Diseases and insects in Michigan cucurbits and their management

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DISEASES

Cucurbit crops are an important component of the processing and fresh market vegetable industry in Michigan. There are many plant pathogens that can affect these crops and cause significant economic loss if left untreated. Downy mildew is an airborne pathogen that has been an annual threat to cucumber production in Michigan since 2005 and needs to be intensively managed to prevent catastrophic losses. Phytophthora blight affects all commercially available cucurbit cultivars. The fruit rot phase of this disease can be especially challenging to manage due to direct contact of fruit with the soil and the dense foliar canopy that precludes thorough fungicide coverage of the fruit. Anthracnose and angular leaf spot are sporadic in Michigan, but can be devastating in certain years and environmental conditions.

Phytophthora lesions on squash (left) and watermelon (right). Note the white "powdered sugar" appearance of *Phytophthora capsici* sporangia on surface of lesions.

Wilting summer squash plant infected with *Phytophthora*.

Water-soaking and blight of immature summer squash fruit and stems.

Please refer to **MSU Extension Bulletin E0312, "Insect, Disease and Nematode Control for Commercial Vegetables,"** to learn which pesticides are labeled for the uses suggested in this bulletin. The publication is updated each year and can be purchased by searching for E0312 at the website shop.msu.edu.

Phytophthora blight

Phytophthora capsici ("fungal-like" organism or water-mold)

Identification

- Damping off of seedlings.
  - Typically occurs in soils that remain saturated for extended periods, especially low lying areas of a field.
- Crown and root rot.
  - Wilting of mature plants followed by collapse. Crown tissue may be water-soaked and sunken. Wilted plants do not regain turgor after irrigation.
- Fruit rot.
  - Lesions on fruit are water-soaked, soft and sunken, and appear darker than surrounding fruit. The lesions rapidly join to cover entire fruit during warm and humid weather, especially with free moisture present.
  - Advanced lesions on fruit are covered with pathogen spores (sporangia) that have a powdered sugar appearance.

Biology

- The "fungal-like" organism produces an overwintering structure (oospore) when two mating types of the pathogen are present on infected plant tissue.
- The oospore resides in soil and can remain in a field for 10 years in the absence of a susceptible crop. Most fields with a Phytophthora problem in the Midwest have oospores in the soil.

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- The oospore will germinate and infect squash, cucumbers and melons (all cucurbit crops) during periods of warm temperatures and moisture favorable for plant growth.
- The asexual spores (sporangia) are produced on infected plant tissue and often appear in lesions as a layer of "powdered sugar."
- Each sporangia releases swimming spores (zoospore) when in contact with free moisture. The swimming spore spreads with irrigation water, ponding water in the field and saturated soil conditions. The spores of *Phytophthora capsici* are not airborne.
- Virgin fields can become infected with *Phytophthora capsici* if irrigated with water infested with spores or if infested soil adhering to machinery is moved among fields.

Management

- Managing Phytophthora blight takes an integrated approach, no single tactic is completely effective in managing the pathogen.
- Water management.
  - » Use raised plant beds and well-drained, tiled fields.
  - » Use a clean irrigation water source like well water.
  - » Avoid irrigating with surface water such as streams, dikes and ditches.
- Crop rotation.
  - » Rotate with non-host crops for three years.
  - » All cucurbits, peppers, tomatoes, eggplants and snap beans are susceptible to Phytophthora blight.
- Power wash equipment when moving between fields.
- Do not dump diseased culls into production fields.
- Fumigation: Refer to MSU Extension Bulletin E0312, "Insect, Disease and Nematode Control for Commercial Vegetables," for available fumigants and http://www2.epa.gov/soil-fumigants for fumigation requirements.
- Fungicide application.
  - » Fungicides should be applied to the soil at transplant.
  - » Sprays directed at the crown of the plant are beneficial if product applied with sufficient solution to soak the soil.
  - » Drip applied fungicides are recommended for root and crown rot.
  - » Use foliar sprays to protect fruit, applied with an air-assist sprayer that forces product into the lower plant canopy.

Downy mildew

Pseudoperonospora cubensis ("fungal-like" organism or watermold)

Identification

- Yellow lesions on leaf surface that are bound by leaf veins.
- Lesions may look similar to angular leaf spot. The "dirty" or "fuzzy" appearance of downy mildew fungal growth on the underside of leaves is a telltale sign of downy mildew and is best observed in the morning.
- Leaf yellowing turns brown as infection progresses.

