Great Lakes Fruit, Vegetable & Farm Market EXPO
Michigan Greenhouse Growers EXPO

December 5-7, 2017

DeVos Place Convention Center, Grand Rapids, MI

Greenhouse Vegetable Production

Where: Gallery Overlook (upper level) Room E & F
MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
CCA Credits: CM(2.0)
Moderator: Bruce Mackellar, Van Buren Co. MSU Extension

2:00 pm	A Beginner's Guide to Hydroponics • Beth Scheckelhoff, OSU Extension Putnam County, Ottawa, OH
3:00 pm	Bumblebees and Pollination • Ben Phillips, Vegetable Extension Educator, MSU Extension, Saginaw, MI
3:20 pm	Keys to Greenhouse Plant Health • Beth Scheckelhoff, OSU Extension Putnam County, Ottawa, OH
4:00 pm	Session Ends

Bumble Bees in the Greenhouse

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Growing produce in greenhouses and hoophouses can be an effective and economical venture for early production of warm-season fruiting vegetables, and for winter production of cool-season leaf and root vegetables. In addition, these structures are sometimes subsidized by state and federal agencies to support local four-season production of high-value crops. However, pollination of fruiting vegetables can be a challenge in enclosed structures.

Which fruiting vegetable crops work well in the greenhouse?

Cucumbers, watermelon, melon, summer squash, tomatoes, peppers, eggplant, and beans are great greenhouse candidates for early summer production. Peas can be started early in these structures as well. For larger fruited vine crops, trellising can be utilized with mechanisms to support the weight of fruits (onion bags, panty hose, etc). Bush type and vine type squash plants can be utilized with extra attention paid to spacing.

Which greenhouse crops require pollination assistance?

Standard cucurbits have separate male and female flowers, which require a pollinator to bring pollen from a male flower over to a female flower. Cucurbits naturally produce many more male flowers than female flowers to ensure that bees come in contact with pollen while searching for the larger nectar pots in female flowers. Breeding has created different flowering behaviors of these crops. Gynoecious cucumbers have been bred to produce predominately female flowers to maximize yield. But, they require 15% interplanting with a conventional "sire" cucumber with the typical number of male flowers. Some seed companies will sell these seeds pre-mixed. Seedless cucumbers do not need pollination at all, and pollination will actually cause misshapen fruit. But, the female flowers of seedless watermelon still need to receive pollen from a regular seeded diploid watermelon to trigger fruit set. Seedless watermelons require 30% interplanting with diploid "pollinizers" to maximize fruit set and yield. Often, a standard seeded watermelon is used as a pollinizer. Some muskmelons and cantaloupe cultivars can have self-fertile hermaphroditic flowers with both male and female parts, but still require a pollinator.

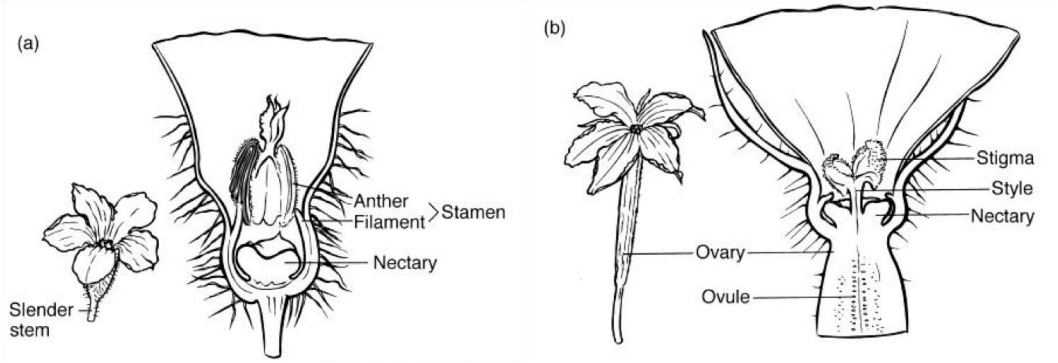

Figure 1. The male (a) and female (b) flowers of cucurbits require pollinators to move pollen from one to the other.

Solanaceous crops have both male and female parts on the same “perfect” flower, and can self-pollinate. However, the tubular, downward-facing flowers need to be agitated to release pollen from the male part onto the female part. Though this occurs naturally by wind, pollination can be enhanced with mechanical vibration provided by growers or bees. Bumble bees do this particularly well with a technique called “sonication”, wherein they clamp onto the flower tube, and flex their flight muscles to vibrate the pollen out. Environmental conditions can greatly affect the quality and quantity of pollen release to the female part of the plant. Tomatoes and peppers need night time temperatures between 55-70 F to produce pollen, and day time temps should not exceed 90 F. Flowers will abort completely after 4 hours over 100 F. In addition, relative humidity should be between 50-80% to prevent pollen from being too dry to stick to the female part or too sticky to fall away from the male parts. Some parthenocarpic varieties exist that set fruit in cooler temperatures without pollen transfer.

