Vegetable Crops Hotline

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

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IN THIS ISSUE

Vegetable Diseases in Greenhouses - (*Dan Egel and Shubin Saha*) - Over the last several years, an increasing number of growers have built greenhouses to facilitate the early production of vegetables. (By definition, a greenhouse is heated, whereas a high tunnel is not. This article will use the term greenhouse. However, the disease management issues are similar for both types of structures.) By far, the most common crop in greenhouses is tomatoes.

The diseases common in field-produced tomatoes differ from diseases of greenhouse grown tomatoes. Tomatoes grown in a greenhouse are often exposed to higher relative humidity than field grown tomatoes. High humidity in greenhouses is due to the covering over greenhouses that tends to keep moisture inside the greenhouse. Also, greenhouse tomatoes are often grown closer together than field grown tomatoes, decreasing airflow and increasing humidity. Finally, tomatoes grown in greenhouses to maturity are often not rotated with another crop, increasing disease pressure. (Tomatoes grown in the greenhouse are most often grown in the soil; tomatoes that are grown in containers in the greenhouse do not have the same crop rotation requirements.) This article will discuss common tomato diseases of the greenhouse and management recommendations.

Botrytis gray mold is favored by cool conditions. Lesions on leaves often start as small water soaked areas. Under drier conditions, the lesions turn a light brown. Lesions often are wedge shaped with the wide edge on the leaf margin (see Figure 1). The growth of the causal fungus is easily visible with a 10X hand lens. Similar lesions may be observed on stems and fruit. Gray mold affects many other crops such as several flowers/ornamentals, lettuce, pepper and snap beans. Since gray mold is often associated with injury to tissue, practices that cause wounding of plants should be avoided. Temperatures above 75 F decrease disease severity. Although high humidity for extended periods is not necessary for gray mold, any practice that lowers relative humidity tends to lower disease severity of gray mold and many other diseases (see suggestions at the end of the article). Adding lime to soils to increase the calcium content of tomato plants helps to reduce the susceptibility of tomato plants to gray mold.

Leaf mold causes bright yellow lesions on the top of tomato leaves (see Figure 2). On the underside of leaves, the fungus that causes leaf mold can clearly be seen as olive-green 'fuzz'. The spores blow around the greenhouse easily; spore germination is favored by high humidity. The optimum temperatures for disease are between 72 and 75 F. It is possible to find tomato varieties that are listed as partially resistant to leaf mold. However, the fungus that causes leaf mold is extremely variable and host resistance is often overcome. Management options should include measures to reduce humidity/increase airflow and sanitation.

White mold (also known as timber rot) causes woody looking lesions on the stems that can girdle and kill the tomato plant. The white growth of the causal fungus can often be found on the diseased tissue as well as the dark, irregularly shaped fungal structures (sclerotia) (see Figure 3). Sclerotia may be found on the outside or inside the stem and are overwintering structures for the fungus. In the spring, sclerotia germinate to form very small mushrooms. Spores from these mushrooms can infect a wide host range of plants. White mold is favored by cool temperatures (from 59 to 70 F). High humidity and moist conditions contribute to the disease. Crop rotations of tomato after tomato seem to favor the disease, however, the causal fungus has a large host range so crop rotation may not be sufficient to control the disease.

General Management Methods for Greenhouse Diseases

Crop Rotation. A good crop rotation of 3 to 4 years out of tomato or a related solanaceous crop will help to control most tomato diseases. However, many vegetable growers who operate out of greenhouses find that it is not practical to rotate away from tomatoes. In such cases, I recommend that the grower take as much of the tomato plant as possible out of the greenhouse and away from all potential production areas as soon as the crop is finished in the late summer or fall. I also recommend a landscape cloth be used between the plastic mulch on each row. The landscape cloth will help to prevent crop residue that might contain plant disease microbes from entering the soil. Landscape cloth is also easily cleaned up, facilitating sanitation. The landscape cloth would be changed or cleaned between seasons. Further, the landscape fabric almost entirely eliminates weed problems in the greenhouse in addition to reflecting light into the canopy to maximize solar radiation.

