Integrated Pest Management
University of Missouri

AUGUST 2017

Missouri Produce Growers *Bulletin*

A Joint Publication of the University of Missouri and Lincoln University

Help Us Understand the Missouri Specialty Crop Industry

Enclosed in this *Missouri Producer Growers Bulletin* is an important survey about Missouri's specialty crop industry. **Please mail respond by September 1, 2017** *(later responses might not be received in time to include).*

Please consider completing the anonymous survey. The survey takes five minutes. A postage paid return envelope is included.

Survey results will be used to explain and communicate the importance of the Missouri specialty crop industry. The goal is to improve research focus and increase research funding to benefit Missouri specialty crop growers.

This survey is part of a grant project funded by Missouri Department of Agriculture's Specialty Crop Block Grant Program. MU Extension horticulture specialists (James Quinn, Patrick Byers, Sarah Denkler, Debi Kelly, Pat Miller) and agricultural economists (Joe Horner and Ryan Milhollin) are working on this project.

What is a specialty crop? USDA defines a specialty crop as "fruits and vegetables, tree nuts, dried fruits, horticulture, and nursery crops (including floriculture)." Also includes growers of honey, mushrooms, sod, cut Christmas trees and even maple syrup producers.

Your responses will be collected anonymously. Survey data will be analyzed by the University of Missouri's Assessment Resource Center. Your responses will be combined with other Missouri producers in a summary report that will not contain personal identifying information.

Thank you for your consideration and assistance.

Save the Date

Wednesday August 30, 2017

The 18th Central Missouri Vegetable & Greenhouse Tour - "Rain or Shine"

Consistent with previous years, we will meet at the Central Missouri Produce Auction (CMPA) and then set out.This event is free and open to all.

Tentative schedule (you are welcome to arrive up until noon)

10:00 AM	Gather & visit 'on your own' the auction. Stop by a booth to discuss herbicide issues, such as concerns about dicamba drift or glyphosate resistant weeds.
11 - 11:45	Free Lunch*
11:45 AM - 12:15 PM	Introductions and discussion at the produce auction
12:30 - 4	Visit nearby farms….details available by August 16th.

To register or for more information:
call (573) 378-5358 or e-mail klindworthd@missouri.edu. Just let us know you are coming and how many will be in your party. ***Free lunch is limited to the first 70.**

Sponsored by:
Missouri Vegetable Growers Association

In This Issue

IPM Issues and Vegetable Crops in 2017 *Patricia K. Hosack and James Quinn*

Weeds: Glyphosate resistant weeds, like waterhemp, are increasing for vegetable growers around the Central Missouri Produce Auction. To address these weeds growers will have to try other herbicides. Having the most recent year's edition of the Midwest Vegetable Production Guide for Commercial Growers will be helpful, as changes to herbicide labels can occur. Glyphosate resistant weeds have become particularly troublesome for soybean growers and an outcome has been the development of soybeans resistant to dicamba. This summer was the first year these soybeans could be grown and sprayed with dicamba. The fact that this would likely occur in hot humid weather had many concerned, even with the new formulations of dicamba that were required, as dicamba is prone to moving off site in that kind of weather. The concerns were warranted and an excellent article, by Kevin Bradley (MU Weed Scientist), reviews what transpired thru July 'Ag Industry, Do We Have a Problem Yet?'. The next issue of MPG will delve into 2017 and accidental herbicide contamination of vegetables in Missouri.

Insects: Japanese beetles have been getting a lot of attention throughout the central part of Missouri. In past years, field corn and soybean growers often just sprayed the edges of their fields for control. This year many are spraying entire fields. Some vegetable growers reported enough pest pressure that both green beans and sweet corn required treatment. This is notable, as the vegetable production guide (mentioned above) does not list this insect as a pest for either. One grower reported the beetles attacking the tassel whorls such that he had to spray BEFORE he normally does for corn earworm. And then he had to shorten his spray interval to keep them off the corn silks, spraying every two days instead of at three days. A MU agronomy specialist, with scouting experience for this pest, said the beetles are especially attracted to silks at 4 to 5 inches long.

Diseases: Vegetable diseases have been common this year. The mild winter and heavy spring rains promoted disease in numerous types of crops. A list of diseases, diagnosed on vegetables are listed in Table 1. Disorders and pest issues are not listed.

Table 1: Diseases that were diagnosed more than once are noted with an asterisk (*).

