Tomato / Pepper / Eggplant

Tuesday morning 9:00 am

Where: Grand Gallery (main level) Room A & B
MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
OH Recertification credits: 1.5 (presentations as marked)
CCA Credits: PM(1.5) CM(0.5)
Moderator: Ron Goldy, Senior Vegetable Educator, MSU Extension, Benton Harbor, MI

9:00 am — Maintaining Tomato, Pepper and Eggplant Quality During Postharvest Handling
- Steve Sargent, Horticultural Sciences Dept., Univ. of Florida

9:30 am — Late Blight Management: Strategies Used In Pennsylvania (OH: 2B, 0.5 hr)
- Beth Gugino, Vegetable Pathology, Penn State Univ.

10:00 am — Nematode Management on Vegetables With Fumigation, Non-Fumigants and Host Resistance (OH: 2B, 0.5 hr)
- Donald Dickson, Entomology and Nematology Dept., Univ. of Florida

10:30 am — Herbicide Drift: What's A Grower to Do? (OH: CORE, 0.5 hr)
- Doug Doohan, Horticulture and Crop Sciences, OARDC, Wooster, OH

11:00 am — Session Ends

Maintaining Tomato, Pepper and Eggplant Quality During Postharvest Handling

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HARVEST, HANDLING AND COOLING GUIDELINES

These crops are very sensitive to mechanical injury and low temperatures. Impacts during harvest and handling should be minimized. Time in the field should also be minimized to avoid unnecessary increases in pulp temperature after harvest. These crops should never be stored below the recommended temperature.

a) Tomato

- Green harvest: mature green ripeness stage
    - Days from flowering, size, development of stem scar around calyx
    - Must take subsample and slice to observe internal ripeness
        - Maturity Stages 1 to 4.
        - Gel formation in locules; seed maturity, beginning of red color development
    - Unload into sanitized, recirculated water (“dump tank”) or dry dump
    - Wash with overhead spray in roller brush bed
    - Ripening initiation
        - Ethylene concentration: 50 to 100 parts/million;
        - Ripening room: 68 to 72°F; 85-90% relative humidity; up to 5 days, sort out ripening fruit
- Vine-ripe harvest: breaker stage and beyond – clusters are clipped
    - Ripen under above conditions; can hold to 53°F without chilling injury
    - Greenhouse-grown: cluster (tomatoes on the vine, TOV) or individual fruit; air cool to 53°F

b) Pepper

- Bell pepper: green (immature green stage) and color (ripe stage) harvest
    - Harvest at desired color stage
    - Pulled vs. clipped harvest
    - Unload directly onto conveyor (“dry dump”); do not immerse
    - Wash with overhead spray in roller brush bed
    - Forced-air cool to 48 to 50°F
- Specialty pepper
    - Many varieties available; harvest at desired color stage

c) Eggplant

- Clip harvest above calyx at immature or mature stages, while peel is shiny
- Peel very sensitive to abrasion, bruising during handling
- Unload directly onto conveyor ("dry dump"); do not immerse
- Wash with overhead spray in roller brush bed
- Forced-air cool to 50°F

d) For further reference:

- Handling Florida Tomatoes – Round and Roma Types. http://edis.ifas.ufl.edu/vh079
- Guide to Identifying and Controlling Postharvest Tomato Diseases in Florida. http://edis.ifas.ufl.edu/hs131
- Ripening Tomatoes with Ethylene. http://ufdc.ufl.edu/IR00004698/00001
- Production of Greenhouse-Grown Peppers in Florida. http://edis.ifas.ufl.edu/hs228
- Guide for Maintaining the Quality and Safety of Organic Vegetables and Melons during Harvest and Handling Operations. https://edis.ifas.ufl.edu/hs396
- Food Safety on the Farm: An Overview of Good Agricultural Practices. https://edis.ifas.ufl.edu/fs135