Greenhouse Ventilation. In general, any practice that reduces relative humidity and moisture in a greenhouse will reduce disease severity of many tomato diseases. These practices may help to ventilate and thus reduce disease severity.

- Ventilate the greenhouse at dusk so that the drier air from outside may replace humid air inside the greenhouse.
- In high tunnels where heating is passive, it becomes important to close the vents before dusk to allow some heat to buildup before temperatures start to drop. This allows the trapping of heat to avoid cold damage overnight. Note, this is how to approach ventilation when cool temperature damage is a concern. However, once cool temperatures are no longer a concern, one can manage the ventilation the same way as you would for a greenhouse.
- Avoid the temptation to crowd as many tomato plants as possible into the greenhouse. Spacing of plants can vary depending on your situation, but a good starting point would be rows spaced 4 to 5 feet apart and 24 inches between plants within the row.
- Prune tomato plants to facilitate airflow. Lower leaves may be pruned periodically without reducing yields. This is especially true with indeterminate tomato varieties.
- Avoid pruning too much material at any one time. As a general rule indeterminate tomatoes should be left with at least twenty fully mature leaves after any pruning.
- To further facilitate reduction of humidity and leaf wetness, in greenhouses it is important to utilize appropriate air circulation fans. The placement and number of fans depends on the volume of air within the structure.

Fungicides. The use of fungicides can help to reduce the severity of tomato diseases in the greenhouse. However, fungicides will not substitute for good management practices. The *Midwest Vegetable Production Guide for Commercial Growers* (ID-56, **http://mwveguide.org**) can help with fungicide recommendations. See page 119 for the start of the tomato disease section and see page 41 to see which fungicides can be used in the greenhouse. As always, read and follow the label carefully.

While greenhouse conditions may favor certain vegetable diseases, such as the ones discussed above, greenhouse conditions may also slow the spread of several diseases since there is no rain on greenhouse tomatoes to splash spores and bacteria from plant to plant. For example, the fungal disease early blight and the disease bacterial spot may occur under greenhouse conditions, but are likely to be limited due to the lack of rain that is necessary for disease spread.

The list of diseases given here is not exhaustive. Many more diseases may occur in Indiana greenhouses. This article includes the top three diseases of greenhouses that I have observed over the last several years. If you have disease questions, please contact Dan Egel. If you have questions regarding culture or environmental management conditions for greenhouses or high tunnels, please contact Shubin Saha.

Figure 1: The symptoms of Botrytis gray mold include a wedge shaped lesion on tomato leaves. The gray sporulation of the fungus can be observed with a 10x hand lens. *(Photo by Dan Egel)*

Figure 2: Leaf mold of tomato causes bright yellow lesions on the top of leaves (shown here). The underside of such lesions often has an olive colored fungal growth visible (not shown). *(Photo by Dan Egel)*

Figure 3: The wood-like area of the stem shown here is typical of white mold (timber rot) of tomato. The dark, irregular shaped fungal bodies shown here are diagnostic for the disease and function as overwintering structures. *(Photo by Dan Egel)*

Summary of Research on 2,4-D and Dicamba Drift on Vegetable Crops - (*David Hynes, Extension Educator, Clark County, dhynes@purdue.edu*) - Glyphosate is a broad-spectrum herbicide introduced to market under the Roundup® label by Monsanto in 1974. Monsanto introduced the first glyphosate-tolerant crop with Roundup Ready® soybeans in 1996, followed by Roundup Ready® corn in 1998. By 2011, 72% of total corn acres and 94% of soybean acres in the United States were planted in glyphosate-tolerant crops. This technology has reduced farmer cost and effort, and has helped usher in wider adoption of conservation tillage and no-till systems, which reduce soil erosion compared to standard tillage.

The downside to this technology is that many farmers became over-reliant on glyphosate as a standalone herbicide, which has led to evolution of glyphosate-resistant weeds. There are now 14 weed species reported as glyphosate-resistant in the United States and 22 worldwide. The occurrence of resistant weeds in major agronomic crops has put the glyphosate weed management system at risk.

