26 Greenhouse Vegetable Production

Where: Grand Gallery Overlook E & F
MI Recertification Credits: 2 (COMM CORE, PRIV CORE)
OH Recertification Credits: 0.5 (presentations as marked)
CCA Credits: CM (1) NM (0.5) PM (0.5)
Moderator: Bruce Mackeller, Michigan State University

2:00 PM **In-house Nutritional Monitoring of Vegetable Transplants**
- W. Garrett Owen, Michigan State University

2:30 PM **Increasing Greenhouse Energy Efficiency**
- Charles Gould, Michigan State University Extension
- Heidi Lindberg, Michigan State University Extension

3:00 PM **Greenhouse Produce Safety Regulations: Am I On The Hook?**
- Phil Tocco, Michigan State University Extension

3:30 PM **Tips and Tricks to Limit Disease (OH 2B, 0.5 hr)**
- Mary Hausbeck, Michigan State University

4:00 PM **Session Ends**

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Increasing Greenhouse Energy Efficiency

Greenhouse Vegetable Production Session; 2:00 Tuesday, December 4, 2018
Great Lakes Expo
Charles Gould and Heidi Lindberg

What are ways that greenhouse growers can increase their energy efficiency?

1. Manage temperature based on crop & finish date
2. Reduce air leaks
3. Install and/or use horizontal air flow (HAF) fans to circulate air
4. Install infrared anti-condensate poly film
5. Use photoperiodic lighting on long day plants (to reduce production time)
6. Use high-intensity lighting on young plants (to reduce production time)
7. Transplant larger plugs and liners (to reduce finishing time)
8. Install high-efficiency heaters
9. Insulate side, knee and/or end walls of the greenhouse
10. Install retractable energy and/or shade curtains
11. Replacing lighting fixtures with more energy-efficient alternatives (light-emitting diodes)
12. Installing solar PV system
13. Using in-floor heat to reduce air temperature and reduce heat loss
14. Using environmental control systems to vent, heat, and control lights automatically

Where can growers look for assistance for energy efficiency or renewable energy projects?

1. **Utility/gas/electrical rebates** through their suppliers
2. **USDA Rural Development Rural Energy for America Program (REAP)**
    a. REAP provides grant funding and guaranteed loan financing to agricultural producers and rural small businesses to purchase or **install renewable energy systems or make energy efficiency improvements**. Grants and loan guarantees cover up to 25% and 75% respectively of total eligible project costs. The amount of the grant/loan combination cannot exceed 75% of the total project cost. Growers with at least 50 percent of their gross income coming from agricultural operations and small businesses in eligible rural areas can apply for REAP funding.
    b. Select examples: lighting projects, high-efficiency heating, insulation, doors and windows, solar PV systems
3. **USDA Environmental Quality Incentives Program (EQIP)**
    a. The EQIP on-farm Energy Initiative provides funding up to 75% of the total project cost on projects that increase energy efficiency.
    b. EQIP grants are not available for renewable energy projects.

For more information:

- Download Extension bulletin E-3160, "**Greenhouse Energy Conservation Strategies**" at https://www.canr.msu.edu/resources/greenhouse_energy_conservation_strategies
- Check out MSUE article, "**Reducing greenhouse expenses**" at http://www.canr.msu.edu/news/decreasing-greenhouse-expenses
- Check out MSUE article, "**Incentives aid greenhouses and nurseries in implementing energy efficiency practices**" at http://www.canr.msu.edu/news/incentives-aid-greenhouses-and-nurseries-in-implementing-energy-efficiency-practices

Tips and Tricks to Limit Disease

Dr. Mary K. Hausbeck, 517-355-4534, and Sheila Linderman
Michigan State University, Department of Plant, Soil & Microbial Sciences

The key to managing and limiting diseases on greenhouse vegetables is to remember that the warm and moist greenhouse environment is very favorable to those plant pathogens that are most troublesome to vegetables. While warm temperatures are needed to grow many vegetables, efforts to reduce the relative humidity and minimize the time that the foliage is wet will pay dividends in disease control. If the moisture within the greenhouse can be reduced on a consistent basis, the plant pathogens won't be able to reproduce and infect the crop. A general rule of thumb is to keep the relative humidity level below 85% all of the time. Watering should be accomplished at a time of the day when the foliage will dry rapidly. Plants that are watered in the late afternoon or early evening will likely remain wet throughout the night. Such an extended period of free water will ensure the occurrence and development of troublesome spots and blights. Venting and heating late in the afternoon is helpful in removing humid air before sunset. Most plant pathogens need a minimum of six hours of leaf wetness to germinate and penetrate the tissue. Many growers do not realize that at certain times of the day/night, some areas of their greenhouse routinely exceed the 85% relative humidity threshold that may allow a thin film of moisture to form and remain on the plant's surface. This could be in an area of the greenhouse where there is standing water under the plant benches or where the ventilation is poor thereby creating a "pocket" of high relative humidity. Adequate spacing of plants is important in reducing the relative humidity of the microenvironment that forms within the plant canopy. Spacing plants closely together results in dense canopies that limit light and air penetration and promotes senescence of the lower leaves. Under humid and wet environmental conditions, plant pathogens readily infect these senescent leaves and sporulate, providing ample inoculum to infect nearby healthy plants. Forcing heated air under lath, wire mesh, or expanded metal benches via perforated polyethylene tubes is an effective way of reducing the relative humidity within the plant canopy.