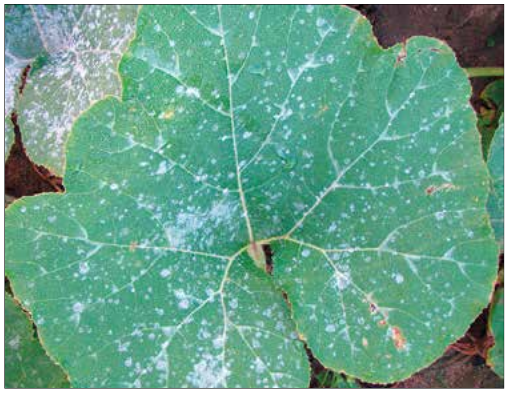
Biology

- The pathogen is "obligate" and cannot survive without a living crop.
- Survives in southern production states and in greenhouses that grow cucurbits, and moves into Midwest production fields during the growing season.
- Infects foliage and produces spores on the underside of the leaf. The spores are airborne.
- Cool (about 60 degrees Fahrenheit), wet and cloudy conditions are ideal for infection and pathogen spread.
- Can completely blight foliage in as little as 14 days.

Field with severe downy mildew.

Top and bottom surface of downy mildew-infected cucumber leaf. Note the gray-purple fungal growth on the leaf underside.

Shriveled pumpkin handle caused by powdery mildew.



Powdery mildew colonies on upper and lower surface of cucurbit foliage.

Management

- Maintain good plant spacing for adequate airflow.
- Plant cultivars with partial resistance (no resistant cultivars available).
- Scout regularly for initial lesions.
- A map of Michigan counties affected by cucurbit downy mildew during each growing season can be found at http://veggies.msu.edu.
- Apply fungicides on a seven-day schedule before disease is detected and a five-day schedule after disease is detected.

Powdery mildew

Sphaerotheca fuliginea (fungus)

Identification

- White powdery fungal colonies (powdery layer) on top and bottom surface of leaf.
- "Colonies" range in size from 0.0625 inches to covering the entire leaf surface.
- Powdery colonies on the underside of the leaf are often apparent as yellow spots on the upper surface of the leaf.
- "Powdery layer" does not wash off with rain or irrigation.

Biology

- Usually occurs in mid-summer on all cucurbits.
- Is favored by warm temperatures and high moisture.
  - Often observed first in low areas of a field with limited air flow.
  - Does not need free-water on leaf surface to infect.
- Is favored by dense plantings because the fungus likes shaded areas, such as the middle of the plant canopy.
- Older leaves are more susceptible, but all leaves can be infected.
- Can infect stems and pumpkin handles, causing shriveling.
- Infection pre-disposes plants to other diseases.

Management

- Avoid planting early squash and cucumbers adjacent or downwind of fields that will later be planted to pumpkins and winter squash.
- Use resistant cultivars, although resistance not available in watermelon.
- Scout fields before applying fungicides. An IPM approach is to initiate spraying when there is one colony per 45 leaves.
- Use air-assist sprayers to apply fungicides to promote thorough coverage of foliage.
- Alternate fungicides with different FRAC groups to delay pathogen resistance. The FRAC group can be found at the top of the fungicide label.

Anthracnose

Colletotrichum lagenarium (fungus)

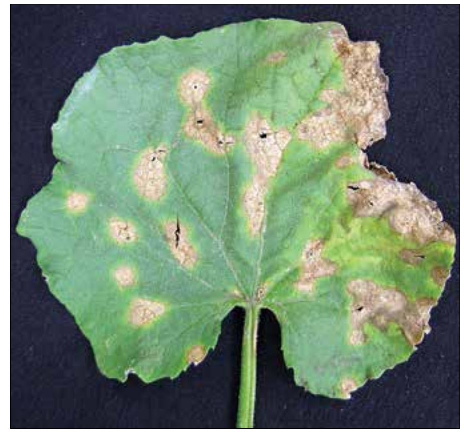
Identification

- Roughly circular, light brown lesions on foliage.
  - Lesion center may fall out, leaving shot-hole appearance.
- More frequently seen on mature and senescent foliage.
- Lesions on stems appear elongated and tan.
- Sunken lesions may form on fruit approaching maturity. They are often circular and may contain pinkish spore masses and black fungal growth during high humidity.

Biology

- Pathogen produces abundant spores in lesions under humid conditions and is favored by warm temperatures of 75 F.
- Requires splashing water for spore dispersal.
- Survives in crop debris.
- Can be introduced into fields in infested seed or transplants.


Anthracnose fruit rot. Note circular lesions and black fungal growth.



Above and below: Anthracnose lesions.

Management

- One year crop rotation out of cucurbit crops and deep tillage of crop residues after harvest.
- Plant resistant cultivars, which are available for cucumber and watermelon.
- Only irrigate with what is necessary for healthy plant growth. Additional water enhances pathogen spread.
  - » Avoid overhead irrigation.
  - » Irrigate in the morning to limit leaf wetness duration if using overhead irrigation.
- Use weekly fungicide applications once initial lesions are observed.
- Harvest in the afternoon after dew has dried from leaves. Field activity can facilitate disease spread when leaf moisture is present.

