VEGETABLE CROPS HOTLINE

A newsletter for commercial vegetable growers prepared by the Purdue University Cooperative Extension Service

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In This Issue

Botrytis Gray Mold on Greenhouse Tomatoes

(Dan Egel, egel@purdue.edu, (812) 886-0198) & (Wenjing Guan, guan40@purdue.edu, (812) 886-0198)

The recent cool and cloudy weather has influenced conditions in the field as well as in greenhouses and high tunnels. I have observed more Botrytis gray mold of tomatoes in greenhouses this spring than usual. This is due in part to the weather. This article will discuss this disease on tomatoes and some management options.

Gray mold is caused by a fungus that attacks many types of vegetables and ornamentals. The fungus is not a strong pathogen and often starts on weakened or senescent tissue such as old flower petals. The gray mold fungus, *Botrytis cinerea*, may be a weak pathogen, but it is a good saprophyte, growing well on old crop debris and organic matter until a good plant host is available.

Figure 1 shows a tomato leaf on which a flower petal has fallen. Since the gray mold fungus is sporulating on the flower petal, there is a good chance that a lesion will soon start on the leaf. A gray mold lesion on a leaf is shown in figure 2 and a gray mold lesion on a tomato fruit is in figure 3. Note the flower petal on the top of the tomato fruit in figure 3.

Figure 1. Tomato blossom with sporulation of leaf mold fungus.

Figure 2. Lesion of gray mold on tomato leaf.

Figure 3. Fruit rot caused by leaf mold of tomato.

Gray mold is favored by temperatures from 64° to 75°F and requires only high humidity (not leaf wetness) to become established. Our recent cool, cloudy weather fits these criteria.

Greenhouses and high tunnels usually have higher humidity than adjacent fields.

Since the gray mold fungus can thrive on organic matter and crop debris, sanitation is key for management of this disease. Keep greenhouse floors clear of crop debris. Regularly remove tomato prunings from the greenhouse and surrounding area. Keep weeds to a minimum and don't allow volunteer tomatoes from last year to grow. Just as dirty kitchens are associated with being unhealthy, I associate dirty, unkept greenhouses with disease.

As much as possible, keep greenhouses well ventilated. Weather permitting, vent the greenhouse in the evening to replace the humid air with relatively dry air from outside. Avoid the temptation to crowd as many tomato plants as possible into the greenhouse. Research has shown that spacing plants much closer than about 20 inches within the row and 5 feet between rows doesn't increase yield and may reduce ventilation.

If possible, prune or sucker to improve ventilation. For determinate type tomatoes, ventilation can be improved with little chance of yield sacrifice by pruning the suckers from the plant bottom until the node below first flower cluster.

For more details on the management of foliar diseases of tomatoes in greenhouse, see "Tomato disease management in greenhouses" at https://www.extension.purdue.edu/extmedia/BP/BP-197-W.pdf or call Dan Egel for a hard copy.

Gray mold is known to be favored by low calcium levels in the plant. In particular, calcium to phosphorus levels of less than 2:1 may make the tomato plant more susceptible. In short, make sure your tomato plants have adequate nutrition.

Several fungicides are available to help manage gray mold of tomatoes in greenhouses or high tunnels. See the *Midwest Vegetable Production Guide for Commercial Growers* at mwveguide.org for more detailed information. Botran®, Fontelis®, Scala® and Switch® should all be effective against gray mold. Copper products such as copper hydroxide or copper sulfate will be less effective than the above products, but should offer some help. Oxidate® will help to sanitize the surface of the foliage of the gray mold fungal spores. However, Oxidate® will have no residue; therefore, Oxidate® will not protect against spores that land on foliage after the product has dried. Mancozeb products such as Manzate® and Dithane® are not labeled for gray mold. The fungicide Fracture® is a new product from FMC that is labeled for Botrytis gray mold, however I do not have any data or experience with this product yet. Fracture® and Oxidate® may be acceptable in organically managed systems. Many products with copper as an active ingredient may also be acceptable in organic systems. Note that only products allowed for greenhouse use are discussed here.