Dow AgroSciences and Monsanto propose to combat the resistance problem by introducing agronomic crops tolerant to 2,4-D and dicamba. Dow expects release of 2,4-D-tolerant corn late in 2013 for the 2014 season with soybean and cotton to follow in 2014-2016. Monsanto's dicamba-tolerant soybean and cotton are expected in the 2014-2016 timeframe.

The worry for vegetable growers is that these herbicides could be applied well after vegetables have been transplanted, leading to concerns about herbicide drift onto sensitive horticultural crops. For this article, drift is defined as the off-target movement of herbicide droplets immediately after being sprayed.

Based on the potential for off-target movement of 2,4-D and dicamba and the potential danger to vegetable crops, I performed field experiments in 2010 and 2011 for my MS degree on how low-level concentrations of 2,4-D and dicamba might cause injury and affect the growth and yield potential of muskmelons, watermelons, tomatoes, and bell peppers. Herbicide amounts of $1/50^{th}$, $1/100^{th}$, $1/150^{th}$, $1/200^{th}$ or $1/400^{th}$ the recommended labeled rates were sprayed over these vegetables, and foliar injury and yield were recorded and compared to untreated plants. The fractional rates were based on the labeled rates for 2,4-D (Weedar 64® herbicide, 1.5 pints/acre) and dicamba (Clarity®, 1 pint/acre). The results were as follows:

Muskmelon Treated with 2,4-D. All fractional rates resulted in foliar injury to muskmelon plants that was observed 3 days after herbicide treatment and continued through the middle of the season. In 2010, all 2,4-D-treated plants had lower yields than untreated plants, and $1/50^{th}$ and $1/100^{th}$ rates caused complete loss of fruit. In 2011, only the $1/50^{th}$ and $1/100^{th}$ treatment rates resulted in lower yield than untreated plants.

Muskmelon Treated with Dicamba. All fractional rates caused foliar injury to muskmelon plants starting 3 days after treatment and continuing through the middle of the season. In both years, only the $1/50^{th}$ rate of dicamba resulted in lower yields than untreated plants.

The results show for muskmelon low doses of 2,4-D and dicamba will cause foliar injury, and in cases where the herbicide concentration is high enough, yield reduction. There was some delay in fruit maturity at some doses.

Watermelon. For both herbicides, all fractional rates caused foliar injury to watermelon plants starting as early as 3 days after treatment and continuing through the middle of the season. Due to large variations in the data, total yield differences could not be obtained from the numbers; however, there were delays in maturity.

Watermelon is susceptible to injury from low doses of 2,4-D and dicamba, which caused foliar damage in this study. Watermelon appeared to be more tolerant of injury from exposure to low doses of 2,4-D and dicamba than muskmelon.

Pepper. Injury symptoms were consistently observed on plants treated with 2,4-D by 14 days after herbicide exposure. On plants treated with dicamba injury was observed by 7 days after treatment. All fractional rates of both herbicides caused plant injury that was visible on the plants through the middle of the season. In 2011, plants treated with either herbicide had delayed fruit development, probably due to flower bud loss immediately after treatment. After the first harvest, treated and untreated plants produced fruit equally, so that no differences in total harvest were noted. While there were no differences in total harvest, growers should remember that delayed fruit set on plants was observed in both years. Bell peppers are clearly susceptible to injury and delayed fruit development from exposure to 2,4-D and dicamba.

Tomato Treated with 2,4-D. In both years, all treated plants exhibited greater injury than untreated plants within 3 to 7 days of herbicide exposure, and injury remained visible through the middle of the season. Some harvest delay was noted but total yields were similar for treated and untreated plants in both years.

Tomato Treated with Dicamba. In both years, all fractional rates resulted in plant injury within 3 days of herbicide exposure, and injury was present through the middle of the season. No harvest delays or total harvest differences were noted on plants treated with dicamba when compared to the controls.

