

## Weed Control in Greenhouses Michele Warmund

Unwanted plants or weeds can become problematic beneath benches and around walkways of greenhouses. These plants can harbor aphids, whiteflies, thrips, and mites that will damage desirable plants. Weeds can also be a source of viruses, such as tomato spotted wilt virus or impatiens necrotic spot virus, which are transmitted to crop plants by thrips. Weeds and seeds are easily transported into greenhouses by animals, people, and tools, or in infested growing media. Weed seed can also be dispersed inside greenhouses by water dripping from hoses or plant containers.

Several simple measures can be used to prevent weed dispersion in greenhouses. Maintaining a weed-free zone around the outside perimeter of the greenhouse will minimize seed brought inside by foot traffic. Also, fine-meshed screens on greenhouse vents or other structural openings will reduce entry of wind-blown weed seed and insects. Also, the use of sterile media will help limit weed infestations. When bringing container-grown plant material inside, especially for overwintering, make sure pots are weed-free before placing them in the greenhouse. Also, clean tools after each use to minimize weed seed dispersion or disease transmission.

Always try to control weeds at a young stage before they flower and produce seed. Just one common chickweed plant can produce and release as many as 800 seeds (Figure 1). The three common types of pigweed usually produce 10,000

to 30,000 seeds per plant. Thus, just one or two uncontrolled seed-bearing weeds can result in rapid multiplication of these unwanted plants in a greenhouse.

Weed block fabric can be used to cover areas beneath benches and walkways and prevent weed emergence. If the fabric is covered by gravel, spilled potting media, or plant debris, this provides an environment conducive for weed seed to collect and germinate. Thus, periodic sweeping of the fabric to remove spilled media and plant debris will aid in weed control.



**Figure 1** A common chickweed (*Stellaria media*) plant with flowers and a capsule containing many seeds. Photo credit: Kevin Bradley

When weeds become problematic in a greenhouse, they can be removed manually or eliminated using a post-emergent herbicide. Few herbicides are labeled for use in enclosed structures, such as greenhouses due to the potential for crop injury to desirable plants or harm to human health. Some formulations of herbicides, labeled for outdoor use only can volatilize (change from a liquid to a gas) and then drift away from the target area, causing harm

to other crops. However, herbicides labeled for greenhouses are usually low-drift products and are applied when air-circulating fans are turned off.

A good time to apply a herbicide is when a crop production cycle is completed and the greenhouse is empty. Roundup® Pro (glyphosate) may be used for weed control at this time. When the greenhouse is weed-free, the preventative pre-emergent herbicide Marengo® (indaziflam) can be applied to gravel or the ground beneath benches before ornamental (non-edible) crops are placed in a greenhouse. Marengo® is the only pre-emergent labeled for greenhouse use.

Most post-emergent herbicides labeled for greenhouse use are non-selective (i.e., will kill any plant contacted with spray), except for Fusilade® II (fluazifop-butyl) and Envoy® Plus (clethodim) which control grasses only. Also, some herbicides, such as Finale® (glufosinate) and Reward® (diquat) may only be applied in greenhouses where ornamental (non-edible) crops are grown. In contrast, Axxe® (ammonium nonanoate), Scythe® (pelargonic acid), Reward® (diquat), and WeedPharm® (acetic acid) can be applied in greenhouses where edible crops are grown. Also, Sporatec® fungicide, which contains rosemary, clove, and thyme oil as active ingredients, can be used to control mosses, liverworts, and hornworts in greenhouses where edible crops are grown.

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# Another Look at Tomato Powdery Mildew David Trinklein

Powdery mildew continues to be a troublesome disease on greenhouse tomatoes here in Missouri. Unfortunately, more greenhouse and high tunnel tomato growers find themselves trying to manage a disease that ten years ago was nearly unheard of in our state. By means of this article, I would like to review the nature of powdery mildew and offer approaches to its management.