LATE BLIGHT MANGEMENT: STRATEGIES USED IN PENNSYLVANIA

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Late blight, caused by the pathogen *Phytophthora infestans*, was a disease once considered sporadic, but is now an annual concern for tomato and potato growers in Pennsylvania as well as in the Great Lakes, mid-Atlantic and Northeast regions and elsewhere. On tomato, symptoms can develop on leaves, stems, branches and fruit at any growth stage. On leaves, pale green to brown lesions will develop on the upper leaf surface and have pale green or water soaked margins. The lesions may enlarge rapidly until entire leaflets are killed. Under conditions of high relative humidity, grayish white sporulation will develop on the lower leaf surface opposite to the lesions. Stem lesions are chocolate brown in color and can girdle causing them to break. Greasy-brown lesions can develop on both immature and mature fruit and the fruit typically remain firm unless infected by secondary soft-rotting organisms. Disease development and spread is favored by temperatures between 65 and 70°F with high relative humidity (RH) near 100%. Survival of the spores is greatly reduced when the RH is below 95%; at 80% RH they can survive only five hours. Once the spores have landed on the plant, a film of water must be present to initiate infection. Infection can occur in a matter of hours under ideal conditions and visible symptoms are evident in the field after 5 to 7 days.

Since the pandemic in 2009 when late blight was distributed via infected transplants destined for home gardens on a widespread scale, in PA, late blight has been confirmed as early as 17 May in 2010 in tomato greenhouse transplants and as late as 15 July in 2015 in a commercial potato field and cull pile. Aside from 2009 when late blight became widely established in home gardens before moving into commercial production, late blight over the past six years has originated in commercial fields and then later in the season as the population of the pathogen built-up it moved into home gardens. In three of the past six years, it is suspected that either volunteer potatoes, cull potatoes or infected potato seed were the source of the first confirmed outbreak in PA. The past several years, the majority of the samples were genotyped from PA were the US-23 clonal lineage which has also been dominant in the Great Lakes, mid-Atlantic and Northeast regions. In 2015, approx. 117 late blight reports were made to USAblight.org representing 22 states and 2 Canadian provinces. Of these, approx. 71% were sampled and submitted for genotyping and the majority was again characterized as US-23. US23 is the A1 mating type and is aggressive on both tomato and potato; however it produces many more spores on tomato. US-23 is also characterized as sensitive to the systemic fungicide mefenoxam which was again effectively used in several potato fields early in the season to manage the disease outbreak. Knowledge of the pathogen population structure is an important component of an integrated disease management program and helps growers make informed in-season disease management decisions.

Until recently, late blight management has focused on the frequent use of fungicides, especially under favorable conditions however, as more cultivars are released with resistance to late blight, **host resistance** becomes an important and more feasible component of an IPM program. To-date, three major late blight resistance genes (*Ph-1*, *Ph-2* and *Ph-3*) have been identified in the red-fruited tomato wild species *Solanum pimpinellifolium* and transferred through conventional breeding into the cultivated tomato (*S. lycopersicum*). Unfortunately, the pathogen population is constantly changing and *Ph-1* was overcome when the pathogen population shifted from race T_0 to T_1, rendering this resistance gene no longer effective. More recently, *Ph-2* and *Ph-3* have been introgressed into a few commercial cultivars in both the heterozygous and homozygous state (e.g. Mountain Magic, Mountain Merit, Plum Regal and Defiant). Currently, commercially available cultivars that contain both *Ph-2* and *Ph-3* (e.g. Mountain Merit and Mountain Magic) are considered most effective against the current genotypes of late blight. Dr. Majid Foolad, tomato breeder at Penn State has been working to identify new late blight resistance genes (e.g. *Ph-5*) in the wild species *S. pimpinellifolium*. The goal is to combine multiple resistance genes to increase the strength and durability of resistance. Molecular markers and marker-assisted selection (MAS) technology are used to facilitate this process. In addition, planting only certified potato seed and visibly healthy tomato transplants as well as diversifying plantings to include some resistant or less susceptible cultivars will help ensure some crop in the event of a late blight outbreak especially for organic growers. Selecting less susceptible cultivars with host resistance can also reduce your reliance on fungicides and provide more flexibility in the timing of application, especially when you are delayed getting into the field to spray.