Host	Diagnosis
Cucumber	Alternaria leaf spot (*Alternaria spp.*)
Cucumber	Anthracnose (*Colletotrichum spp.*)
Onion	Bacterial blight (*Xanthomonas spp.*)
Pepper	Alternaria leaf spot (*Alternaria spp.*)
Tomato	Bacterial canker (*Clavibacter michiganensis* pv. *michiganensis*)
Tomato	Bacterial leaf spot
Tomato	Early blight* (*Alternaria solani*)
Tomato	Fusarium wilt (*Fusarium oxysporum* f.sp. *lycopersici*)
Tomato	Powdery mildew*
Tomato	Root-knot nematode (*Meloidogyne spp.*)
Tomato	Stem lesion and leaf spot (*Cercospora spp.*)
Tomato	Tomato spotted wilt virus*(TSWV)
Watermelon	Alternaria leaf blight (*Alternaria cucumerina*)
Watermelon	Root and crown rot (*Phytophthora spp.*)
Watermelon	Root and crown rot*(*Pythium spp.*)

The most notable disease has been *Pythium* root rot of watermelon. *Pythium* diseases on watermelon are typically seedling blights. We usually see these when seeds are planted in cold soils that become saturated, thus promoting damping off. Or we see *Pythium* root rot diseases on young plants that were recently transplanted prior to cool, wet weather. However, due to heavy spring rains and fluctuating soil temperatures *Pythium* root rot has been diagnosed twice. Both incidents have predispositioning factors that most likely led to the issue. One case, the plants are growing in a low area and heavy rains flooded the site twice. Both causing plants to be in standing water. The second case, the plants were not in standing water and in a well-draining area. However, the grower had worked in a lot of composted manure and straw. Therefore the site has high organic matter. Organic matter holds moisture in the soil, a necessary component for good growing conditions. But in certain situations you can have too much of a good thing. In this case, the high organic matter is keeping soils saturated and promoting *Pythium*.

Pythium is commonly referred to as a water mold, same as its "cousin" *Phytophthora*. Now, *Phytophthora* diseases on mature watermelon are quite common in wet years but we haven't seen any at the clinic this year. There are diagnostic differences between the two, besides the serological assay we run at the Plant Diagnostic Clinic for confirmation. Plants with *Pythium* have rotted roots, similar to *Phytophthora*, the visual difference is the discoloration is more of a yellowish to dark brown opposed to the red-brown / black discolor caused by *Phytophthora* (Opposite page). Also the cortex tissues (epidermis), of a *Pythium* infected root, are slimy to the touch and remove easily. When crowns are split, the *Pythium* infected plants have little discoloration, compared to *Phytophthora*, that has so far been limited to the lower crown and are the yellow to yellow-brown color (Picture 2). Recommendations are to manage water, don't over irrigate and create drainage in low areas. Also, remove and destroy infected plants but do not compost as the pathogen can remain active in the tissues. After plant removal, till the soil to break up any plant debris left behind and promote aeration. A rotation could be useful but *Pythium* species are hosted by many plants. Incidence and severity of *Pythium* diseases are determined by the weather and overall plant health. Thus, the growers should avoid planting too early, when soil temperatures are low, and minimize wounding when transplanting. Fungicides can be used preventatively, recommended products include, but not limited to, Agri-fos, Previcur Flex and/or Ridomil. Follow label instructions when applying pesticide products.

Watermelon crowns have slight discoloration due to *Pythium* rot. Rot is in the lower crown as noted by circle.

LEFT Watermelon roots infected with *Pythium* are slightly discolored, lack fine roots and the cortex is easily removed and feels slimy to the touch. **RIGHT** Note area in the circle where cortex was removed by rubbing a finger along it gently.

Tomato Powdery Mildew Revisited *David Trinklein and Zalalem Mersha*

Several years ago in this publication, we brought to light the fact that powdery mildew was becoming a troublesome disease on greenhouse tomatoes here in Missouri. Unfortunately, management of the disease continues to be a challenge for tomato growers this year thanks in part to the warm weather that started unusually early and the limited effectiveness of control measures. This has resulted in a negative impact on Missouri's greenhouse tomato industry. This article reviews the nature of powdery mildew and several new approaches to its management.

Powdery mildew is a tomato leaf disease that seldom kills the plant, but has the prospect of drastically reducing yields. 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 of the recent 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.

Both of the above fungi produce airborne spores which land on leaves, germinate and infect the plant, given favorable environmental conditions exist. Moderately warm temperature (conidia of both fungi can germinate between 50° to 95°F) and high relative humidity are important environmental factors that affect powdery mildew severity. The increase in greenhouse and high tunnel tomato production in Missouri has led to the creation of more ideal conditions for the disease to become virulent.