BOTRYTIS can cause leaf spots, blighting, and stem cankers on many vegetable and ornamental plants. *Botrytis* also causes damping-off of young seedlings, and can limit all phases of vegetable production. The most common symptom of the disease is blighting which may affect leaves, stems and blossoms. Infection begins as small, water-soaked spots which can enlarge and affect large portions of tissue. *Botrytis* typically becomes established on aging lower leaves that are near the moist soil surface and under the plant canopy. Infected tissue such as leaves or flowers that fall onto healthy tissue can initiate new infections. Stem blight begins in a broken stem surface and progresses downward, causing a dieback of the entire stem. In severe cases stem blight extends into the base of the plant, killing it. *Botrytis* readily produces abundant masses of gray spores (conidia) on diseased and dead tissue, appearing as a fuzzy or powdery gray mold. When sporulation of *Botrytis* is extensive, a cloud of gray conidia typically can be observed if the plant is physically disturbed. *Botrytis* spores may be picked up and carried on air currents and transported to healthy plants where blight can become established. Monitoring the occurrence and build-up of this inoculum in the greenhouse can signal the need for implementing control measures.

Sanitation is an important management tool in controlling *Botrytis*. However, to ensure effectiveness it must be remembered that *Botrytis* can infect and produce conidia on tissue that is dead or alive. Leaves and flowers that are senescent are often favored hosts for *Botrytis*. If plants drop petals or flowers onto benches or the floor, that tissue is still a suitable host for infection by *Botrytis* and subsequent production of conidia as long as the environment is wet and humid. Even if infected debris is collected and put into a trash container, *Botrytis* can produce conidia. If a trash container is kept in the greenhouse and is uncovered, air currents can pick up the conidia being produced by *Botrytis* on this diseased tissue and disperse them to healthy plants throughout the greenhouse. To prevent this, trash

containers should always be covered, emptied frequently, and preferably stored in an area other than the plant growing area.

Removing infected plants (roguing) is also an important component of sanitation. A plant may be so severely infected with *Botrytis* and have such a large load of conidia that the entire plant should be discarded so it does not contaminate neighboring healthy plants. In such a case, it is better to bring a covered container or plastic bag that can be sealed to the site of the infected plant to be discarded, rather than carrying the infected plant throughout the greenhouse to a trash container. When an infected plant has a significant amount of tissue covered with conidia, the air currents created by carrying the plant out of the production area will result in many conidia being released and "shaken" off en route. The physical action of removing infected leaves with sporulating *Botrytis* is sufficient to release conidia into the atmosphere thereby putting healthy plants at risk. For instance, prior to workers "cleaning" tomato plants in a greenhouse by removing the lower senescent leaves, blossoms, or infected plant parts, it would be wise to have a protectant fungicide on all of the plants in the greenhouse prior to the activity and reduce the relative humidity (<65%) for three days following the cleaning. Growers can be sure that if *Botrytis* is present, a cleaning activity will result in a high number of conidia being released into the atmosphere where they can be spread throughout the greenhouse and be deposited onto healthy plants. Since plants are often wounded during cleaning, the lowered relative humidity helps to make these wounds a less suitable entry point for *Botrytis*.

CLADOSPORIUM LEAF MOLD (*Fulvia fulva = Cladosporium fulvum*) is an important and common greenhouse disease of tomatoes. Yellow-green areas appear first on the upper leaf surfaces with a brown-purplish, velvety fungal growth on the underside of the leaf. Infected leaves turn brown, curl, wither and drop off of the plant. The leaf mold pathogen moves readily from older leaves to younger ones. Blossoms may become infected and often die before fruit set. Tomato fruit can develop a stem-end rot or appear yellow or green on the undeveloped side. The leaf mold pathogen prefers high relative humidity of 85% or more or is favored by free water or "dew" on the foliage. The leaf mold pathogen produces a large number of spores (conidia) on infected tissue and can spread rapidly through the greenhouse. Conidia are moved by air currents, water, and greenhouse workers. The pathogen can readily survive in the greenhouse for one year or more even if the conditions are not favorable.