Fungicides can be used to effectively manage late blight however they are most effective when applied either preventatively when late blight has been confirmed nearby or when the very first symptoms are observed in the field. This means that having a good scouting program is essential and knowing if and where there are nearby late blight outbreaks. The latest information on confirmed outbreaks at the county level can be found on the USAblight.org website. When you click on a county on the map, information about all the samples including host crop and pathogen genotype (if the sample was submitted) submitted from that county are presented. You can also sign-up for email or text alerts notifying you when late blight is confirmed with a pre-determined radius from your location. You can also check your local extension team website for information on late blight and in PA, I have a 1-800-PENN-IPM hotline that I update voice messages on a weekly basis. In 2015, a fungicide efficacy trial was conducted for late blight on tomato cv. Mountain Fresh Plus at the Russell E. Larsen Agricultural Research and Extension Center in PA Furnace, PA. Each plot was 12-ft-long and separated by a 5-ft break within the row and 5-ft between row centers. Guard rows of tomato cv. H4007 separated each treatment row. Each plot was planted with 8 transplants spaced 18-in. apart. Treatments were replicated five times and arranged in a randomized complete block design. Fungicide treatments were applied using a tractor mounted, R&D CO_2 powered side boom sprayer traveling 3 mph and calibrated to deliver 28 gpa at 32 psi at the tank through one center and two drop TX-18 hollow-cone nozzles on 12, 19, 27 Aug, and 1, 9, 16, 23 Sep for a total of 7 applications. All symptoms of late blight results from natural infection moving from adjacent guard rows artificially inoculated with a mix of three Pennsylvania *Phytophthora infestans* isolates US-23 (approx. 10^6 spores/ml sprayed in three to four spots per 12 ft guard row plot using a hand-held Hudson sprayer) on 17 Aug. Supplemental water was delivered using overhead misters to extend the dew periods to create more favorable conditions for disease progression. Late blight symptoms were first observed on 29 Aug. The results can be found in Table 1. Disease severity was assessed as the percent of plant tissue showing symptoms across the whole plot.

Fungicides applications can also be timed based on weather driven models such as Blitecast or the Cornell Decision Support System (DSS) that utilized Blitecast as one component of a more comprehensive system. The Cornell DSS also incorporates information about host resistance, fungicide use and pathogen traits. The **forecasting** system is composed of four components that include 1) location specific weather data; 2) disease forecasting models Blitecast and SimCast; 3) late blight disease simulator; and 4) an alert system. The grower sets-up a free account and inputs information regarding location, cultivar, and planting date. This information is saved and can be accessed when logged-in during subsequent sessions when information about fungicides applications is entered. The report provides information regarding past and forecasted temperatures, relative humidity and precipitation as well as both accumulated and forecasted disease severity values based on Blitecast. The first fungicide application is based on blight units (disease severity values) and then subsequent applications are made based on the SimCast thresholds that take into account fungicide residue levels which decline between applications. For more information, visit http://usablight.org/dss.

Cultural practices such as maximizing row spacing, trellising, and drip irrigation to improve air circulation and promote leaf drying will reduce potential losses from late blight but creating less favorable conditions for the pathogen. Managing weeds especially solanaceous weeds like nightshade and volunteer tomato and potato plants that could be sources of late blight. Rogueing out symptomatic plants or hot spots in the field when symptoms are first observed will reduce potential spread of the pathogen. Rogueing in the middle of a warm sunny day will minimize the chances of dislodged spores spreading and infecting the crop.

