Vegetable Crop Update

A newsletter for commercial potato and vegetable growers prepared by the University of Wisconsin-Madison vegetable research and extension specialists

No. 30– September 5, 2015

In This Issue

Calendar of Events

September 8 – UW-West Madison ARS Organic Vegetable Field Day, Verona, WI
December 1-3 – Midwest Food Processors Assoc. Convention & Processing Crops Conference, Green Bay, WI
January 12-14, 2016 – WI Crop Management Conference, Madison, WI
January 25-26, 2016 – WI Fresh Fruit & Vegetable Growers Conference, WI Dells, WI
February 2-4, 2016 – WPVGA & UWEX Potato Grower Education Conference, Stevens Point, WI

Amanda J. Gevens, Associate Professor & Extension Vegetable Plant Pathologist, UW-Madison, Dept. of Plant Pathology, 608-890-3072 (office), Email: gevens@wisc.edu.
Veg Pathology Webpage: http://www.plantpath.wisc.edu/wivegdis/.

Current P-Day (Early Blight) and Severity Value (Late Blight) Accumulations (R.V. James, UW-Plant Pathology/R.V. James Designs): A P-Day value of ≥ 300 indicates the threshold for early blight risk and triggers preventative fungicide application. A DSV of ≥ 18 indicates the threshold for late blight risk and triggers preventative fungicide application. Red text in table below indicates threshold has been met/surpassed. NA indicates that information is not available. Blitecast and P-Day values for actual potato field weather from Grand Marsh, Hancock, Plover, and Antigo are now posted at the UW Veg Path website at the tab "P-Days and Severity Values." http://www.plantpath.wisc.edu/wivegdis/contents_pages/pday_sevval_2015.html

Location	Planting Date	50% Emergence	P-Day Cumulative	Disease Severity Value	Date of DSV Generation	Increase in DSV from 8/27
Antigo	Early 4/25	5/25	**707**	**134**	9/4	19
	Mid 5/5	6/1	**707**	**134**	9/4	19
	Late 5/15	6/15	**610**	**108**	9/4	19
Grand Marsh	Early 4/5	5/10	**841**	**158**	9/4	25
	Mid 4/15	5/15	**831**	**157**	9/4	25
	Late 5/1	5/21	**797**	**155**	9/4	25
Hancock	Early 4/10	5/15	**602 (8/2)**	**114***	9/4*	12*
	Mid 4/20	5/18	**577 (8/2)**	**111***	9/4*	12*
	Late 5/5	5/25	**543 (8/2)**	**106***	9/4*	12*
Plover	Early 4/15	5/20	**855**	**154**	9/4	25
	Mid 4/25	5/22	**816**	**151**	9/4	25
	Late 5/10	5/30	**753**	**135**	9/4	25

Potato Early Blight Preventive Management: P-Days have surpassed threshold of 300 in all potato plantings Wisconsin. Early blight pressure is especially heavy this year. We have noted primarily *Alternaria solani* (early blight) in field, with just minor findings of *Alternaria alternata*

(brown spot). On May 8th, I provided a summary of fungicides for control of early blight in conventional potato in this newsletter, please find the link to this information below.
http://www.plantpath.wisc.edu/wivegdis/pdf/2015/May%208,%202015.pdf
My lab, through the work of PhD student Shunping Ding, is conducting azoxystrobin resistance tests if you are interested in learning about relative resistance to Quadris (and other generics) in your Alternaria pathogen population. Please contact me (gevens@wisc.edu).

Late Blight Updates: Weather was not favorable for late blight over this past week, with accumulations of Disease Severity Values ≤2 for the entire week in most locations. Recall that 4 DSVs per day is the maximum accumulation. Our Hancock weather station has not been functioning properly over the past few weeks. In this newsletter, I included DSVs as generated for the Hancock location by our web-based disease forecasting tool (annotated in the above table with asterisks). This weather data is generated from NOAA environmental data and is not from an in-field weather station.