When should one make the decision to apply fungicides? Growers may make the decision to spray if the weather has been cool and wet for an extended time. Greenhouses that have had little chance of ventilation with outside air are more likely to have gray mold problems. Additional factors that may favor a fungicide application is if the greenhouse has had gray mold problems in the past and if tomatoes have been grown after tomatoes for several years. The first application should be make at or shortly after first bloom.

The weather should become warmer and drier soon. With the change of weather, gray mold should become less of a factor. The above discussion, however, should help growers to understand the biology and management of this important disease.

Flea Beetles

(Rick Foster, fosterre@purdue.edu, (765) 494-9572)

Many of our vegetable crops are subject to feeding by one or more species of flea beetles (Figure 1).

Figure 1. Flea beetles on brassica (photo by John Obermeyer)

Flea beetles get their name because they have enlarged hind legs that allow them to jump like fleas. Most species are quite small, and with their ability to jump, often seem to just disappear when disturbed. Flea beetles tend to feed on the leaves, chewing small round holes. When populations are high, the feeding holes with overlap, creating larger holes. Flea beetles tend to be early season pests, primarily because smaller plants are more affected by their feeding. Treatment thresholds vary from crop to crop. For example, eggplants, on of the most commonly damaged vegetable crops, should be treated when there is an average of 4 beetles per plant. For tomato, the threshold is when leaves are 30% defoliated. Crucifers have no particular threshold, so treatment should be made when leaves start to show considerable damage. Flea beetles are easy to control with a variety of insecticides including Sevin® and the pyrethroids. One application is usually all that is required.

Striped Cucumber Beetles

(Rick Foster, fosterre@purdue.edu, (765) 494-9572)

We found our first striped cucumber beetle on Friday, May 20 and several more on May 23 (Figure 1). Given the cool weather, this is a little earlier than we

Figure 1. Striped cucumber beetles on melon plants (Photo by John Obermeyer)

would have expected. As the temperatures warm up this week, it would not be surprising for cucumber beetles to become very numerous in our melon and squash fields. Striped cucumber beetles are more attracted to squash so growers with those crops should look there first to see if the beetles are active in their area. Growers who direct seeded crops treated with FarMore® insecticide can expect about 3 weeks of control of striped cucumber beetles from that treatment. Growers who grow transplants from seeds treated with FarMore® will receive no benefit from those treatments once plants are in the field because the 3 weeks of control have ended. Likewise, growers who treated at planting with Platinum® or Admire Pro® can expect to receive about 3 weeks of control. Combining FarMore® treated seed with a planting time insecticide application will not provide any additional time of control. Once live beetles are present, growers must decide if a foliar insecticide application is necessary. Research has clearly shown that spraying weekly instead of only spraying when the economic threshold is reached will result in significantly lower yields, so only treat when necessary. For cantaloupes and cucumbers, the threshold is 1 beetle per plant, because these crops are highly susceptible to bacterial wilt, which is vectored by the beetles. For watermelons, squashes, and pumpkins, the threshold is 5 beetles per plant, because those crops are less sensitive to bacterial wilt. The pyrethroid insecticides, Ambush®, Asana®, Baythroid®, Brigade®, Danitol®, Mustang Maxx®, Pounce®, and Warrior®, will provide excellent control of striped cucumber beetles.

Root and Seed Maggots

(Rick Foster, fosterre@purdue.edu, (765) 494-9572)

As predicted last week, I have received a number of reports of damage to various vegetables from the root and seed maggots. These pests need to be managed preventively. First, by limiting the amount of decaying organic matter (cover crops, compost, manure) that attracts the flies, growers can reduce the number of eggs laid. Second, by waiting until soils reach 70° F before planting will greatly reduce the damage. Finally, using soil applied insecticides can reduce damage. In many cases, it's too late for that now. So what can growers do if they have lost a major percentage of their crop from one of these maggot pests? Generally, the only option is to replant. If the crop were seeded with a planter, such as sweet corn, the decision must be made to determine if the crop is worth saving or if a portion of the field needs to be disked up and replanted. For transplanted crops, individual plants can be replaced. However, I suggest that growers wait several days after the original plant died before putting another transplant in the hole to give the maggots there time to complete their development. Spraying foliar insecticides to control the flies before they lay eggs is not effective because flies move in and out of the field and only a small percentage will be affected by a foliar spray.

