quality nectar, and in the case of squash bees, by the pollen. Bees accumulate pollen on themselves because they are covered in tiny branched hairs that capture the pollen as they climb over the male reproductive parts (synandrium) of the flower in much the same way that burrs collect on clothing (Figure 5). As the bees move from male flowers to female flowers, they accidentally deposit pollen on the gynecium. Once the pollen is deposited on the gynecium of the female flowers, each pollen grain produces a microscopic tube that grows down towards the ovules located in the ovary (that small fruit-like organ at the base of the flower). Once the tube joins the ovule, the pollen can fertilize the ovule and a seed can begin to develop. It is the
number of properly fertilized seeds, followed by soil fertility, water availability, and climatic conditions that determine the size and the quality of the fruit that will eventually be harvested for market.

The Pollinator Part of the System:

The most common pollinators of Cucurbita crops in Ontario are squash bees, bumble bees, and honey bees (Figure 6), although other insects can and do visit the crop for nectar. Although honey bees can pollinate Cucurbita crops, they prefer other nectar and pollen sources and have a tendency to avoid Cucurbita crops because of their large spiny pollen. Supplementing Cucurbita crops with honey bee hives to increase pollination is ineffective and unnecessary if squash bees and bumble bees are present.

This factsheet will concentrate on providing information on squash bees in an effort to help farmers conserve these bees and take maximum advantage of their free pollination services on their farms. A drawing of male and female squash bees is provided in Figure 7.

Squash Bees:

Squash bees are ground-nesting, solitary bees that do not live in colonies like honey bees do. Instead each female squash bee makes her own nest by excavating a vertical tunnel in the ground. Off of the vertical tunnel, the female squash bee excavates lateral blind tunnels that end in water-proof cells. A single nest will have 3-5 cells that the female provisions exclusively with Cucurbita pollen, working from the deepest cell to the shallowest one, one at a time (Figure 8). In a commercial pumpkin planting in which there are lots of available flowers, a female squash bee can collect enough pollen during the time when flowers are open to provision about one cell per day. Once she has collected enough pollen into a cell, she lays an egg on the pollen ball and closes up the cell with soil. The egg develops into a grub-like larva and then into a pre-pupa (Figure 9). Most of the life cycle of a squash bee is actually spent in
have squash bees in your Cucurbita crop, tear open a number of wilted flowers during the afternoon or early evening: If you find a small bee sleeping in the Cucurbita flowers, it is a squash bee. Before they are mated, female squash bees spend the afternoon in the flowers with the males. Mated females spend the afternoon constructing their nests in the ground and resting in them. No squash bees are active on the crop once the flowers are closed for the day.

Squash bees are specialist pollinators on Cucurbita crops. They can collect nectar from other plants but female squash bees collect pollen only from Cucurbitas. Adult squash bees do not eat pollen—it is used only as a high protein food for their young (the larva).

Because squash bees are common in Ontario, are specialists on Cucurbita crops, and can build up large populations naturally, establishing and maintaining them on farms that grow Cucurbita crops is fairly easy and makes good sense.

**Best Management Practices to Establish and Maintain Squash Bees on the Farm:**

Because squash bees are wild, ground nesting bees, the best approach is to focus on managing farm conditions rather than managing the pollinators themselves. Furthermore, results are not instantaneous. To achieve large stable populations on the farm, squash bees have to migrate in,
Can Squash Bees be Introduced onto a Farm?

It is definitely possible to introduce adult squash bees onto a farm. However, introducing larval stages has never been done successfully because the larval stages live in the ground and are difficult to move. When attempting to introduce adult squash bees onto a farm, do the following:

1. Get permission to collect adults from a source farm with a population of squash bees. Squash bees should only be collected from a site at which they are plentiful.

2. Collect the bees during the 21 day period in which they are maturing sexually. The easiest way to find the bees at this stage in their life cycle is in the afternoon within closed Cucurbita flowers, where both sexes sleep until the females are mated and begin to build their nests. In Ontario this occurs in early/late June to early July, depending on where you are located.

3. Collect the bees on a sunny day in the afternoon when the flowers have closed and wilted.

4. Collect both males and females in the same quantities. This means you must be able to recognize and sex the bees—see Figure 7.

5. Collect both males and females together into a well-ventilated container and keep the container in the shade until the collecting is complete. They will not sting you. Once you have enough bees, transfer them immediately to their new location. At your destination, put the container on its side with the lid removed in the shade of the leaves of a blooming Cucurbita crop. Check it the following morning to see if the bees have dispersed.

6. You can expect the bees to establish themselves over time. They cannot be relied upon to provide good pollination services in the first year.

7. Attention should be paid to where the bees are building nests and those areas should be left undisturbed throughout the following year to avoid disrupting the bees’ lifecycle.

establish themselves, and multiply slowly over time. This takes planning on the farmer’s part to create a farm environment that supports the needs of these important pollinators. Managing a farm to establish and maintain strong healthy populations of squash bees requires an understanding of how farm management practices such as insecticide use, soil cultivation,
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All insecticides should be applied with great care, and as a last resort, within a well-managed integrated pest management system.

bee pollination system is summarized in Figure 12.