In summary, management of late blight requires an integrated approach that is initiated prior to late blight developing in the field. This starts by preventing the introduction of late blight through planting certified potato seed and visibly healthy tomato transplants. Selecting less susceptible cultivars with host resistance can reduce your reliance on fungicides and provide more flexibility in the timing of application, especially when you are delayed getting into the field to spray. Once detected in the region, continue to scout your crop carefully and, at the very least, initiate a protectant fungicide program depending on the forecasted weather conditions. Rogue out and destroy hot spots in the field to reduce spread both within your farm and across neighboring farms. Be sure to have products available and on-hand and know how to apply them appropriately to maximize their efficacy. Under favorable conditions, late blight can devastate a field in as few as 5 to 7 days if left unmanaged. Please contact your local Extension office if you suspect late blight on either tomatoes or potatoes.

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Table 1. Efficacy of select fungicides and fungicide programs for managing late blight on tomato cv. Mountain Fresh Plus in a replicated field trial conducted at the Russell E. Larson Agricultural Research and Extension Center in PA in 2015. Disease severity was assessed as the percent of symptomatic plant tissue across the whole plot and area under the disease progress curve (AUDPC) is a measure of disease across the entire season (lower number = less disease).

Fungicide(s) and rate/A	Application timing [z]	Disease severity (%) 27 Sept		AUDPC	
Bravo Weather Stik 6SC 1.5 pt	1,3,5				
A20942 SC 1.71 pt (experimental)	2,4,6				
Revus Top 500SC 7.0 fl oz	7	1.6	e [y]	13.8	g
Bravo Weather Stik 6SC 1.5 pt	1,3,5,7				
A20942 SC 1.71 pt (experimental)	2,4,6	1.8	e	14.2	g
Bravo Weather Stik 6SC 1.5 pt	1,3,5,7				
A20942 SC 2.14 pt	2,4,6	1.2	e	14.9	fg
Bravo Weather Stik 6SC 1.5 pt	1,3,5				
A20942 SC 2.14 pt (experimental)	2,4,6				
Revus Top 500SC 7.0 fl oz	7	1.1	e	17.1	fg
Tanos 50WG 0.5 fl oz + Bravo Weather Stik 6SC 2.0 pt	1				
Previcur Flex 6F 1.5 pt + Bravo Weather Stik 6SC 2.0 pt	2				
Zampro SC 14.0 oz + Penetrator Plus 0.5% v/v	3				
Ranman 400SC 2.75 fl oz+ Induce 0.25%v/v + Bravo Weather Stik 6SC 2.0 pt	4,6				
Revus Top 500SC 7.0 fl oz + Induce 0.25%v/v	5,7	2.4	e	39.1	efg
Zing! 4.9SC 32.0 fl oz + Induce 0.25%v/v	1-7	3.4	e	40.6	efg
Zing! 4.9SC 36.0 fl oz + Induce 0.25%v/v	1-7	4.2	e	47.3	ef
Bravo Weather Stik 6SC 2.0 pt	1-7	3.6	e	54.1	e
Previcur Flex 6F 1.5 pt + Manzate Pro-Stick75DF 1.5pt	1				
Tanos 50WG 0.5 fl oz + Bravo Weather Stik 6SC 1.5 pt	2				
Zing! 4.9SC 32.0 fl oz + Induce 0.25%v/v	3,7				
Ranman 400SC 2.75 fl oz + Induce 0.25%v/v + Manzate Pro- Stick75DF 1.5pt	4				
Gavel 75DF 2.0 lb + Induce 0.25%v/v	5				
Zampro SC 14.0 oz + Penetrator Plus 0.5% v/v + Bravo Weather Stik 6SC 1.5 pt	6	5.4	e	77.4	e
Bravo Weather Stik 6SC 2.0 pt	1,3,5,7				
Oxidate 35.7 fl oz	2,4,6	13.4	d	203.1	d
Champ WG 1.06 lb	1-7	26.0	c	362.5	c
Regalia SC 3.0 qt + Badge X2 28DF 28.0 oz	1,3,5,7				
Actinovate AG 12.0 oz + Induce 0.25% v/v + Badge X2 28DF 28.0 oz	2,4,6	26.8	c	391.7	bc
Badge X2 28DF 28.0 oz	1-7	34.2	b	487.1	b
Untreated control	NA	83.6	a	1160.2	a

[z] Application dates were: 1 = 12Aug; 2 = 19 Aug; 3 = 27 Aug; 4 = 1 Sep; 5 = 9 Sep; 6 = 16 Sep; 7 = 23 Sep.