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 disease cannot overwinter outdoors under Missouri conditions. Therefore, tomato growers utilizing greenhouses or high tunnels should start with a "clean slate" each year making sure that all plant debris from the previous crop is eliminated. 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.

Most of the fungicides recommended for the control of powdery mildew caused by Leveillula taurica have not proven themselves to be equally effective for Oidium lycopersicum and related species control. 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. Under field conditions, a mixture of hydrogen peroxide and crop oil was also found to be effective.

Sulfur has been used for many years to control powdery mildew on a number of species. Like most fungicides, it is a preventative and must be applied before the disease appears. Sulfur products used for the control of powdery mildew on vegetables usually contain a surfactant to make them more effective. Sulfur can easily cause irritation and also phytotoxicity, especially under hot and humid conditions. Therefore, care must be taken when it is used.

Potassium silicate (available commercially as Sil-MATRIX®) is relatively new 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 new biofungicide with a novel mode-of-action. An extract of the giant knotweed, Regalia's active ingredient is reportedly 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, gray mold (Botrytis), bacterial speck and spot, early blight and late blight. Preliminary studies at Lincoln University from a weekly spray of Sil-Matrix and Regalia on cucumber powdery mildew indicated slowing down of the disease when compared with the non-treated control, but not sufficient suppression of the disease.

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 new compound not yet available in the United States holds hope for tomato producers who are battling powdery mildew. A recent research article from Spain reported that liquid bioassimilable sulfur (NATURDAI S-SYSTEM) reportedly was effective in powdery mildew control. It was applied both as a foliar spray and as a soil drench. The authors suggested bioassimilable sulfur acts as a preventative by enhancing tomato's resistance to the mildew pathogen. Additionally, applied as a foliar spray, the compound demonstrated curative properties.

A number of fungicides have been recommended for tomato powdery mildew in the Midwest Vegetable Production Guide. Authors of this article would welcome feedback on the performance of these chemistries under Missouri conditions. The fungicides include:

Aprovia Top® at 10.5-13.5 fl. oz. per acre.
Use of a spreader-sticker is recommended. 0-day PHI.

Cabrio® at 8-16 oz. per acre. 0-day PHI.

Inspire Super® at 16-20 fl. oz. per acre. Do not apply to small-fruited varieties such as cherry tomato. 0-day PHI.

Priaxor® at 6-8 fl. oz. per acre. 0-day PHI.

Quadris 2.08EC® at 5.0-6.2 fl. oz. per acre. 0-day PHI.

Quadris Opti®at 1.6 pts. per acre. 0-day PHI.

Quadris Top® at 8-14 fl. oz. per acre. 0-day PHI.

Quintec® at 4-6 fl. oz. per acre.
Must have supplemental label. 3-day PHI.

Rally 40WSP® at 2.5-4.0 oz. 0-day PHI.

Switch® at 11 oz. per acre.
Not for small-fruited varieties in the greenhouse. 0-day PHI.

Vivando® at 15.4 fl. oz. per acre.
Must have supplemental label. 0-day PHI.

Finally, genetic resistance is the easiest and least expensive way to control any disease. There is a limited number of new tomato varieties that exhibit intermediate resistance to powdery mildew. Examples of varieties with intermediate resistance include 'Geronimo', 'Foronti', 'Ducovery' and 'Touché'.

Fall Greenhouse Cleanup *David Trinklein*

Benjamin Franklin once famously observed: "An ounce of prevention is worth a pound of cure". In actuality, Franklin was talking about fire prevention in the city of Philadelphia. However, he just as easily could have been talking about pest control in greenhouse and high tunnel crops. Prevention always is the easiest cure for pests; in certain cases it's the only cure.

Greenhouse and high tunnel growers who find themselves continually battling certain diseases and insect pests might not be doing an adequate job of greenhouse sanitation. Prevention is one of the basic IPM principles for both disease and insect management, and proper sanitation is the first step in prevention. It is advisable to sanitize a greenhouse as early as possible following the growing season opposed to waiting just before planting the following spring.

Cleaning is the first step in sanitizing and involves physically removing weeds and all living plant material from the greenhouse. The importance of this step cannot be overemphasized since living plant material is an ideal refuge for pests such as aphids, thrips and mites. Plant debris, spilled potting media, etc. also should be eliminated prior to disinfecting a greenhouse. Shop vacuums are useful in removing debris from concrete and covered floors. Additionally, there are cleaning agents on the market (e.g. STRIP-IT™) that can make the job of algae, grime and fertilizer residue removal easier. Using a power washer with soap and water is another possibility. Care must be taken, however, since soap can leave residues that can inactivate certain disinfectants (i.e. the quaternary salts) used later in the sanitation process.