Management includes cultural practices and resistant cultivars, if available. Spacing plants widely can help to avoid excessive shading and improve air circulation. Excessive nitrogen fertilizer should be avoided. Keep the relative humidity low and promote ventilation by removing lower leaves to improve air circulation around plants. This is particularly important if the greenhouse is not heated. Irrigation should occur early in the day to allow plants to dry. Diseased leaves should be removed, sealed in a plastic bag and disposed. After harvest, all plant residue should be completely removed and destroyed/disposed and the entire greenhouse disinfested. In general, this pathogen is considered difficult to manage with the currently available registered products. Fungicides should be used in combination with overall efforts to keep the environment dry and unfavorable for the development of leaf mold.

DOWNY MILDEW causes symptoms on the leaves of cucumber similar to a mosaic or angular leaf spot. The tell-tale symptom of downy mildew is the purplish/gray fuzz on the underside of the leaf that gives a somewhat "dirty" or "velvet" appearance. This fuzz is made up of thousands of spores and may be most evident in the morning or when the conditions are humid and wet. When the conditions are favorable, unprotected foliage can become completely infected and appear to be frosted within 10 days of initial infection. Downy mildew is not known to produce overwintering spores in nature, but can survive Michigan winters in heated greenhouses.

Currently, there are few cultivars with resistance to downy mildew; chemical control is the most effective tool when the environmental conditions favor the disease. Products should be used in combination and alternated with each other and applied at short intervals when the disease is present.

POWDERY MILDEW can be a common and difficult problem on cucumbers, peppers and tomatoes. Powdery mildew can occur on all above-ground plant parts (i.e. leaves and stems) and results in white, talcum-like growth on the plant's surface. Detection of powdery mildew may be delayed if the first colonies occur on the undersides of lower leaves. When the fungus reproduces, the abundant conidia (spores) give a white, powdery or fluffy appearance. Severe infection can cause yellowing and withering of leaves and restrict plant growth. Powdery mildew can infect plants even when the relative humidity is low (less than 85%), but epidemics are prompted when relative humidity is high. Sometimes the powdery mildew progresses unnoticed until many plants are infected and the disease appears to "explode." Once conidia are produced in great quantities, the disease spreads rapidly and becomes evident. Powdery mildew is well known for its ability to adapt and develop resistance to fungicides, and it is important to rotate among fungicides with different modes of action. Using as few sprays as possible also helps to delay the development of resistance. Usually, powdery mildew is best controlled when fungicides are begun prior to the appearance of the disease. With especially susceptible crops, it would likely be of benefit to begin a spray program prior to disease development and apply systemic fungicides (alternate products) effective against powdery mildew at two to three week intervals (depending on product used, crop susceptibility, and environment) to maintain a healthy crop. Scouting can be a critical component of managing powdery mildew; it is important to note whether colonies are living and active.

REGISTERED PRODUCTS				CROP GROUPS[1] and DISEASES[3]													
				Brassica			*Cucurbit*		*Leafy*			*Fruiting*				*Herbs*	
Active ingredient	Name	FRAC code[2]	REI (hr)	broccoli	cabbage	other	cucumber	other	celery	lettuce	spinach	eggplant	pepper	tomato	basil	other
acibenzolar-S-methyl	Actigard	P01	12			B/D	B/D/P			D			B			
	Bion 50WG												B			
	Blockade 50WG									D						
aluminum tris	Aliette WDG, Linebacker WDG	33	12		D		D/Ph			D				P/Py		
azoxystrobin	Heritage Fungicide	11	4		L	D	D/L/P		L	D/L/P			L/P		D	D/L/P
azoxystrobin/benzovindiflupyr	Mural	11/7	12				D/L/P						L/P			
copper products	Nu-Cop HB, Nu-Cop 50DF, Champ DP Dry Prill, ChampION++, Kentan, Kocide, Badge SC, Badge X2, Cuprofix Ultra 40 Disperss	M01	48				D/L					L	B	B/L		
	C-O-C-S			D			L		L	D	D/L	L/Ph		B/L		
	Camelot O		4	B/D/L			B/D/L/P		B/L	B/D/L/P		B/L		B/L/Ph	B/D/L	
cyazofamid	Ranman	21	12											Py	D	
	Ranman 400SC												Ph/Py	Py	D	
cymoxanil	Curzate	27	12				D			D				Ph		
cyprodinil/fludioxonil	Switch 62.5WG	9/12	12	L			L/P		L			L/P			L	
dicloran	Botran 75-W	14	12							L				L		
famoxadone/cymoxanil	Tanos	11/27	12											L/Ph		
fenamidone	Reason 500SC	11	12												D	
fluazinam	Omega 500F	29	12		D/L		D/L/Ph					Ph				
fludioxonil	Emblem, Spirato 480 FS	12	12	L			L/P		L			L/P			L	
fluopicolide	Adorn supplemental label	43	12												D	
iprodione	Iprodione 4L AG, Rovral 4F	2	24							R						
mancozeb	Protect DF	M03	24				D/L/Py	D/L						B/L/Ph		
	Dithane M45 Rainshield, Manzate Pro-Stick, Penncozeb 75DF						D/L			D			L	B/L/Ph		
mancozeb/zoxamide	Gavel	M03/22	48				D/L/Ph							B/L/Ph		
mandipropamid	Micora	40	4	D						D		Ph			D	
	Revus			D			D/Ph		D			Ph			D	
mandipropamid/difenoconazole	Revus Top	40/3	12											L/P		
mefenoxam	Subdue MAXX	4	48	D/Py			Ph/Py		Py	D/Py	Py	Ph/Py			D/Py	
myclobutanil	Sonoma 20EW AG, Sonoma 40WSP	3	24				P			P		P				P
oxathiapiprolin	Orondis Gold 200	49	4					Ph					Ph			
oxathiapiprolin/mandipropamid	Orondis Ultra	49/40	4											Ph		