Corn Earworm

(Rick Foster, fosterre@purdue.edu, (765) 494-9572)

I am continuing to catch a small number of corn earworms in my trap. Usually we talk about earworm moths being attracted to silking corn to lay their eggs. However, moths will lay eggs on whorl stage sweet corn and the larvae can cause damage (Figure 1 and 2). The larvae will often feed inside the whorl, similar to European corn borer feeding. This damage is usually not very serious, but growers with very early sweet corn should be aware of the potential.

Figure 1. Corn earworm larva inside whorl of sweet corn plant (Photo by John Obermeyer).

Figure 2. Earworm damage on whorl stage of sweetcorn (Photo by John Obermeyer)

Cool Temperatures and Excess Rain may Increase Crop Injury from Labeled Herbicides

(Liz Maynard, emaynard@purdue.edu, (219) 548-3674)

The cool weather this spring means that many early-planted warm season crops have probably been stressed by cool temperatures more than usual. A number of herbicides labeled for vegetable crops include warnings not to use when the crop is or will be under stress. A stressed crop may not be able to detoxify the herbicide or outgrow its effects quickly enough. In the case of a soil applied herbicide, the crop roots may not grow into untreated soil fast enough to avoid injury.

High rainfall amounts can also lead to crop injury from soil-applied herbicides. Many herbicides move with soil water, and when there is too much water they can move where they are not wanted. Preemergence herbicides may move deep enough to injure crops with a low margin of tolerance. For instance rain may move Curbit® deep enough to injure seeded pumpkins.

If you are seeing some of the symptoms described below, stress from cool temperatures may have made the crop more susceptible to a herbicide that was applied before or soon after planting, or herbicide may have been moved into the root zone of the crop. At this point, there is not a lot one can do about it other than minimize any additional stress to the crop. It goes without saying that it is important to keep an extra close eye on the crop to determine whether harvest will be delayed, and, if necessary, make adjustments in the marketing plan.

What type of injury might you see? Active ingredients in the dinitroaniline group, including ethalfluralin (in Curbit® and Strategy®), trifluralin (Treflan®), and pendimethalin (Prowl®) cause root stunting. Roots will appear stubby. Aboveground the plant will be stunted. Chloroacetamides like s-metolachlor (Dual Magnum®) and dimethenamid-p (Outlook®) can cause leaf malformation. Often on broadleaves the midvein is shortened or puckered, making a 'drawstring' look, or the leaf blade is crinkled. In corn these materials can prevent normal unfurling of leaves. Sulfonylureas like halosulfuron (Sandea®) cause chlorosis, sometimes purpling, and sometimes leaf distortion or, in corn, improper leaf unfurling. Clomazone, which is in Command® and Strategy®, causes bleaching of leaves.

Even without a herbicide, chilling itself can injure sensitive crops like melons and squash. Chilled plants may wilt and develop watersoaked spots on leaves.

Tomato Zippering

(Wenjing Guan, guan40@purdue.edu, (812) 886-0198)

Recent cool weather increases the occurrence of zippering on high tunnel tomatoes. We observed at least 20% of developing fruit (most on the first and second flower clusters) on the variety Mountain Spring showed the zippering symptoms in our high tunnel. A typical symptom of the disorder is a thin, brown, necrotic scar that starts from the stem end and extend fully or partially to the blossom end. The reason the symptom is called zippering is because transverse scars are along with the longitudinal scar that looks like a zipper (Figure 1). In more severe cases, the scar is open and reveal locule (Figure 2). In the initial stage, zippering is often observed with anthers adhering to the fruit (Figure 3), the attached anthers is believed to disturb fruit development and cause the symptom.