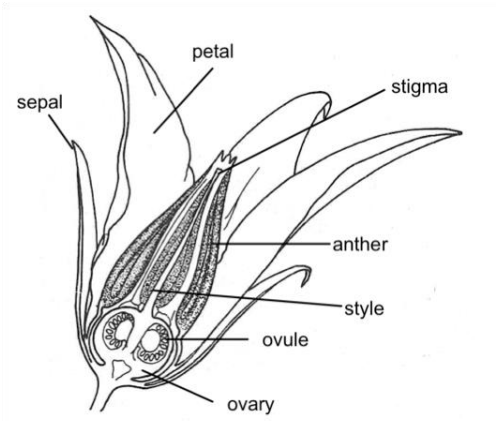

Figure 2. The tomato, pepper, and eggplant flower has a female part (stigma) surrounded by a cone of male parts (anthers). These flowers usually hang upside down, and when agitated will funnel pollen from the male part down through the cone and onto the female part. Bumble bees can enhance this pollen transfer.

Beans are also perfect flowers, and lima beans fully self-pollinate before flowers open. But bees can boost yields of pole beans, snap beans, green beans, and are necessary for setting pods in scarlet runner beans. Due to the complicated flowers of legumes, bees must learn to pollinate them.

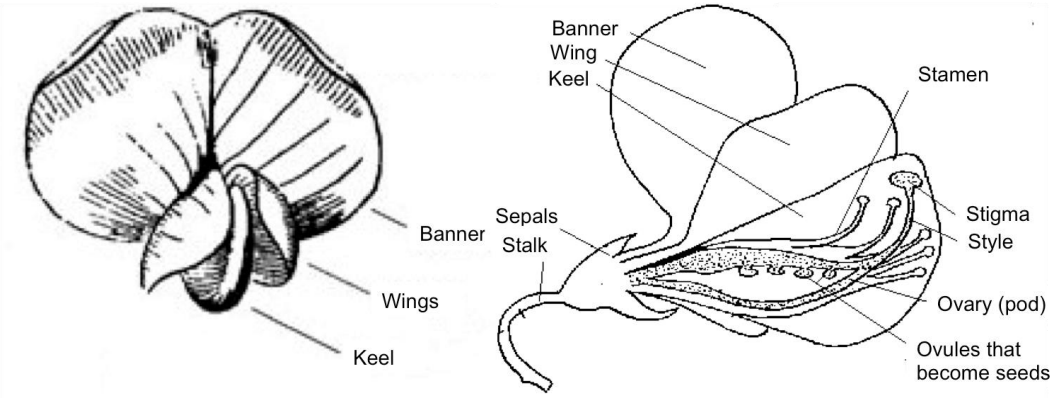

Figure 3. Beans have complicated flowers that require bees to learn how to access them. They are mostly self-pollinating, and bees may work them if nothing else is available.

Which pollinators are amenable to enclosed structures?

All bees can see ultraviolet light, and use it for orienting to their surroundings. Among the types of structures to grow in, those covered in a material that allow the transmission of UV light are the most preferable, such as glass, acrylic rigid materials, and polyethylene films. Polycarbonate rigid materials, and Polyvinyl chloride (PVC) films tend to block UV light. Additionally, additives can be mixed with polyethylene plastics to block more UV as an integrated pest management tactic, as photodegrading pesticides have a longer residual activity in the absence of UV light. Thus, UV-blocking coverings can impact pollination fruiting crops in two ways: by disorienting bees, and by potentially increasing insecticide exposure over time.

Artificial lighting during the winter months appears to significantly reduce bumble bee colony populations upon introduction. In tomato greenhouses the populations never recover under artificial light, and eventually stabilize under ambient natural light. In pepper greenhouses bumble bee colonies stabilize under artificial light, and recover with additional growth in ambient natural light. Winter management of these crops requires a balance of lighting to maintain colony strength, or continual replacement of colonies.