Owners of greenhouses with bare soil or gravel as a floor might consider the installation of weed barriers. In addition to preventing weed growth, weed barriers make algae management easier. Weed barrier should not be used below a gravel greenhouse floor since it tends to trap soil and moisture, creating an ideal environment for weeds, diseases, insects and algae.

After thoroughly cleaning a greenhouse, it should be disinfected. To a certain degree, a number of pathogens (e.g. *Pythium* or *Rhizoctonia*) can be managed effectively by the use of disinfectants. Dust particles or other organic residue in the greenhouse might contain bacteria or fungus inoculum which disinfectants can eliminate. In addition to plant pathogens, some disinfectants are also labeled for managing algae. The latter tends to promote populations of fungus gnats and shore flies to develop.

There are four disinfectants commonly used in greenhouses. When possible/practical, rotation between these four is recommended. The four disinfectants include:

Isopropyl alcohol (70%) is an effective disinfectant that kills microbes on contact. Since it is volatile, its effect is not long-lived. Alcohol is best suited for disinfecting propagation equipment such as knives or shears by dipping or wiping.

Sodium hypochlorite (household bleach) probably is the most widely used disinfectant in greenhouse management. Additionally, it is the least expensive. Bleach should be used within two hours of mixing since its active ingredient (chlorine) is quite volatile. Typical household bleach contains 5.25% chlorine. A mixture of one part of bleach to nine parts of water produces a solution with 0.5% chlorine which is satisfactory for killing microbes associated with greenhouses and related equipment. When disinfecting pots or flats with bleach, first wash out all excess growing medium since organic matter tends to neutralize the chlorine in the bleach solution. Bleach should be used in a well-ventilated area for personal safety. Also, it should be noted that bleach can be phytotoxic to some plants, (e.g. poinsettia).

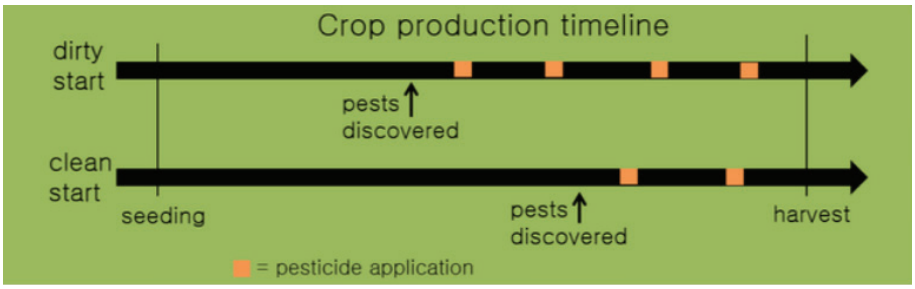
Hydrogen dioxide is available under a number of brand names such as ZeroTol®, OxiDate® and SaniDate®. Hydrogen dioxide is a potent oxidizing agent that kills a wide range of microbes and their inoculum on contact. It is very effective in sanitizing benches, pots, tools, etc. as long as the solution used is still active. Kits are available which allow growers to test the solution to determine it has lost its potency. At such time more hydrogen dioxide must be added. Note: Special care should be taken when using hydrogen dioxide since it is extremely harmful to the eye.

Quaternary ammonium salt (e.g. Physan 20®, Green Shield® and Klean Grow™) is an effective disinfectant that, unlike bleach and hydrogen dioxide, does not lose potency as it is being used. As with bleach, it is important to remove organic matter from the surfaces of items (pots, flats, etc.) being disinfected. Physan 20® also is labeled for use on seeds, cut flowers and plants. Carefully read and follow label instructions.

For those who produce vegetables in greenhouses or high tunnels using soil culture, sanitation is equally important. As mentioned above, remove all of the debris from the previous crop as possible. Be mindful of weeds around the perimeter of the greenhouse or high tunnel, since weeds harbor insect pests that can serve as vectors for certain plant diseases. Deep cultivation should follow debris and weed removal to bury any plant residue missed deep in the soil.

Good sanitation practices provide growers with a longer pest free window, reducing the need for pesticide and reducing labor and expenses associated with pesticide application. The following graph illustrates how proper sanitation can reduce the need to apply pesticides:

Dirty starts have early pest occurrance requiring 4 pesticide treatments before harvest. Clean starts have later pest occurrance which requires 2 pesticide applications before harvest.