Powdery mildew is a tomato leaf disease that seldom kills the plant, but has the potential of drastically reducing yields. In Missouri, it appears to be exclusive on tomatoes grown “under cover” (i.e. greenhouses and high tunnels). Three different species of fungi can cause tomato powdery mildew: *Leveillula taurica*, *Oidium neolycopersicum* and *Oidium lycopersicum*. All produce airborne spores which land on leaves, germinate and infect the plant, given favorable environmental conditions exist.

Most cases of powdery mildew on tomatoes in the sub-tropical areas with arid to semi-arid conditions involve the fungus *Leveillula taurica*. Initial symptoms appear as bright spots or “blotches” up to one-half inch in diameter on the upper surface of leaves. As the spots enlarge, they eventually turn brown. Powdery, white colonies of mycelium later appear on the lower surface of the leaves as the disease progresses.

Most outbreaks of tomato powdery mildew in Missouri have been traced to the fungus *Oidium lycopersicum*. Disease symptoms appear as powdery, white colonies of mycelium on the upper surface of leaves. Yellowing, necrosis and defoliation can result as the disease progresses.

The fungus responsible for powdery mildew infection produces airborne spores which land on leaves, germinate and infect the plant, given favorable environmental conditions exist. Moderately warm temperatures (between 50 to 95F) and high relative humidity are important environmental factors that promote powdery mildew severity. The increase in greenhouse and high tunnel tomato production in Missouri has led to the creation of more tomatoes being produced under ideal conditions for the disease to become problematic.

Tomato powdery mildew management should follow the principles of integrated pest management (IPM). Start with healthy, disease-free transplants. If the latter are purchased, inspect them thoroughly for early signs/symptoms of the disease. Producers who grow their own transplants should be especially vigilant for the disease in the transplant-rearing greenhouse.

The inoculum for the powdery mildew cannot overwinter outdoors under Missouri conditions. Therefore, tomato growers utilizing greenhouses or high tunnels should develop a “start clean, stay clean” attitude. Make sure that all plant debris from the previous crop is eliminated between crops. Soil preparation via deep plowing can help rid the production area of remaining inoculum on plant debris that might have been missed.

Since moderate temperatures along with high relative humidity favors disease outbreak, the combination of very high temperatures and low humidity can limit powdery mildew severity. Unfortunately, maintaining the latter combination of conditions in greenhouses or high tunnels can be very challenging. Therefore, chemical application might be required.

A study conducted several years ago reported sulfur (WP) and potassium silicate to be the most effective chemicals for control of *Oidium* in growth chamber conditions.

Sulfur has been used for many years to control powdery mildew on a number of species, including tomato. Sulfur can easily cause phytotoxicity, especially under hot and humid conditions typical of a greenhouse. Therefore, care must be taken when it is used. Like most fungicides, it is a preventative and must be applied before the disease appears.

Several growers have reported good powdery mildew suppression by vaporizing elemental sulfur in commercially-available “sulfur evaporators”. These devices heat the sulfur to a controlled temperature causing it to change into an isotope of elemental sulfur which is distributed via air currents throughout the greenhouse. In the process, the leaves of tomato plants are coated with elemental sulfur which acts as a deterrent to powdery mildew spore germination. Evaporators are rated in size according to the square footage of greenhouse space they can service. Good horizontal air movement is needed for them to be effective. Carefully follow the instructions that accompany sulfur evaporators to avoid plant damage.

Potassium silicate (available commercially as Sil-MATRIX®) is labeled as a powdery mildew control agent. The exact mode-of-action of this compound has yet to be determined. However, recent research pointed to the fact that silicon acts to prevent fungal penetration through the formation of a “physical barrier” of some type. Like sulfur, potassium silicate is preventative in action and not curative.

Regalia® is a biofungicide with a novel mode-of-action. An extract of the giant knotweed, Regalia’s active ingredient is reported to enhance a plant’s ability to protect itself against disease attack. It is labeled for a number of tomato foliar diseases including powdery mildew. Taegro® is another biofungicide labeled for powdery mildew control on tomato.