Figure 1. Tomato zippering

Figure 2. Open scar revealing locule

Figure 3. Anthers adhere to developing fruit

Zippering symptom is more noticeable with cool weather. Optimum temperatures for tomato fruit set are 60-75°F (night) and 60-90°F (day). In the past week, when the lowest night temperatures were in the range of 40s during the cloudy days, the lowest night temperatures inside high tunnel were also below 50°F, lower than the optimal fruit-set temperatures. To reduce

zippering tomatoes, maintain idea temperature during tomato fruit set is important. In addition, select varieties that are not prone to zippering. In a study conducted at Southwest Purdue Agricultural Center, we found 'Red Deuce' was less susceptible to zippering than 'Mountain Spring' under the similar environmental conditions.

New Purdue Publication About Pesticide Drift

(Liz Maynard, emaynard@purdue.edu, (219) 548-3674)

Purdue Extension publication PPP-110 'Options for Dealing with a Pesticide Drift Incident' describes causes and effects of pesticide drift. It discusses actions a vegetable farmer (or anyone) might take if they suspect that herbicide drift may have injured their crop. The first step suggested is to find out what caused the symptoms. The publication explains that Purdue Extension educators can help in determining the cause of symptoms, but are not pesticide drift investigators. The Office of the Indiana State Chemist (OISC) investigates pesticide drift complaints. What happens once a complaint is filed is outlined step-by-step. There is also a list of the kind of information it is helpful to collect as soon as a problem is noticed. To order a free, single copy of the publication, call the Education Store at 765-494-6795. It may also be downloaded as a pdf at https://ag.purdue.edu/extension/ppp/Documents/PPP-110.pdf.

Tips for Submitting Greenhouse Samples to the Purdue Plant and Pest Diagnostic Lab (PPDL)

(Gail E. Ruhl, ruhlg@purdue.edu, (765) 494-7071)

Samples in plug trays, as well as unrooted and rooted cuttings, and plants in pots require extra care when they are packaged for submittal to a diagnostic lab. Before you mail the next sample, please take a few minutes to review these suggestions for packaging and submitting samples. This will help preserve the integrity of the sample during shipment and increasing the likelihood of a more accurate diagnosis.

Plugs – keep them in the tray

If possible, do not remove the plugs from the plug tray. Submitting either an entire tray or cutting off a section of the tray helps keep the soil off the foliage where most symptoms are observed. (Figure 1) Secondary decay often occurs when soil is allowed to come in contact with the foliage, interfering with accurate diagnosis. When possible, submit at least 5-10 cells with plugs. This provides the diagnostician with ample material for microscopic observation, culturing, and virus testing if necessary.

Figure 1. Plug flat wrapped and ready for shipment to the diagnostic lab.

Cuttings – separate foliage from media with a plastic bag

The primary concern is to keep the growing media separate from the foliage to prevent contamination and rotting. Put the cuttings into a plastic bag, and seal the bag with a twist tie (Figure 2) at the soil line. Do **not** seal the foliage in a plastic bag. Next, wrap the sample in newspaper to prevent additional drying out of foliage before it is received. Newspaper is one of the best packing materials for plant samples.

Figure 2. Media and roots on left are properly secured for shipment.

Potted Material – pack around the plant

Take into consideration that the mail carrier will not necessarily keep these packages right side up even when those directions are written on the outside of the box. Place plastic wrap, clear packing tape or paper (Figure 3) over the pot surface, or put the pot in a bag and seal it with a twist tie around the base of the plant. Fill any extra space in the shipping box with newspaper, styrofoam peanuts, or another space filling packing material (Figure 4) to prevent jostling of sample during shipment.

Figure 3. Tape keeps soil in the pot during shipment.

Figure 4. Use Styrofoam, packing peanuts, or crumpled newspaper inside a crush proof box to protect the sample during shipment.

If you are delivering the sample to our building…

We welcome delivery of samples in person! There are two short-term metered parking spaces on the west end of our LSPS building. (Figure 5) Samples may be dropped off from 8am-5pm in room LSPS 116 in the two-story brick building (Life Sciences Plant and Soils) located in-between Lily Hall of Life Sciences and the Life Science Greenhouses. A completed submission form must accompany all samples. Sample submission forms can be downloaded from our website (www.ppdl.purdue.edu) and filled out ahead of time or are available at the drop off point.