Gummy stem blight

Didymella bryoniae (pseudothecial stage) and
Phoma cucurbitacearum (conidial stage) (fungus)

Identification

- This fungus causes fruit rot (black rot), foliar blight and stem blight, also known as gummy stem blight. Severe blight can reduce yields and decrease content of fruit soluble solids.
- Lesions on foliage are initially water-soaked and surrounded by a yellow halo and enlarge into dry, papery, tan lesions.
- Stem lesions are initially water-soaked and progress to dry, tan lesions that have a characteristic red-brown gummy exudate that appears bead-like. Tan cankers with gummy exudate also develop on the crown.
- Winter squash and pumpkins are less susceptible to gummy stem blight than melons and cucumbers. Zucchini and summer squash are resistant to gummy stem blight and black rot.
- Black rot affects the fruit of most cucurbits, although watermelon, zucchini and summer squash are less susceptible.
  - » Lesions are initially small and circular or irregular with a greasy appearance.
  - » Lesions merge and turn brown to black, eventually becoming dry and sunken with a cracked surface.
  - » Lesions on butternut squash are brown and concentric, and may cover large areas of the fruit.
  - » Fruit can be affected in the field near maturity, however are more often affected post-harvest.

Biology

- The fungus survives on infected and undecomposed crop residue as fungal survival structures (pseudothecia).
- Pseudothecia germinate when environmental conditions are favorable for plant growth and infect cucurbit crops via airborne ascospores.
- Pseudothecia and pycnidia (fungal structures that produce conidia) are produced in abundance in lesions.
  - » Pseudothecia and pycnidia appear as tiny, black specks in lesions.
  - » Conidia are released from pycnidia and can be splash-dispersed with rain or overhead irrigation.
- High humidity and moisture are needed for infection. Warm temperatures of 65-75 F favor disease.
- The gummy stem blight fungus can be seed-borne.


Initial lesions and advanced black rot (*Didymella bryoniae*) affecting pumpkin fruit.

Gummy stem blight on cucurbit foliage.

Management
- Use a two- to three-year rotation away from cucurbit crops.
- Thoroughly till crop residues after harvest.
- Apply fungicides preventively once lesions are observed.
- Control powdery mildew infection and cucumber beetles that can predispose vines to gummy stem blight infection.

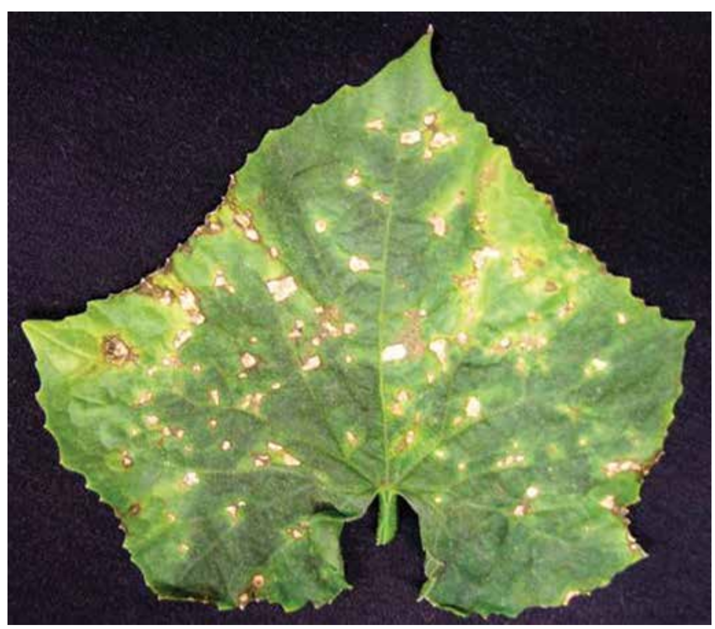
Angular leaf spot

Pseudomonas syringae pv. ***lachrymans*** (bacteria)

Identification
- Initial lesions are small and water-soaked.
- Lesions are usually limited by the leaf veins, giving an “angled” appearance.
- Lesions dry out and become brown with a papery center that may fall out, leaving a shot-hole appearance.
- During high humidity, grayish exudate can be seen on underside of lesions. This dries to form a thin translucent crust on the underside of the lesion.
- Fruit may also become infected and lesions appear as small, water-soaked spots which may have a tan center.

Biology
- Bacterium is seed-borne.
- Young tissue (seedlings and newly expanding foliage) is more frequently affected.
- Spreads by irrigation water and wind-splashed rain.
- Leaf wetness (dew and rain) increases bacterial numbers on leaf, enhancing spread.
- Does not survive in free soil.
- Overwinters in residue for about two years.

Management
- Rotate out of cucurbit crops for two years.
- Thoroughly disk residue after harvest.
- Buy certified, disease-free seed and discard transplant flats containing diseased plants. Symptomless seedlings in close proximity to diseased seedlings may contain latent or “quiet” infection and bring the bacteria into the field if planted.
- Cucumber cultivars with resistance are available.
- Avoid field activity in the morning as the dew on plants can facilitate pathogen spread.
- If using overhead irrigation, irrigate in the morning to minimize the duration of leaf wetness.
- Avoid wounding plants.
- Apply bactericides preventively.
- Once infection is established, bactericides will slow disease spread, but will not cure the infection.