Paraffinic oil (e.g. Ultra-Fine® Oil) has been shown to eradicate mild infestations of powdery mildew, even though its primary use is as an insecticide. As with sulfur, care must be taken when applying oils because of their phytotoxic tendencies.

A number of fungicides have been recommended for tomato powdery mildew by the Midwest Vegetable Production Guide (<https://ag.purdue.edu/btny/midwest-vegetable-guide/Pages/default.aspx>). These include:

- (a) Aprovia Top®; 0-day PHI;
- (b) Cabrio®; 0-day PHI;
- (c) Inspire Super®; 0-day PHI;
- (d) Priaxor®; 0-day PHI;
- (e) Quadris 2.08EC®; 0-day PHI;
- (f) Quadris Opti® at 1.6 pts. per acre. 0-day PHI;
- (g) Quadris Top®; 0-day PHI;
- (h) Quintec®; 3-day PHI;
- (i) Rally 40WSP®; 0-day PHI;
- (j) Switch®; 0-day PHI;
- (k) Vivando®; 0-day PHI.

Unfortunately, many of the fungicides recommended for powdery mildew control caused by *Leveillula taurica* have not proven themselves to be equally effective against *Oidium lycopersicum*.

Finally, genetic resistance is the easiest and least expensive way to control any disease. There are a few new tomato varieties that are advertised to have “intermediate resistance” to powdery mildew by the companies that market them. Examples of varieties include ‘Climstar’, ‘Ducovery’, ‘Federik’, ‘Foronti’, ‘Geronimo’, ‘Granadero’, ‘Rebelski’ and ‘Touché’.

## 'On-Farm' Food Safety Reviews in 2018

James Quinn



An Old Order German Baptist school house outside of Trenton (MO) was used for teaching a FSMA workshop on May 24<sup>th</sup>. About 20 attended; thanks to Tim Baker and Mahlon Bowerman for organizing it.

Missouri Department of Agriculture (MDA) will be leading food safety reviews of farms that have volunteered. An Extension representative will assist MDA. These will start in early July and continue into the fall, as long as vegetables are being harvested. The goal is to conduct about 20 of these at a variety of locations across the state. A farm or two near the larger produce auctions are likely to be included. They will continue in 2019, will start earlier in the season and more should occur.

Officially, these visits are called 'On Farm Readiness Reviews' (OFRR) and anyone conducting them went through a national training. In Missouri those individuals are Bart Hawcroft, Ken Struempf (with MDA), Lindsey Pender (LU Extension), Pat Byers and James Quinn (MU Extension). We hope to get more trained soon. The farm review takes about 4 hours and a light harvest day is preferred. The benefit to the farmer who volunteers for this is they receive a practice inspection to help them prepare for any future one. MDA is not conducting any FSMA inspections in 2018, but will start in 2019. An OFRR is considered confidential, in that any notes taken during the process are given to the farmer; none leave the farm with MDA. Neither MDA nor Extension will invite others on an OFRR. The farmer who has volunteered may invite others [e.g. neighboring farmer(s), family members, etc.] to follow along and learn what a FSMA inspection will cover. If you would like to have an OFRR in 2018 or 2019, call MDA at 573-751-8558.

## High Tunnel Strawberries Through the Summer?

James Quinn

Producing strawberries in high tunnels has been researched, by fall planting and following the annual plasticulture system. Yield increases over field plantings was modest (typically 25%) and being 2-3 weeks earlier. A significant detractor to this system is the length of time the crop is in the ground, 8 or 9 months.

A research program at Kansas State University tried a different approach, just outside of KC (Olathe Horticulture Research and Extension Center). Day neutral cultivars were planted early in the spring and fruited through the summer. The research yielded some potential, which this article will summarize. Cary Rivard\* is a professor at KSU and the lead researcher was Kelly Gude\*\*.