[y] Values within each column followed by the same letter are not significantly different (*P*=0.05) according to Fisher's Least Significant Difference test (SAS v.9.2, SAS Institute, Cary, NC). AUDPC values were square root transformed prior to analysis. Table contains de-transformed values.

Herbicide Drift: What's a grower to do?

The release of 2,4-D and dicamba tolerant corn, soybean and cotton is imminent, beginning with 2,4-D tolerant corn. Grain farmers will embrace these crops because they provide a new method to kill a growing range of glyphosate-resistant weeds. Even modest adoption of this technology on 30% of the corn and soybean acreage in the Midwest will result in an increase in potential 2,4-D and dicamba use to six times the current usage. Because these crops will cause a shift in where 2,4-D and dicamba are primarily used, from western rangeland and wheat production to the corn belt, the actual increased usage in the Midwest could be much more than a 6X increase. Even with advanced drift reduction technology in place, the increased use of these herbicides adjacent to sensitive crops will be such that crop injury resulting from off-site movement is inevitable and almost certainly will exceed current levels (estimated at 300 incidents/ year in Ohio).

Should fruit and vegetable producers in the Michigan be concerned? The short answer is yes, as use of these synthetic plant hormone herbicides is likely to increase throughout the Midwest. In recent decades 2,4-D and dicamba have been used for control of broadleaf weeds in cereal crops and are commonly used in lawn care and for railroad, utility right-of-way and highway maintenance purposes. 2,4-D was introduced in the 1950's and dicamba was first registered for use in the United States in 1967. Unfortunately, some older 2,4-D and dicamba formulations were both notoriously prone to spray drift and to post-application volatilization.

Survey results of state pesticide control officials (2005 AAPCO Pesticide Drift Enforcement Survey) listed 2,4-D as the herbicide most often involved in crop injury resulting from drift incidents for every year the survey has been taken. The same survey listed dicamba as the 3rd most commonly involved in drift incidents for two years in a row. This level of crop damage from drift occurrence far outpaces the relative use of these herbicides. 2,4-D ranked 7th on an EPA list of most commonly applied conventional pesticide active ingredients. Dicamba did not even make the list of the top 25. These active ingredients are highly toxic to sensitive plants at low concentrations hence drift damage symptoms develop readily, are easy to see and are characteristic of growth regulator herbicides.

As a result of extensive research, the causes and fixes of spray drift are well known and documented. For example, using nozzles and pressures that result in the creation of fine spray droplets, and/or spraying during windy conditions are known to greatly increase the risk of spray drift. Much of this information is contained on the pesticide label. The instructions on the pesticide label are given to ensure the safe and effective use of pesticides with minimal risk to the environment. Many drift complaints result from application procedures that violate the label. The potential for a pesticide to volatilize is related to the vapor pressure of the chemicals involved. Pesticides with high vapor pressure are likely to be more volatile than those with low vapor pressure. Pesticides known to have the potential to vaporize carry label statements than warn users of this fact. While there are things that the applicator can control (e.g., nozzle tip, pressure, boom height) to reduce spray droplet or dust drift, vapor drift is dependent upon the weather conditions at the time of application since the likelihood of pesticide volatilization increases as temperature and wind speed increases and if relative humidity is low.