Angular leaf spot lesions on cucumber leaf.

INSECT PESTS

Michigan's cucurbit crop is an economically important component of Michigan's agriculture. There are both beneficial and harmful insects that may be present on these crops. The most common insect pests damaging Michigan cucurbits include squash bugs, squash vine borers, striped cucumber beetles and spotted cucumber beetles. With the exception of squash vine borers, adult and immature stages of these pests feed on cucurbit plants and concern growers. These species' larvae attack different parts of the plant. For example, squash bugs attack above-ground foliage and fruit, while squash vine borers tunnel through stems and cucumber beetle larvae attack roots and below-ground vegetation. Integrated pest management (IPM) recommendations for insect pests are in a section following all the insect descriptions.

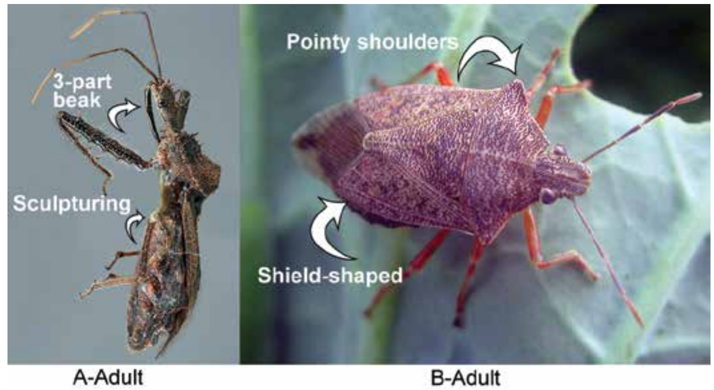


Figure 2. Squash bug look-alikes. A) Assassin bug, which has an in-folded, three-segmented beak and is more sculptured. B) Spined soldier bug, which has a shield-shaped body.

Squash bug

Anasa tristis
Hemiptera: Coreidae

Identification
Squash bug eggs are small, round, lentil-shaped and reddish-orange or bronze. They are often found in clusters of 10-20 on the underside or surface of leaves between major leaf veins or along the stem. When nymphs hatch from the eggs, they have greenish abdomens with red legs and antennae. Subsequently, the legs and antennae turn black or brown. Older nymphs have gray bodies with black legs and antennae; they can be wingless or have small wing pads, which are premature wings.

Squash bug adults are black-brown insects, approximately 0.6 inches long. They are flat and have fully developed wings. The abdomen is wider than the wings with dark and light stripes along the edge of the body. Squash bug adults can be confused with assassin bugs which have a three-segmented beak and their bodies are more sculptured, or with spined soldier bugs which have a shield-shaped body, no banding on the sides and two spines on their shoulders (Figure 2).

Biology
Squash bug adults overwinter indoors or in leaf litter, crop debris or rocky material. Adults emerge in April or May and begin to lay eggs in clusters. Within 10 days, eggs hatch and nymphs begin to feed on the plant. They undergo five nymphal stages, lasting 35-40 days before reaching adulthood. Although only one generation of squash bug occurs in Michigan, every life stage (egg, nymph and adult) may be present throughout the season.

Figure 3. Squash bug damage.

Figure 1. Squash bug different life stages.

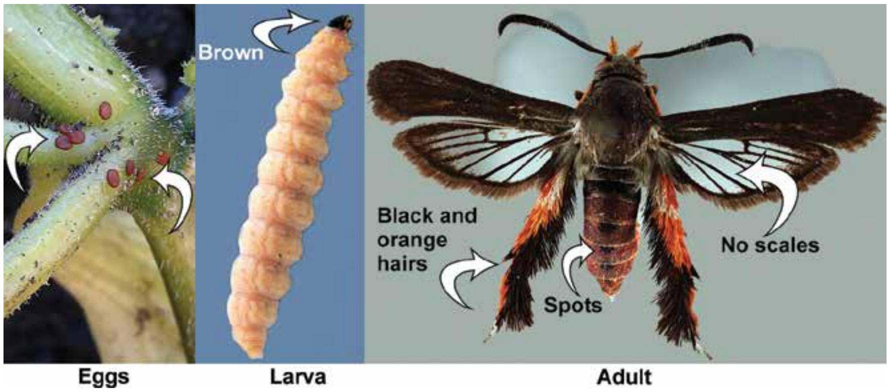


Figure 4. Squash vine borer.

Damage
Squash bugs prefer to feed on pumpkins and squash; however, this pest can cause damage in other cucurbits, such as cucumbers and melons. Squash bug adults and nymphs feed on leaves and fruit by sucking on plant juices. Leaves become brittle and discolored (Figure 3), plants may wilt and blemishes form on the fruit. Significant damage can lead to yield decline and unmarketable fruit. In addition to direct damage, squash bugs can also transmit a bacterial disease called yellow vine decline.