Figure 5. Short-term metered parking spaces on the west end of the LSPS building at Purdue are reserved for PPDF customers.

Shipping – watch the weekend

Do not mail or ship samples on Friday, as we are not here to receive them over the weekend. Samples can be sent via US mail, UPS, FedEx, etc. We encourage you to send samples with priority or express delivery so we receive them in the best condition possible to provide you with the most accurate diagnosis.

Link between Plant Density, Yield and Revenue from a High Tunnel

(Petrus Langenhoven, plangenh@purdue.edu, (765) 496-7955)

Planting density plays an important role in the optimization of labor efficiency and productivity of your high tunnel. For the purpose of this article I will focus on tomato which is commonly grown as a high value crop on small farming operations.

Usually growers select varieties according to customer (market) preference and then try to combine that with other attributes such as ease of production, disease tolerance/resistance and productivity (yield). Consumer preference usually helps to determine the fruit color, size and shape, and the sweetness (soluble solids) of the tomato variety to be grown. The grower again is interested in earliness, growth habit (determinate and indeterminate), and ease of pruning, trellising and picking.

Most growers in Indiana choose determinate varieties for high tunnel production, because it has limited growth and is easy to stake and allows for early production (short production cycle), with most fruit ripening before field grown tomatoes are on the market. Indeterminate varieties continue to grow, flower and fruit throughout the production season. These varieties need to be pruned (either to single or double stem depending on the type and variety), trellised and layered, and most likely require the use of a higher tunnel as well. The yield potential of indeterminate varieties are higher than determinate varieties, but the production season is longer and it requires more labor to complete all the necessary crop husbandry activities.

The ability of a high tunnel to modify the growing environment for crop earliness, to protect the growing crop from environmental stress, to reduce insect and disease pressure and extend the growing and harvesting season, allows the grower to be at least 4 to 6 weeks earlier on the market (compared to field grown tomatoes) and maintain production of high quality fruit over a longer period. It increases marketing opportunities and improves early cash flow for the farming operation.

Variety selection, optimal plant spacing and production methods followed by the grower has an effect on the final outcome of the growing season. Proper spacing helps to achieve the greatest production possible. More plants in the high tunnel does not necessarily mean higher yield. A tunnel crowded with too many plants will restrict airflow which in turn may lead to the development of foliar and fruit diseases. Crowded plants compete for light, water and nutrients, and makes it difficult to maneuver

through the crop to perform activities such as pruning, trellising, spraying and harvesting. Spacing includes the distance between rows and between plants in the row. Grafted plants are generally more vigorous and therefore need more spacing than none-grafted determinate or indeterminate varieties.

High tunnels can vary in size, with variability in width, length and height. High tunnels can also be equipped with different ventilation capabilities. Lower high tunnels will be warmer sooner during the day and very hot during the hottest part of summer. The height restriction in lower high tunnels will also prevent the optimal use of indeterminate varieties. Especially for summer production, it is beneficial to have more space between the crop and the glazing material as this will prevent scorching of leaves and fruit. Therefore the specifications of your high tunnel make or model will also play a crucial role in determining the variety to be grown, the planting density to be used and the ultimate productivity and return on investment. Production practices on your farm will also impact the optimum number of plants that can be grown and will determine how productive they can be. Let's do some examples to illustrate the effect of planting density and the type of tomato crop planted on productivity and gross revenue.

Example 1: A **determinate tomato** crop is planted in soil in a 30' × 96' high tunnel (2,880 sq. ft.), allowing for a 3' walkway at each end of the tunnel. The effective growing area of the tunnel therefore is only 2,700 sq. ft. Seedlings are planted in 6 rows, 5' between rows and 18.3" in-row plant spacing. The total number of plants per row is 63 and per tunnel 378. Therefore the final **planting density is 7.14 sq. ft. per plant**. For illustrative purposes production is estimated at 14 lb per plant and is sold for $2.50 per lb, which translates into a gross revenue of $13,230.