A prior study had indicated that day neutral strawberries could be profitable if yields of 0.75 to 1.25 pounds per plant were achieved at a market price of \$2-4 per pound. This study occurred with high tunnel trials during 2014 and 2015 using six cultivars: Albion, Evie 2, Monterey, Portola, San Andreas, and Seascape (Nourse Farms, South Deerfield, MA). They were planted with bare root plants in early to mid-April (earlier would be OK, but obtaining the plants can be an issue). Beds were spaced 5 foot apart and there were two rows per bed, one foot between rows and the plants spaced one foot apart (staggered). A typical 30 x 100 ft high tunnel would have 1200 plants. A yield goal of 1 lb per plant at \$3 per pound would return \$3600. Not the return possible with tomatoes, but a potential alternative to give a high tunnel and its soil a break from tomatoes.

Pre-plant fertilizer was 30lb/N acre and plants were fertigated 9 or 10 times. Shade cloth (30%) was applied in mid-May. Evaporative cooling was used with sprinklers on some plots for about the hottest two months, whenever temperatures reached 85 F, in which the plants were sprinkled for 5 minutes. The mature fruit (90% to 100% red) was harvested twice weekly for total and marketable (fruit with no defects) fruit yield. The plants flushed with production into early, mid and late season periods, typically being May/June, July to mid-August, and mid-August to early October, respectively. Total yield was 1 pound per plant in 2014 and ¾ pound per plant in 2015. (A later planting in 2015 was cited as a likely factor, and March planting should be considered if planting material is available. Additionally, the 2014 plants were first put in plug trays with potting mix, as the ground was still froze. By the time they were planted they had rooted in and leafed out; this 'jump start' may have benefitted the yield.)

Marketable fruit was 80 to 89%. The mid-season yields were greatest and early or late season yields varied with cultivar, but were similar when averaged. Largest berry size was in early season. Evaporative cooling had no measurable benefit. The top three cultivars both years were Portola, Evie 2, and Seascape. Typical berry size was 10 grams (45 berries per pound). Sweetness was assessed (Brix), but was not presented in the research report (HortTechnology, April 2018). Contact James Quinn if you would like the complete report.

\* Associate Professor, Extension Specialist & Director of K-State Research & Extension Center. Olathe.

\*\* Article reviewed by Kelly Gude.

## Three MVGA sponsored farm tours this August

**North Central Missouri:** Tuesday, August 28 in Adair and Linn County. We will leave the Adair County Extension center at 10 am for our first stop. Please arrive around 9:45.

The first tour stop will be at the farm of Junior and Connie Fountain northwest of Kirksville. They grow a variety of vegetables including high tunnel tomatoes and melons in the Chariton river bottoms. We will return to the Adair County Extension Center for lunch and to cool off.

The second stop will be at the farm of Steve and Velda Salt in southwest Adair County. They grow a variety of vegetables including ethnic vegetables.

The third stop will be at the farm of Winigan Farm/Rod Belzer. See website <http://www.winiganfarms.com/> Rod grows a variety of produce including grafted tomatoes, garlic, mushrooms and elderberries. To register for the tour, contact the Adair County Extension Center at 660-665-9866.

**Central Missouri:** Wednesday, August 29th. This is the 19th Central Missouri Vegetable and Greenhouse Farm Tour, on its typical date of the Wednesday before Labor Day weekend and traditional start, the Central Missouri Produce Auction (37808 Highway E, Fortuna, MO). Arrive anytime up until 11:30 to check in. The auction starts at 10 and is pretty active by 9 with grower deliveries. There will be some announcements, grab lunch from the food stand when you want, the goal is to leave by noon for two farms.

The 2nd farm is a bit of a drive, but was a big hit in 2016- Happy Hollow Farm in Jamestown, an organic vegetable operation with several high tunnels. More info will be available in August. To register, contact the Morgan County Extension Center 573-378-5358

**NW Missouri:** A tour is being planned for Lafayette County in August. Contact Kathi Mecham for details at 660-542-1792.

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