[1]See product label for 'other' crops included in the crop group. [2]Alphanumeric code assigned by the Fungicide Resistance Action Committee based on the mode of action of the active ingredient.

[3]Disease abbreviations: B=bacterial blight/rot. D=downy mildew. L=leaf spot/blight (see product label for specific leaf diseases) including Alternaria, anthracnose, Botrytis, Cercospora. P=powdery mildew. Ph=Phytophthora foliar/root. Py=Pythium. R=Rhizoctonia. S=Sclerotinia.

Registered Products for Common Greenhouse Diseases on Vegetables and Herbs

Dr. M. Hausbeck, S. Linderman, and B. Harlan, 10/16/18

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REGISTERED PRODUCTS				CROP GROUPS[1] and DISEASES[3]													
				Brassica			*Cucurbit*		*Leafy*			*Fruiting*			*Herbs*	
Active ingredient	Name	FRAC code[2]	REI (hr)	broccoli	cabbage	other	cucumber	other	celery	lettuce	spinach	eggplant	pepper	tomato	basil	other
pentachloronitrobenzene	Terraclor 400, Blocker 10G, Turfcide 10G	14	12	R									R			
phosphorous acid products	Agri-fos, Fosphite, Fungi-Phite, K-Phite 7LP, Rampart, Prophyt	33	4	D/Ph/Py			D/Ph/Py		Py	D/Py		D/Ph/Py			D/Ph/Py	
	Reveille			D			D/Ph			D			Ph			
polyoxin D zinc salt	Affirm	19	4				L					L				
	Ph-D						L			S		L				
potassium phosphite/chlorothalonil	Catamaran	33/M05	12	D/L			D/L		L/R			L		L/R/Ph		
propamocarb hydrochloride	Previcur Flex, Promess	28	12				Ph/Py			Py			Ph/Py			
pyraclostrobin/boscalid	Pageant Intrinsic	11/7	12											L/Ph/Py		
pyrimethanil	Scala SC	9	12				L									
streptomycin sulfate	Ag Streptomycin, Agri-mycin 17, Agri-mycin 50, Bac-Master	25	12										B			
tebuconazole	Barrier, Buzz Ultra DF, Monsoon, Onset, Orious, Tebu-Crop, TebuStar	3	12			L/P	P									
	Tebucon, Tebuzol, Toledo, Willowood Teb					L/P	P					L				
thiophanate-methyl	3336 WP, 3336 F, 3336 EG	1	12				L/P/R									
	Topsin 4.5FL, Topsin M WSB		24													
triflumizole	Terraguard SC	3	12				P							P		
	Procure 480SC			L/P			P			L/P						

These recommendations are not intended to replace the specific product labels; the pesticide label is the legal document on pesticide use. Read the label carefully, as they change often and follow all instructions closely. Some products listed in this bulletin may be dropped by the manufacturer or distributor after the publication of this bulletin. The use of a pesticide in a manner not consistent with the label can lead to the injury of crops, humans, animals, and the environment. The use of a pesticide inconsistent with the label directions can also lead to civil or criminal fines and/or condemnation of the crop. Pesticides are good management tools for the control of pests on crops, but only when they are used in a safe, effective and prudent manner according to the label.

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[3]Disease abbreviations: B=bacterial blight/rot. D=downy mildew. L=leaf spot/blight (see product label for specific leaf diseases) including Alternaria, anthracnose, Botrytis, Cercospora. P=powdery mildew. Ph=Phytophthora foliar/root. Py=Pythium. R=Rhizoctonia. S=Sclerotinia.