Insecticide Use: Ontario Cucurbita crops face pest pressure from striped cucumber beetles, squash bugs, aphids, flea beetles, and cutworms. Damage by striped cucumber beetle is caused by feeding on young plants, but more importantly, striped cucumber beetles are carriers of the bacteria that causes bacterial wilt in cucurbits. Controlling the damage from the striped cucumber beetle has been the top priority for this sector for many years.

Presently in Ontario, a variety of insecticides are available to control the insect pests of Cucurbita crops. Some are contact insecticides while others are systemic. Most insecticides should be considered toxic to bees and applied with great care, and as a last resort, within a well-managed integrated pest management system that includes other tools such as the use of resistant varieties, trap crops, feeding barriers such as kaolin clay, and crop scouting. Do not apply contact insecticides onto blooming Cucurbita crops at any time from dawn until noon because the flowers are open during this period and pollinators are active. Contact insecticides are best applied before the crop comes into flower at all. (See figure 12)

Neoncotinoid insecticides pose a risk to pollinators because they are systemic. As a result, although the neonicotinoid is applied to seed or to young plants, it travels throughout the plant and is found in the pollen and nectar of Cucurbita flowers, sometimes in lethal doses. Although this is a problem for all pollinators, it is especially problematic for squash bees because they only forage on Cucurbita crops and feed their larva exclusively on Cucurbita pollen. There is also concern that neonicotinoids applied as seed coatings may migrate away from the seed and directly into the ground nests of squash bees, potentially poisoning the larva. Neonicotinoids may also accumulate in the soil with repeated use and have a detrimental effect on squash bee larva.

Soil Cultivation: Research shows a strong cause-and-effect relationship between cultivation and squash bee abundance on Cucurbita farms because squash bees are ground nesters. The survival of squash bee larva and pre-pupa depends on nests not being disturbed during development, a process that takes most of the year. Squash bee nests are located up to 18 inches (46 cm) deep in soil, with most of the cells located in the 6-8 inch (12-22 cm) range. If soils are being cultivated every year at depths of greater than 5 inches in cropping areas on Cucurbita farms, it is unlikely that strong stable populations of squash bees will ever become established. As an alternative to tillage in all parts of the field, Cucurbita growers may want to consider using no-till practices or leaving an untilled or shallowly tilled swath around the edges of Cucurbita fields and protecting those areas on a long-term basis.

To Avoid Destroying Squash Bee Nests:
- Use no-till techniques
- Leave field margins uncultivated
- Cultivate no deeper than 5 inches
- Scout for nesting aggregations in July and August, flag them, and leave those areas uncultivated as nesting preserves.

If cultivation is necessary, it should be timed to correspond to the 21-day period during which adults have emerged but are not yet actively building nests. It is difficult to predict when this cultivation-window is because it will vary from farm to farm in Ontario. However a farmer who learns to interpret the behaviour of squash bees on the farm can become skilled at identifying this cultivation window. At all times, cultivation should be kept as localized and as shallow
(maximum depth 5 inches) as possible. Another approach is for the farmer to scout the fields in July or August for nesting aggregations and to mark them with small flags (see Figure 10). These areas can then be purposefully left untilled in order to protect the nests and the larva living in them. By doing this, over time these designated, untilled nesting areas will become more and more heavily populated with nests as squash bees tend to nest close to the nest from which they emerged. Once a well-populated nesting area has been established, tillage in other areas becomes less problematic.

**Crop Rotation:** Crop rotation is an excellent management tool for maintaining soil fertility and reducing disease pressure in Cucurbita crops. When designing a rotation plan for these purposes, care should be taken to consider the needs of established squash bee populations on the farm. Squash bees will tend to nest in and near the fields where Cucurbita crops are grown and will have to migrate onto new fields if the crops are rotated because they only forage on Cucurbita crops. Keeping the distance between field locations in a rotation as small as possible will help to maintain strong squash bee populations on the farm. Another approach is to maintain an uncultivated nesting area between fields in a rotation, thus keeping the nesting area stable while moving the crop in rotation around that nesting area. Rotating Cucurbita crops between farms will cause the squash bee population to disperse and will prevent the establishment of a strong stable population of this important pollinator at either location.

**Summary:** Squash bees are common in Ontario. They are excellent, reliable pollinators of Cucurbita crops, and if care is taken, can be become part of a well-managed Cucurbita farming system. Look for them in your Cucurbita crops, understand them, and take advantage of the free pollinating services they can provide.

If you have questions, feel free to contact: Susan Chan, Native Pollinators Program Manager, Farms at Work; sue@farmsatwork.ca.

**Credits:**
Illustrations: Ann Sanderson; www.annisciart.com
Photographs: Susan and Margaret Chan

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Keeping the distance between field locations in a rotation as small as possible will help to maintain strong squash bee populations on the farm.

Pollination Canada

Farms at Work is a local not-for-profit project of Tides Canada Initiatives, dedicated to promoting healthy and active farmland in east central Ontario. Farms at Work provides support for farmers in diversification and expansion, ensures access to local farmer training opportunities and creates partnerships and outreach that result in on-the-ground farm stewardship in the region.