Squash vine borer

Melittia cucurbitae
Lepidoptera: Sesiidae

Identification
Eggs are 1 millimeter, flattened, brown ovals, and laid singly on stems or petioles of cucurbit plants. Squash vine borer adults are approximately 0.5 inches long with an orange-red body and black spots on the abdomen. This clear-winged, day-flying moth lacks scales on the hind wings and the forewings are black with green edges. Wingspan is approximately 1 to 1.3 inches. Adults have orange, black and white striped legs with distinctive black and orange hairs on the hind legs. The squash vine borer larva is a white caterpillar, approximately 1 inch long at maturity, with a dark brown head capsule. Pupae are approximately 0.6 inches long, dark brown and encased in silk.

Figure 5. Squash vine borer damage to squash plant and stem, where it enters the plant.

Biology
Squash vine borers overwinter as mature larvae or as pupae in the soil. Adults emerge in June and start laying eggs on cucurbit plants. Eggs hatch in seven to 10 days and larvae tunnel into the plant stem. Larvae undergo four instars over two to four weeks, before mature larvae exit the plant and pupate in the soil. In Michigan, one to two generations of squash vine borers can occur. These larvae are concealed within the plant stem. However, feeding activity can be detected visually as larvae push their sawdust-like excrement (frass) out of entrance holes in the stem. Stems with larvae often wilt.

Damage
Unlike other squash pests, only the larval stage of the squash vine borer damages cucurbit crops. The favored foods for the larvae are squash and pumpkin vines and stems, but occasionally they can be found in cucumber or melon crops. Tunneling destroys tissue, causing vines and stems to become hollow. In cases of severe infestation, the plant eventually wilts and dies (Figure 5).

Striped cucumber beetle

Acalymma vittata
Coleoptera: Chrysomelidae

Spotted cucumber beetle

Diabrotica undecimpunctata howardii
Coleoptera: Chrysomelidae

Identification
Striped cucumber beetle adults are yellow with three straight, black lines down their back. They have a black abdomen (Figure 6) and are approximately 0.25 inches long. Spotted cucumber beetle adults are yellow or green with 12 black spots on their backs and have a yellowish abdomen (Figure 7). Striped and spotted cucumber beetle larvae are white or yellow with dark head capsules and a darkened tip on the abdomen. Striped cucumber beetle larvae have a more flattened appearance than spotted

Figure 6. Adult striped cucumber beetle.

Figure 7. Adult spotted cucumber beetle.

cucumber beetles. Striped cucumber beetles should not be confused with the western corn rootworm, which has roughly three stripes on its abdomen (Figure 8). Only the spotted cucumber beetle has spots and a yellow abdomen.

Biology
Striped cucumber beetles overwinter as adults, finding shelter in field debris or leaf litter in wooded areas. Adults move into agricultural fields in April to feed and mate. In contrast, spotted cucumber beetles do not overwinter in Michigan, but migrate from the southern United States. They arrive in Michigan usually in late June.

Adult cucumber beetles lay eggs at the base of cucurbit plants or just below the soil surface. In five to eight days, the eggs hatch and larvae begin feeding on roots. Larvae pupate underground two to three weeks later. Two generations of striped cucumber beetles occur in Michigan. The first generation can cause significant economic damage.

Damage
Striped cucumber beetle adults typically specialize on cucurbit crops, although they are occasionally found on beans, peas and corn. Larvae feed on roots of these crops and can reduce production of female flowers and fruit set


Figure 8. Look-alike to striped cucumber beetles: western corn rootworm. Striped cucumber beetles have three distinct stripes and a black abdomen, while western corn rootworms have three amorphous stripes and a yellow abdomen.

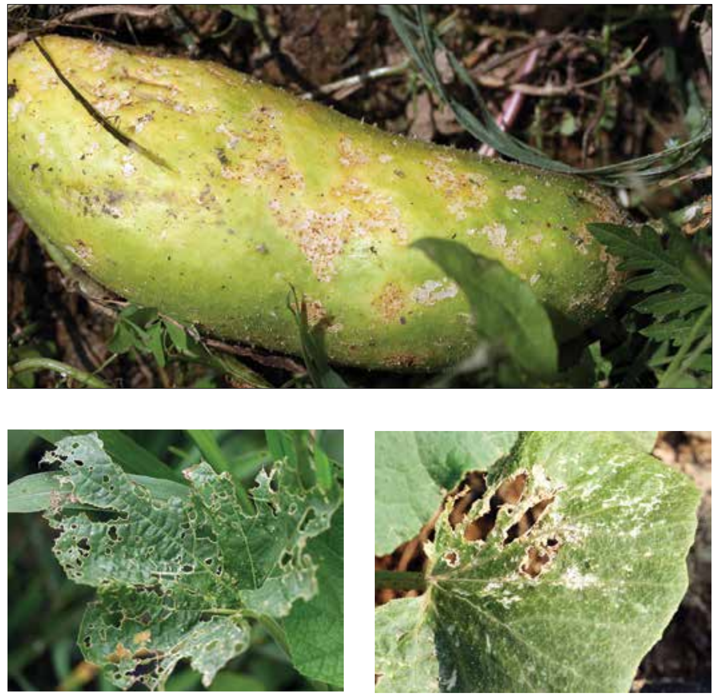


Figure 9. Cucumber beetle damage.