Dow AgroSciences and Monsanto, the developers of 2,4-D-tolerant and dicamba-tolerant cropping systems, respectively, have both taken great care to minimize the known negative attributes of the older 2,4-D and dicamba formulations. Dow AgroSciences has developed Enlist Duo™ that includes a new ultra low-volatility formulation of 2,4-D with minimized drift potential, lower odor, and better handling characteristics than currently available 2,4-D amine or ester formulations. They have also embarked on an educational and outreach program to farmers, dealers, and commercial applicators (Enlist™ Ahead) to promote and encourage good stewardship of the new system. Risks associated with dicamba will also be reduced through product formulation, stewardship programs. An herbicide premix of dicamba and glyphosate branded Roundup Xtend™ with VaporGrip™ technology will be introduced upon regulatory approval of the Roundup Ready Xtend Crop System.

Despite everyone's best intentions and efforts drift happens. To reduce the risk of angry exchanges with neighbors and resultant hostility we suggest an ongoing dialogue with neighbors who grow corn and soybean and with commercial spray applicators who are likely to use 2,4-D and dicamba. Create awareness! Help these individuals better understand specialty crop production and the impact of it on the state's economy. Promote awareness among agronomic crop producers that vineyards, extensive landscape plantings, or other susceptible crops are located in their neighborhood. Creating and maintaining a heightened awareness of the industry is probably the most important thing we can do to reduce risk of future herbicide damage and the lawsuits that would inevitably follow.

We believe that the following steps may be useful in order to help the specialty crop industry develop a process for creating and maintaining awareness and reducing the risk of drift damage.

Step 1. Inform your neighbors.

Develop and maintain a good relationship with your neighbors who grow grain and forages. A good relationship starts with open communication. Offer a tour of your operation; explain how damaging drift of glyphosate, 2,4-D and dicamba can be to your crops. In the case of vineyards make sure to point out the potential for yield loss, poor grape quality, increased susceptibility to cold injury, and reduction in long-term profitability. Discuss the possibility of planting buffer vegetation between your crops and your neighbors' crop/s to reduce risk.

Step 2. Have your farm or vineyard included in an online database.

Neighboring farmers and commercial spray applicators will need accurate information on where specialty crops are being grown. Michigan growers and those from several other states can register fields and greenhouses with FieldWatch (driftwatch.org). Unfortunately, not all states and provinces participate in the program. For Ohio growers, register with the Ohio Sensitive Crop Registry (www.agri.ohio.gov/scr/). Applicators can check this website for proximity of sensitive crops to fields they are planning to spray. If you farm near roadways or other rights-of-way contact your county or state highway department, power company etc., since hormone-type herbicides may be used for weed control in those situations.

Step 3. Manage drift of the herbicides used on your own farm or vineyard.

Set an example of pesticide stewardship. Grapes are one of the most intensively sprayed crops grown in the United States. Consider the unspoken message you send to the community every time you apply pesticides; especially when using high pressure/high volume equipment. While many herbicides are registered for vineyard use, most have severe restrictions due to the sensitivity of the crop. As mentioned previously, we investigate a lot of complaints and in some cases the herbicide injury problem is caused by an application in the vineyard. The likelihood of drift is a multiple of many factors, but some important ones are wind speed, droplet size (determined primarily by nozzle type), the height of the nozzle above the ground or canopy and the operating pressure. Drift can be minimized by spraying on a morning or evening with low but not zero wind conditions (3-10 mph), keeping the nozzle close to the ground, reducing pressure (less than 30 psi), and using low drift nozzles that generate large droplets.\

What if drift damage occurs or is suspected?

Know the symptoms of 2,4-D and dicamba injury on your crops and plan on scouting regularly during the time when grain growers are spraying. Early symptom detection (within a few days of drift) is important if you hope to detect residues of the causal agent – a data point that may be of great value in obtaining compensation.

Prevention is better than cure. We encourage open and frank communication between all parties. Spell out the risk. Inform your neighbors about the high dollar value per acre of the crops you grow. Specialty crops (especially grapes) are relatively small in acreage but high in value, and are highly sensitive to trace amounts of 2,4-D and dicamba. Many are perennial crops and the consequences of drift damage can be dire and long-lasting.