Other factors that can impact pollinator foraging behavior are air flow and CO2 concentrations. Air flow can indirectly impact foraging behavior of bees by influencing the direction in which they fly. All flying species prefer to take off into the wind. Placing boxes in an area facing an on-coming breeze and facing the target crop can make their colony exits more efficient. CO2 concentrations have a debatable impact on pollinator behavior by impacting the growth characteristics of crop plants. In some cases higher levels of CO2 above 350 ppm increased nectar volume, flower number, or flower bloom longevity. However, the data in meta-analyses goes both ways. If bloom number, longevity, or nutrition increases, then bees would likely be positively impacted.

Commercial bumble bees (*Bombus* spp) are the main pollinator inside structures in Europe and North America. Bumble bees live in much smaller colonies, making them easier to transport. Companies, such as Koppert Biological Systems, and Biobest, have devised ways to rear them continually through the winter in artificial environments for seasonal production needs across the continent, and have designed special packaging enabling them to be shipped through the mail with a food source. The bees are less aggressive than honey bees, and can be acclimated to low-UV conditions. They are effective pollinators of vine crops and solanaceous crops inside and outside growth structures, but are short-lived (~8-12 weeks). Growers can determine the visitation level of bumble bees on tomatoes and peppers by the bruising that occurs on the anther cone of the flower: the darker the bruise, the longer the visit and more effective pollination. Bumble bees have also been shown to successfully pollinate muskmelons in New Zealand greenhouses, and are one of the most prominent wild pollinators of field-grown squashes. If too few flowers are in the greenhouse they will forage outside to supplement their diet or stay inside their colonies feeding on the sugar water, but will return when flowers are more plentiful. Growers can plug the feeder to force the bees out if needed. Current recommendations are 1-3 colonies per quarter acre of enclosed space. For a 30 x 48 ft, up to a 30 x 192 ft greenhouse, one bumble bee colony would be more than adequate for a tomato, pepper, or vine crop. Colonies cost about $175, and contain approximately 45 foraging bees, which can increase to around 200 bees under good foraging conditions. A 12-week lead-time on bumble bee orders is appreciated by suppliers, as they raise colonies on demand.

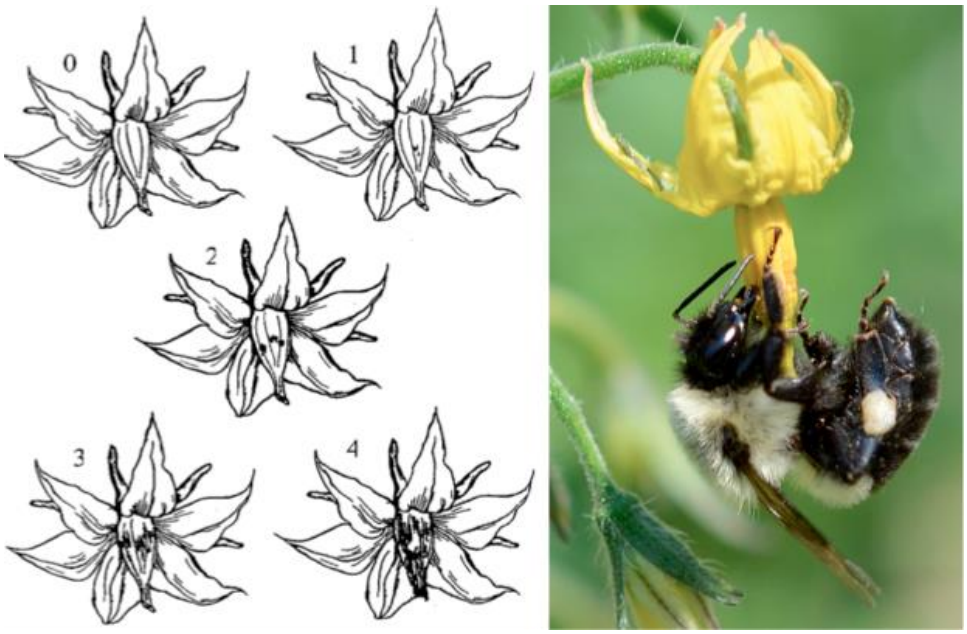

Figure 4. Bumble bee grasp tomato flowers with their mandibles as they buzz pollinate. Their visits to tomato flowers can be estimated by the bruising on the stamen cone. From 0 to 4, the amount of bruising increases in this illustration, which indicates multiple visits.

Figure 5. This comme II. They will last up to 12 weeks, and require minimal management except for being placed off the ground and shaded. Inside each colony is a pre-packaged sugar water source to keep bees fed when flowers are unavailable, or when sprays are applied. But, growers must be proactive about closing the entrance before spraying insecticides.