in rare cases. Spotted cucumber beetle adults are generalists, feeding on cucurbits, cabbage, beans, peas, potatoes, tomatoes and other crops. Spotted cucumber beetle larvae feed on the roots of corn, grains and grasses.

Adults of both beetles chew on leaves, blossoms and rinds of fruit (Figure 9). This causes defoliation, reduced pollination due to destruction of flowers and fruit scarring. These beetles can also vector *Erwinia tracheiphila*, a bacterial wilt of cucumbers and muskmelons. They transmit bacterial wilt to plants through their feeding and frass, even when beetle densities are low.

Aphids (assorted species)

Hemiptera

Identification
Aphids are small true bugs with sucking mouthparts and often two cornicles, or "tailpipes," arising from the end of their body. Color ranges from black to gray and various shades of green. Individuals are small, usually no greater than 0.1 inches long. There are winged and non-winged individuals. Species identification is difficult, however, the different species typically transmit similar diseases and cause similar damage and can be managed as a complex.

Biology
Aphids drink plant sap by piercing squash leaves and fruit with their mouthparts. Aphids can rapidly increase in abundance because females may often be born pregnant with their progeny already developed. They are able to reproduce without mating, which may lead to severe infestation.

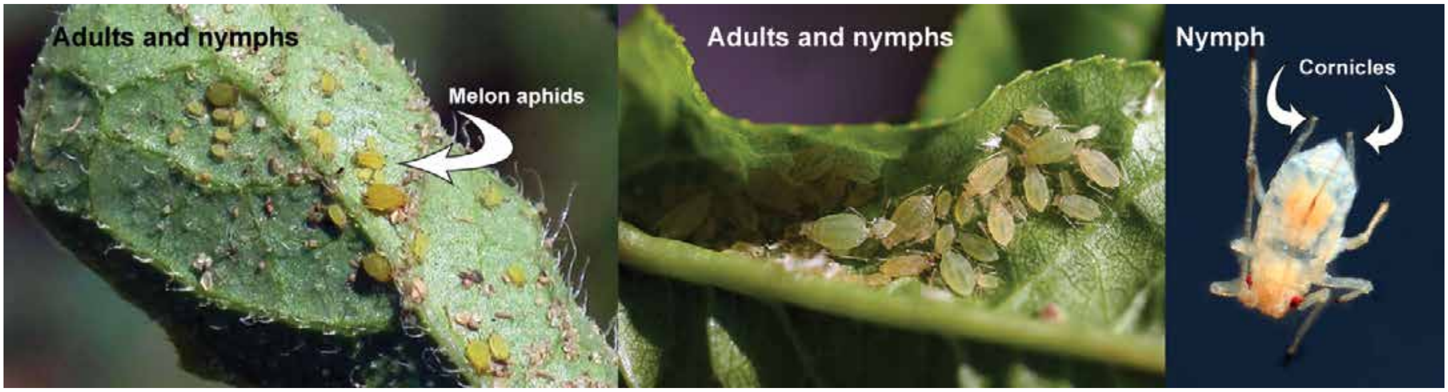


Figure 10. Aphid colonies on leaf and a single aphid.

Aphids produce honeydew, or surplus sugar water, which may drip on the plant and promote development of sooty mold. Ants often form an association with aphids whereby ants protect the aphids and feed on their sugary secretions in exchange.

Damage

High aphid numbers can cause leaf curling that, in severe cases, leads to wilting and plant death. However, the majority of economic loss is due to their ability to transmit viral diseases. In the early spring, aphids are attracted to weeds infected with viruses that they feed on and then transmit to the cucurbit crop. The specific viruses transmitted by aphids to squash include cucumber mosaic, watermelon mosaic I and II and zucchini yellow mosaic virus.

Symptoms of cucumber mosaic virus, one of the most common viruses in the northern United States, include wilting of summer squash leaves around the mid-vein and reduced leaf production. In addition, the color of squash fruit becomes inconsistent and mottled, though this may occur with watermelon mosaic I and II as well. Fruit distortion and mottled color may be an issue in some squash varieties with watermelon mosaic virus II. Watermelon mosaic virus I is mostly confined to the western United States. Symptoms of zucchini yellows include yellowing, necrosis and distortion of leaves and fruit that are severely reduced in size, malformed and green-spotted.