If the planting density is adjusted to **6.25 sq. ft. per plant**, with the same number of rows and in-row spacing decreasing to 16.0" (432 plants per tunnel), the gross revenue per tunnel will rise to $15,120. A slight increase in plant density from 7.14 to 6.25 sq. ft. per plant resulted in a gross revenue increase of about 14.3%. Data can vary widely between grower operations. In certain case studies done elsewhere in the U.S. determinate tomatoes yielded up to 20 lb per plant which will have a further increase in revenue.

Figure 1. A determinate tomato variety planted in the soil.

Example 2: In the same tunnel footprint as above, **indeterminate tomatoes** can be planted in the soil at a planting density of up to **5.56 sq. ft. per plant**. The in-row spacing therefore further decreased to 14.2". The total number of plants per row is 81 and per tunnel 486. Production can reach between 20 and 25 lb per plant if grown for 8 months. At a 20 lb yield per plant and a market price of $ 2.50 per lb the potential gross revenue per tunnel can be $24,300.

Figure 2. Tomatoes planted in a double row at 4.3 plants per sq. ft. The soilless substrate is pine sawdust.

In **soilless culture**, using a growth substrate and hydroponics techniques and more advanced equipment to produce the tomatoes, the potential is there to produce even more tomatoes from one tunnel. In this instance you might be required to use a climate controlled greenhouse. Using the same footprint as above and increasing the plant density to **4.35 sq. ft. per plant** allows us to plant 104 plants per row and 624 plants per tunnel. Production estimated at between 30 to 40 lb per plant can be achieved over 8 months of production. At a 30 lb yield per plant and a market price of $2.50 per lb the potential gross revenue per tunnel can be $46,800. This is a potential gross revenue increase of 92.6% compared to soil grown indeterminate tomatoes.

Figure 3. Round tomatoes planted in a single row at 4.3 plants per sq. ft. in coconut coir. Note the closer plant spacing in the row and wider walkways compared to the crop planted in sawdust (Figure 2).

Figure 4. Plum cherry tomatoes planted in a single row at 4.3 plants per sq. ft. in coconut coir.

From the scenarios created it is evident that by increasing the planting density you can potentially increase revenue. Indeterminate varieties, planted at a higher planting density than determinate varieties, can potentially earn the grower a higher income. However, soilless culture can potentially earn the grower even a higher income, when compared with soil production. Although, not discussed in this article is the associated higher cost of production between determinate and indeterminate varieties and between soil and soilless production techniques. The value of the increased yield does not always offset the cost of the increased labor required to take care of the additional plants. It is important to have well-kept production records to assist with decision making, to determine which crop and production technique works best for you. And remember, the customer (market) always determine what you do on your farm.

*The planting densities used in this article are not recommendations for Indiana. Further research is required.

Upcoming Events

(Wenjing Guan, guan40@purdue.edu, (812) 886-0198)

Beginning Farmer Tours

June 25, 2016: Silverthorn Farm, Rossville. Organic fruits and vegetables, pastured pork and working with restaurants.

July 14, 2016: Melon Acres, Oaktown. Community-supported agriculture and agritourism.

Sept. 29, 2016: River Ridge Farm, Roann. Four-season vegetable farming, operating an on-farm store, and farm-to-school programs.

The tours are free, but registration is required. Registration at https://mdc.itap.purdue.edu/wk_group.asp?wk_group=BeginFarmer

For more information about the Beginning Farmer and Rancher program, or the farm tour schedule, contact Kevin Gibson at (765) 496-2161 or kgibson@purdue.edu.

Hops Field Day

Location: Crazy Horse Hop Farm. 8781 S. County Road 925 West Knightstown, IN 46158

Date: June 4 2016, 1:00 pm to 3:00 pm EST

Learn about irrigation management, hilling in hops yards, petiole test for nutrients, pruning lower foliage for mildew management and insect identification (bring specimens). Please register at http://bit.ly/1rkkciw or at The Purdue Extension – Monroe County Office at (812) 349-2575 or afthompson@purdue.edu. Registration deadline is June 1.

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