Greenhouse Vegetable Production

Tuesday afternoon 2:00 pm

Where: Grand Gallery (main level) Room E & F
MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
CCA Credits: PM(0.5) CM(1.5)
Moderator: Christina Curell, Extension Educator, MSU Extensioin, Baldwin, MI

2:00 pm Prepare Now, Sweat Less Later: Keys Elements of Greenhouse Sanitation
- Heidi Wollaeger, Extension Educator, MSU Extension, Nazareth, MI

2:30 pm Cucumber Production
- Shalin Khosla, Greenhouse Vegetable Specialist, Harrow Research Centre, Ontario, Canada

3:00 pm Pollination in the Greenhouse
- Ben Phillips, Vegetable Extension Educator, MSU Extension, Saginaw, MI

3:30 pm Leafy Greens Production
- Shalin Khosla, Greenhouse Vegetable Specialist, Harrow Research Centre, Ontario, Canada

4:00 pm Session Ends

Prepare Now, Sweat Less Later: Key Elements of Greenhouse Sanitation

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Greenhouse and Nursery Extension Educator, Michigan State University Extension

Sanitation is the easiest way to prevent the spread of pathogens and insects, maintain a healthy crop, and prevent food-borne illness in consumers of greenhouse vegetables. Greenhouse growers should:

1. Start clean, end clean.
2. Power-wash empty greenhouses or replace plastic covering.
3. Using sanitizing agents between crops, such as:
    a. Ethanol, chlorine bleach, quaternary ammonium, hydrogen dioxide, chlorine dioxide. For more: https://www.extension.purdue.edu/extmedia/ho/ho-250-w.pdf
4. Prevent overlap between crops susceptible to similar diseases.
5. Do not hang ornamental hanging baskets over vegetable crops.
6. Remove weeds in the greenhouse, manually. We strongly recommend that you do not apply herbicides in the greenhouse as they can volatilize and damage crops months after application. Marengo (OHP) is a pre-emergent herbicide labeled for greenhouse use.
7. Clean irrigation equipment according to manufactures' recommendations. Some growers fill the irrigation lines with sulfuric acid and rinse to dissolve buildup and sanitize.
8. If you had an outbreak of any serious pathogen, like *Pythium*, *Phytophthora*, *Thielaviopsis* or tobacco mosaic virus, during last growing season, be sure to replace all weed mats in affected areas.
9. Clean up leaf litter throughout the season.
10. Take out the trash: infected plant material should never be composted but instead placed in a plastic garbage bag and removed from the premises.
11. Use foot bathes, disinfectant mats, and disposable plastic "booties."
12. Require lab coats, coveralls, or uniforms that should never leave the premises.
13. Require hairnets in packing areas.
14. Monitor vapor pressure deficit (VPD) and other environmental factors. Environments with very low VPD (aka high relative humidity) are conducive to disease.
15. Remove all dirt (on equipment, floors, pots, pipes etc.) that can carry many pathogens including *Pythium, Fusarium, or Phytophthora.*
16. Implement security procedures:
    a. Monitor visitors entering and leaving the premises
    b. Check-in and check-out procedures for all employees
    c. Prevent workers of one area of the greenhouse into another area of the greenhouse
17. Learn about Good Agricultural Practices (GAP) and Good Handling Practices (GHP)
    a. Know the microbial hazards in your water
    b. Install proper sanitation and environmental protection equipment
    c. Encourage good worker hygiene and develop appropriate worker sick-time policies
    d. Learn about proper handling/packing requirements for vegetable or herb being grown

For more, check out: Ontario Ministry of Agriculture, Food, and Rural Affairs' Sanitation Factsheet:

http://www.omafra.gov.on.ca/english/crops/facts/14-033.pdf or my article:
http://msue.anr.msu.edu/news/a_guide_to_greenhouse_sanitation_for_growers_prepare_now_sweat_less_later

Pollination of Greenhouse Vegetables

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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.

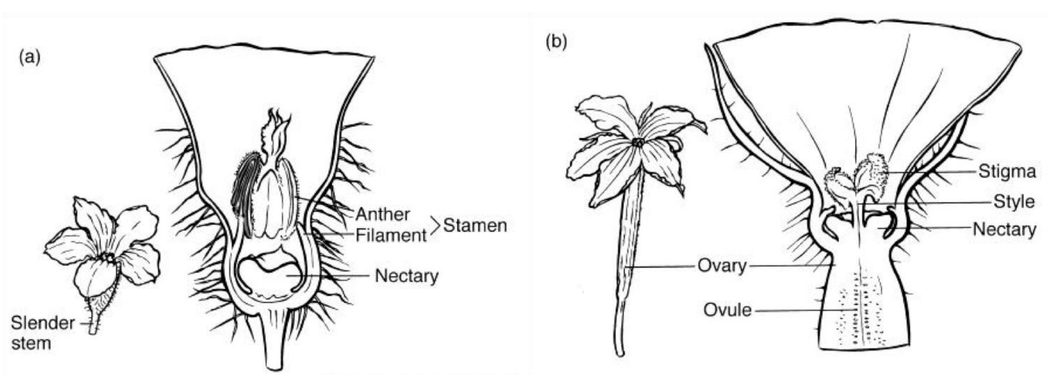

Figure 1. The male (a) and female (b) flowers of cucurbits require pollinators to move pollen from one to the other.

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.