Seedcorn maggot

Delia platura
Diptera: Anthomyiidae

Identification

Adults are small and slender, about 0.2 inches long, gray and somewhat resemble a housefly. These flies also resemble cabbage and onion maggots, though seedcorn maggots are active earlier in the season. Eggs are small, oblong and white with ridges running length- and width-wise, which form small, rectangular impressions. Maggots are whitish-yellow, legless and about 0.25 inches long with a tapered end. The pupae are reddish-brown and about as large as the adults.

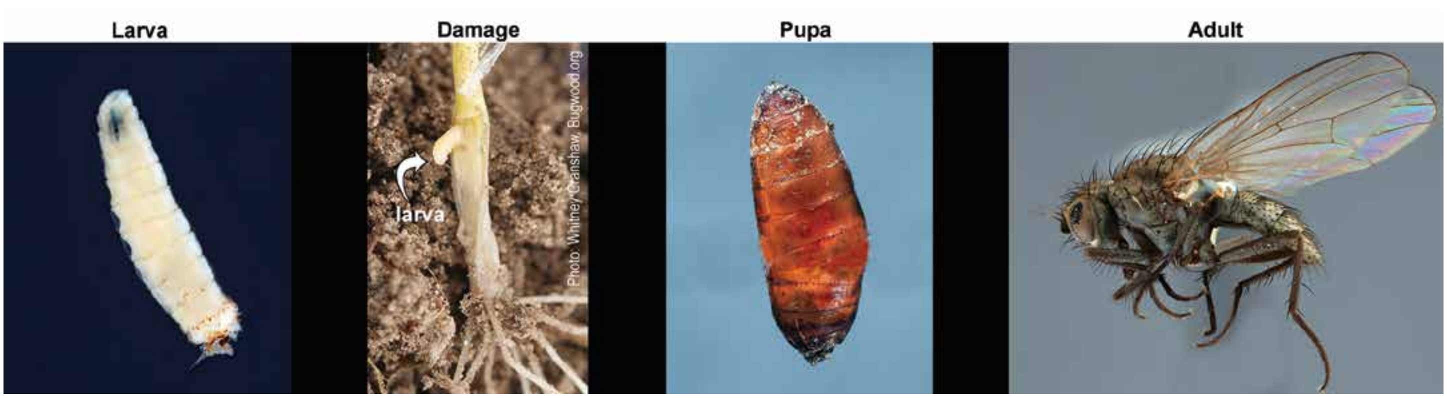
Biology

Eggs are deposited on the soil surface near decaying or sprouting seeds and other organic matter in the field in early spring after adult emergence, typically from April to May. Seedcorn maggots usually prefer other crops to squash when depositing eggs. Upon hatching, the maggots burrow into neighboring seeds and feed on developing embryos. The pest overwinters in the soil as a pupa.

Damage

This pest has the ability to damage seeds, roots and stems. Slow emergence and poor stand quality are signs of seedcorn maggot infestation and should be confirmed by digging up a few plants and checking the plant's roots and base for signs of maggots. Fields are at a greater risk if

Figure 11. Seedcorn maggot developmental stages and damage.



they have a high amount of organic matter, including fields where manure has been applied, residue is left from the previous year or where the same crop has been previously planted. Additionally, fields that have experienced cool weather recently may also be at risk. A good rule of thumb is that if the soil temperature at 4 inches has been at 70 F or higher for five days or more, then the risk of damage by seedcorn maggots is greatly reduced.

Once damage occurs, it is too late to control seedcorn maggots, so management has to be preventative. Cover crops sown before cucurbits should be incorporated prior to planting and left with sufficient time for the organic matter in the field to decay. Seed and soil treatments may be used at planting to decrease the likelihood of seedcorn maggot infestation. Poor emergence after spring planting may be indicative of seedcorn maggot damage, at which point scouting for maggots should occur.

Integrated pest management of squash insect pests

Scouting

Visual sampling for aphids and all squash bug life stages should occur from June to September in Michigan. Scouting for squash vine borers should last from June through July by examining pheromone traps to monitor adult populations. Visual sampling can also be used to determine the presence of eggs and damage to stems. Scouting for cucumber beetles should begin in June and continue through August, using yellow sticky traps or visual sampling for adults.

Treatment thresholds and chemical control

When scouting indicates a field has reached thresholds for squash pests, management action should be taken to prevent crop loss.