Credit: Scott DiLoreto, Penn State Univ.

In summary, effective greenhouse and high tunnel management requires growers and managers to develop a "think clean" mindset. Proper sanitation does requires time and attention to detail. However, the benefits of following good sanitation practices will be evident when used effectively and consistently. A clean production facility leads to healthy plants, and healthy plants lead to happy growers and greater profits

Produce Safety Alliance- Grower Training Course Information

Contact (to register): Debi Kelly, kellyd@missouri.edu; 636-797-5391
Farmer registration: $130
Workshop Date: October 11, 2017 8:00 am - 5:30 pm CDT
Location: University of Missouri Extension Office – 260 Brown Road, St. Peters, MO. 63376
Note: Registration limited to 40; please confirm interest in attending ASAP.

Who Should Attend

Fruit and vegetable growers and others interested in learning about produce safety, the Food Safety Modernization Act (FSMA) Produce Safety Rule, Good Agricultural Practices (GAPs), and co-management of natural resources and food safety. The PSA Grower Training Course is one way to satisfy the FSMA Produce Safety Rule requirement outlined in § 112.22(c) that requires 'At least one supervisor or responsible party for your farm must have successfully completed food safety training at least equivalent to that received under standardized curriculum recognized as adequate by the Food and Drug Administration.'

What to Expect at the PSA Grower Training Course

The trainers will spend approximately seven hours of instruction time covering content contained in these seven modules:

- Introduction to Produce Safety
- Worker Health, Hygiene, and Training
- Soil Amendments
- Wildlife, Domesticated Animals, and Land Use
- Agricultural Water (Part I: Production Water; Part II: Postharvest Water)
- Postharvest Handling and Sanitation

How to Develop a Farm Food Safety Plan

In addition to learning about produce safety best practices, key parts of the FSMA Produce Safety Rule requirements are outlined within each module. There will be time for questions and discussion, so participants should come prepared to share their experiences and produce safety questions.

Benefits of Attending the Course

The course will provide a foundation of Good Agricultural Practices (GAPs) and co-management information, FSMA Produce Safety Rule requirements, and details on how to develop a farm food safety plan. Individuals who participate in this course are expected to gain a basic understanding of:

- Microorganisms relevant to produce safety and where they may be found on the farm
- How to identify microbial risks, practices that reduce risks, and how to begin implementing produce safety practices on the farm
- Parts of a farm food safety plan and how to begin writing one
- Requirements in the FSMA Produce Safety Rule and how to meet them.

After attending the entire course, participants will be eligible to receive a certificate from the Association of Food and Drug Officials (AFDO) that verifies they have completed the training course. To receive an AFDO certificate, a participant must be present for the entire training and submit the appropriate paperwork to their trainer at the end of the course.

Included with Registration

The $130 registration includes the PSA Grower Training Manuals and a Certificate of Course Attendance from AFDO. Lunch will be provided.

Additional Information

For more information about scheduled PSA Grower Training Courses, please visit the PSA website at http://producesafetyalliance.cornell.edu.

WHO'S WHO

MU Extension

James Quinn
Editor
573-634-2824
quinnja@missouri.edu

Dave Trinklein
State Floriculture Specialist
573-882-9631
trinkleind@missouri.edu

Amy Hess
MU IPM Program
Media Specialist
573-884-6361
hessa@missouri.edu

LU Extension

Touria Eaton
State Floriculture Specialist
573-681-5174
eatont@lincolnu.edu

Jaime Pinero
State IPM Specialist
573-681-5522
pineroj@lincolnu.edu

Zelalem Mersha
Plant Pathologist
573-681-5522
mershaz@lincolnu.edu

MU Extension County Specialists

Adair: Jennifer Schutter
660-665-9866

Daviess: Tim Baker
660-663-3232

Greene: Pat Byers
417-881-8909

Henry: Travis Harper
660-885-5556

Morgan: Joni Harper
573-378-5358

Vernon: Pat Miller
417-448-2560

Webster: Bob Schultheis
417-859-2044

The Missouri Produce Growers (MPG) bulletin is published by the University of Missouri and Lincoln University with federal funding support from the USDA NIFA (National Institute of Food and Agriculture) CPPM – Extension Implementation Program. Current and back issues are available at http://ipm.missouri.edu/mpg. Mention of trademarks, products, or vendors is included as a convenience to the reader, and does not imply endorsement or discrimination against similar products or services not mentioned.