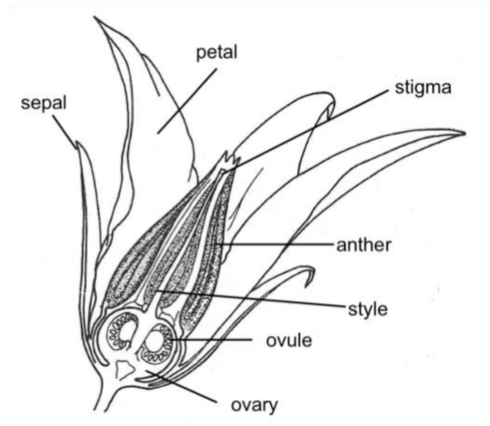

Figure 2. The tomato, pepper, and eggplant flower has a female part (stigma) surrounded by a cone of male parts (anthers). These flowers usually hang upside down, and when agitated will funnel pollen from the male part down through the cone and onto the female part. Bumble bees can enhance this pollen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

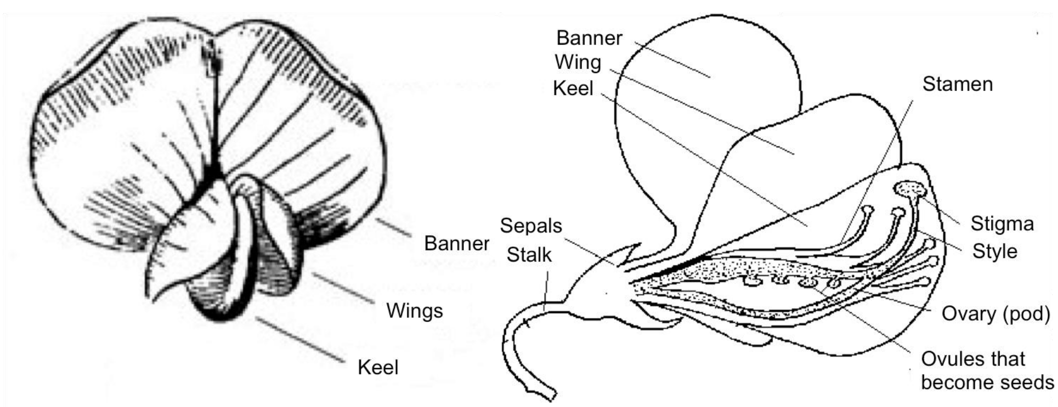

Figure 3. Beans have complicated flowers that require bees to learn how to access them. They are mostly self-pollinating, and bees may work them if nothing else is available.

Which pollinators are amenable to enclosed structures?

There are four primary managed pollinators used in agriculture, with different propensities for use in 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, polymethacrylate (PMMA), and polyethylene (PE). Polyvinyl chloride (PVC) and polycarbonate (PC) tend to block UV light and disorient bees.

Honey bees (*Apis mellifera*) are the most commonly used pollinator for fruiting vegetables inside and outside the greenhouse, but can be difficult to keep under the glass or plastic of growth structures for a number of reasons. The traditional hives are heavy and hard to move, and so smaller nucleus and micro-nucleus colonies are used. But, these need to be managed carefully to avoid swarming, absconding, and overheating. In addition, they are the most aggressive managed pollinator, and would not suit an operation where people need to work close by. Keeping a hive outside of the greenhouse can provide a source of bees to enter and exit structures through vents or roll-up sides, and they can be trained to find crops under plastic and glass with sugar baits. But, the first honey bees tend to become disoriented in these structures and get trapped, before other members of the colony get used to navigating inside. On cloudy days they don't forage as well, which is a poor feature for vine crops that bloom for one day.

Figure 4. This honey bee queen-rearing box in Caro, MI is broken into 4 micro-nucleus colonies, each with it's own queen. These "micro-nucs" are sometimes used for greenhouse pollination. Other times, a full colony is used. Either way, honey bees demand management throughout the season.

Commercial bumble bees (*Bombus* spp) have been an emerging market for pollination 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 fly under glass and plastic without getting trapped. 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, but will return when flowers are more plentiful. Current recommendations are 4-6 colonies per 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.

Figure 5. This commercial bumble bee colony is deployed in a greenhouse in Saginaw, MI. 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.

Solitary cavity nesting bees are supported by a smaller industry than honey bees and bumble bees. But they are the least aggressive commercial bees, rarely sting, are more effective pollinators of particular crops, and have potential for indoor use. Mason bee (*Osmia* spp) life cycles are limited to flight in April – June, and they are used for early-blooming tree fruit. They have been successfully used in pollination of brassica crops for seed production in cages, and high-tunnel strawberries. One species was found to be successful as indoor pollinators of peppers in Denmark, but could not maintain adequate nutrition to provide continued pollination of later flowers. Multiple pollen sources may be an important factor for some species of Mason bees, and access to wet soil will help them to construct nests.

Leafcutter bees (*Megachile* spp) are solitary cavity nesting bees, and a complex of species span the summer months, using leaf cuttings to partition their nests. They visit a larger diversity of flowers than Mason bees, and are used widely in seed production of field-grown alfalfa. They have also been successfully experimented with in field-grown low-bush blueberry production in Maine. Greenhouse studies with these bees concluded that high light levels and temperatures around 80 F are important factors influencing their flight activity. In cucumbers, they were found to prefer the upper-most flowers in the brightest area of the structure, and they needed alternative softer-leaved plants to construct their nests.

Figure 6. Mason bees and leafcutter bees utilized the same nesting tube structures in East Lansing, MI. Mason bees only fly between April and June. Leafcutter bees make their nests with soft leaves, and mason bees use mud. Both bees can be purchased as cocoons and deployed in crop systems. Leafcutter bees can be incubated and timed for release more easily than mason bees, fly for longer periods of time, and visit a larger diversity of flowers.