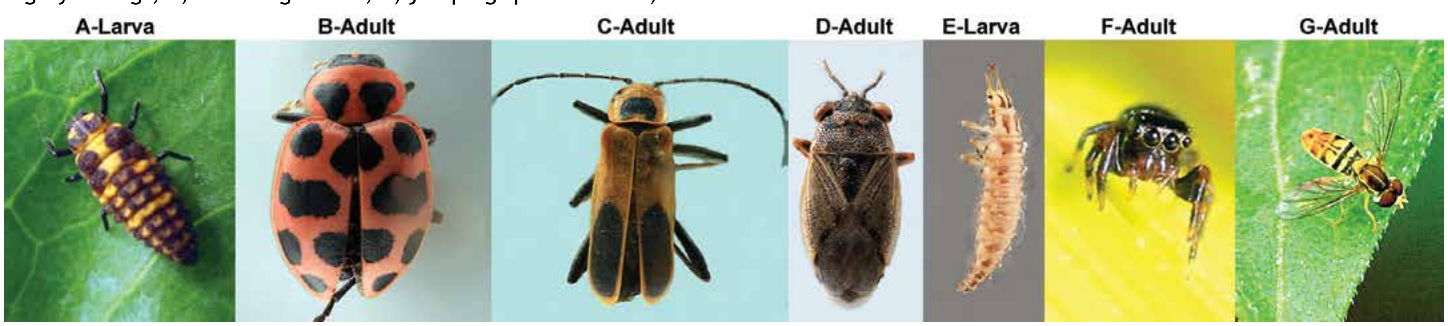
- *Squash bugs.* **Early in the season, the threshold for squash bugs is the presence of any squash bugs on seedlings.** The threshold for squash bugs is greater after the seedling stage with chemical applications recommended if the average egg density reaches **one egg mass per plant**. Insecticides are most effective for managing squash bugs when early instar squash bug nymphs are present in the field.
- *Squash vine borers.* Due to the difficulty of managing tunneling squash vine borers once larvae are protected inside the plant, insecticides should be applied **when eggs or damage from early instar borers are first detected** using visual sampling. Alternatively, if tracking adult moths using pheromone traps, the threshold is **three moths per trap**. Products containing pyrethroids, pyrethrin or *Bacillus thuringiensis* (Bt) are available to manage squash vine borers.
- *Cucumber beetles.* The threshold for cucumber beetles on most cucurbit plants is **one beetle per plant using visual sampling** when in the **seedling stage** (three true leaves or less). Mature squash plants, including pumpkins, have a threshold of **five beetles per plant.** Bacterial wilt transmission by cucumber beetles can be significantly reduced if fields are treated with insecticides.
- *Seedcorn maggots.* There are no economic thresholds for seedcorn maggot damage. Once damage is detected, it is too late to attempt to control further seedcorn maggot damage. Adult populations can be monitored with yellow sticky traps. Outbreaks can be prevented by using treated seed and cultural methods, such as cover crops and conservation tillage.

Insecticide applications for all cucurbit crops should be applied after peak pollinator activity later in the day to avoid harming pollinators.

Cultural control

In the fall, any field debris that could support overwintering squash bugs or striped cucumber beetles should be removed. Cultural controls including delayed planting, companion planting, border crops, plowing any vegetation in the field in the spring prior to planting and trap cropping can reduce pest populations. In addition, using reflective mulches can decrease aphid populations and delay onset of mosaic virus by up to two weeks. Insecticides for squash

Figure 12. Some common natural enemies of cucurbit pests, including A) pink lady beetle larvae and B) adults, C) soldier beetles, D) big-eyed bugs, E) lacewing larvae, F) jumping spiders and G) flower flies.



will not completely prevent virus transmission by aphids since aphids transmit the virus before the active ingredient can kill them, but it will slow the further spread of the virus in the field.

There are virus-tolerant varieties of squash available to growers that may decrease the chances of fields succumbing to a disease. Disease transmission by cucumber beetles can be slowed or stopped by killing the beetles because it takes longer for the beetles to transmit the bacteria.

Biological control

Insects and spiders can provide natural biological control of pests in cucurbit fields. Predators such as lady beetles (e.g., pink lady beetle), ground beetles, soldier beetles, damsel bugs, big-eyed bugs, lacewing larvae and spiders (e.g., jumping spiders) are common predators in cucurbit fields (Figure 12). They feed on eggs, larvae and adults of these pest species, reducing pest populations. The immature stages of these predators can also provide biological control services. Sprays with entomopathogenic nematodes can lead to declines in soil dwelling cucumber beetle larvae and squash vine borer larvae.

Parasitoids that develop inside cucurbit pests can provide biological control. For example, tachinid flies and braconid wasps are native parasitoids that develop inside squash bugs, squash vine borers and cucumber beetles, leading to the death of their hosts. Taken together, a combination of these different tactics in an IPM approach may help increase production of cucurbits and decrease non-target effects associated with excessive use of pesticides.

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Online resources for commercial vegetable production

- MSU Vegetable Entomology lab: vegetable.ent.msu.edu
- MSU Hausbeck vegetable disease lab: www.veggies.msu.edu
- MSU Enviroweather (weather-based pest, natural resources and production management tools): www.enviroweather.msu.edu
- MSU Extension bulletin E0312 (Insect, Disease and Nematode Control for Commercial Vegetables): enter E0312 into the search box at shop.msu.edu
- MSU Extension Vegetable News: http://msue.anr.msu.edu/topic/info/vegetables
- MSU Extension Bookstore: shop.msu.edu

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