The interpretation of the low-dose herbicide exposure response of tomatoes is not as clear as with peppers. Simulated drift of either 2,4-D or dicamba caused foliar injury on both species that remained visible through a large part of the growing season. Some economic losses due to fruit maturity delay could be possible even though harvests were statistically similar.

Overall, results suggest that vegetable growers, row crop growers, contract chemical applicators, and chemical companies need to be aware of the potential for drift of 2,4-D and dicamba onto vegetable crops. Even small amounts of herbicides (1/400th the labeled rate) can cause foliar injury and in some cases harvest delays, reduced total yield, and lower economic returns.

For more detailed information concerning the 2,4-D and dicamba technology see *2,4-D- and Dicamba-tolerant Crops – Some Facts to Consider* (ID-453-W), **http://www.extension.purdue.edu/extmedia/ID/ID-453-W.pdf**.

List Your Field at Driftwatch.org - (*Liz Maynard*) - Vegetable farmers can register their production areas on **http://www.driftwatch.org** to let commercial pesticide applicators know where the fields are. This helps applicators reduce drift or accidental application to vegetable crops. Registration is free and easy. Why not do it today?

Fact Sheets on °Brix Measurements in Vegetables from OSU - (*Liz Maynard*) - °Brix is a measure of soluble solids useful for assessing quality of many vegetables. Matt Kleinhenz and Natalie Bumgarner of the Ohio State University have recently published four bulletins about using °Brix as an indicator of vegetable quality.

From the first fact sheet, *Using °Brix as an Indicator of Vegetable Quality, An Overview of the Practice*, (HYG-1650-12), we learn that the scale was developed in the 1800's by Adolf Brix, and that bending of light by solids dissolved in water is a key principle behind the measurement of °Brix with refractometers. The bulletin also covers common applications, benefits, and limitations of these measurements. A list of references is provided at the end of this and each of the other fact sheets.

The second fact sheet, *Using °Brix as an Indicator of Vegetable Quality, Linking Measured Values to Crop Management*, (HYG-1651-12), includes tables of reported °Brix values for a variety of vegetables crops from agricultural research reports as well as recent on-farm research in Ohio. We also learn that numerous factors that can influence °Brix readings. Some, like variety selection, crop maturity, metabolism, and crop water status usually have "direct and often significant and immediate" effects on °Brix. The bulletin discusses options for crop management to improve °Brix readings.

The third and fourth fact sheets explain how to take °Brix measurements. *Using °Brix as an Indicator of Vegetable Quality, A Summary of the Measurement Method*, (HYG-1652-12) describes refractometers and their operation, materials required, and methods for preparing samples. *Instructions for Measuring °Brix in Cucumber, Leafy Greens, Sweet Corn, Tomato, and Watermelon*, (HYG-1653-12) includes illustrated instructions for how to select, prepare, press and collect, and then filter and read, samples of the listed crops.

This series is a welcome addition to Extension publications for farmers and produce buyers. The fact sheets are available online at **http://hcs.osu.edu/vpslab/extension-and-outreach-articles-publications-and-slidesets**

Bookmark This: http://mwveguide.org - The *Midwest Vegetable Production Guide for Commercial Growers* (ID-56) has a new easy-to-remember URL: mwveguide.org. This is in addition to the old URL; any existing bookmarks to **http://www.btny.purdue.edu/Pubs/ID/ID-56/** will still work.

FDA Webinar April 11 - FDA will present information and answer questions about the environmental assessment of the 2012 Salmonella outbreak on cantaloupe during a webinar on Thursday, April 11, 2013, at 1:00 p.m. Eastern Daylight Time. The webinar is meant for producers, Extension and food safety professionals, and public health agency staff. If there are specific questions or topics you would like FDA to address, please communicate them to Liz Maynard (**emaynard@purdue.edu** or (219) 531-4200 ext. 4206). Details about the webinar including how to participate will be provided when they are available and will be posted at **https://ag.purdue.edu/hla/fruitveg/Pages/default.aspx**. For more information contact L. Maynard.