Continued management of late blight is critical to maintain healthy potato tubers below ground. In field with foliar late blight, assess stolon ends of tubers for symptoms of late blight to determine if tuber blight has already set in. This disease can have a long latency period from time of tuber infection to symptom development.

In tomato, foliar infection may precede fruit infections. As such, I recommend clean harvesting heavily infected plants so as to capture some return on the crop before fruit lesions develop. Fruit that are entirely or dark green will not likely ripen, but can be sold green. Fruit with subtle yellow or blush color can ripen off the vine. Continue to monitor the fruit post-harvest as there may be a latent infection – infected but not yet symptomatic. Fruit that are not showing symptoms but that were harvested from plants with lesions are safe to consume. Please see link regarding food safety precautions for processing/canning tomatoes with late blight, below (from Dr. Barbara Ingham, UW-Madison Food Science. In sum, late blight lesions aren't a health risk, but lesions are damaged tissue and bacteria can enter which may pose a risk for illness.

http://fyi.uwex.edu/news/2009/08/26/tomatoes-and-potatoes-infected-with-late-blight-are-they-safe-for-eating-or-preserving/

In Wisconsin: Sixteen counties in Wisconsin have submitted samples which were confirmed for late blight in potato and/or tomato. While I don't maintain a comprehensive list of how many fields were infected by county, the disease has been detected in several fields within each of the counties I have listed below. In all cases in which we have tested, the *Phytophthora infestans* is of the US-23 genotype. Reports are listed below. The US-23 genotype is sensitive to conventional phenylamide fungicides such as mefenoxam and metalaxyl (ie: Ridomil Gold SL). The use of antisporulant fungicides (ie: Forum, Previcur Flex, AgriTin, Revus Top, Zampro, Ridomil) is critical to manage late blight in a field. In organic systems, copper containing fungicides continue to prove most effective and provide greatest broad spectrum disease control in tomato and potato. EF-400 and BacStop (Anjon Ag) also provides control of late blight as seen in replicated open field trials in MI in recent years.

Date of Confirmation	County (general location)	Host	Late blight pathogen genotype
23 June	Adams (northern)	Potato	US-23
8 July; 24 July; 29 July	Waushara (western)	Potato; Tomato	US-23
8 July; 28 July; 18 August	Wood (southern, central)	Potato; Tomato	US-23
14 July	Marquette (central)	Potato	US-23
15 July; 28 July; 18 August	Portage (central)	Potato; Tomato	US-23
23 July	Columbia (north central)	Tomato	US-23
23 July	Fond du Lac (north central)	Tomato	US-23
4 August	Polk (southeastern)	Tomato	US-23
12 August	St. Croix	Tomato	US-23
17 August	La Crosse	Potato; Tomato	US-23
17 August	Marathon (central)	Tomato	US-23
17 August	Walworth	Tomato	Not yet determined
28 August	Kenosha	Tomato	Not yet determined
28 August	Brown	Tomato	Not yet determined
1 September	Dodge	Tomato	Not yet determined
4 September	Waupaca	Tomato	Not yet determined

Across the nation: There were new detections of late blight in NY this past week on potato and tomato as posted to www.usablight.org. To date, nationally, there have been confirmations of late blight in FL (US-23), CA (US-11), CT (US-23), ID (US-23), IN (US-23), NC (US-23), TX (not reported on usablight.org/strain not yet identified), WA (US-8), MA, MD (US-23), ME (US-23), MI (US-23), NC, NE, NJ (US-23), NM (US-23), NY (US-23), ON and QC Canada, PA (US-23), TX, VT, WA, WI (US-23), and WV. See map below (blue counties are greater than 7 days old; red county indicates detection made in just the past 7 days). Screen shot grabbed at 2:32PM on 4 September, 2015.

Fungicides are still critical for protection of potato and tomato crops in organic and conventional systems at this time.

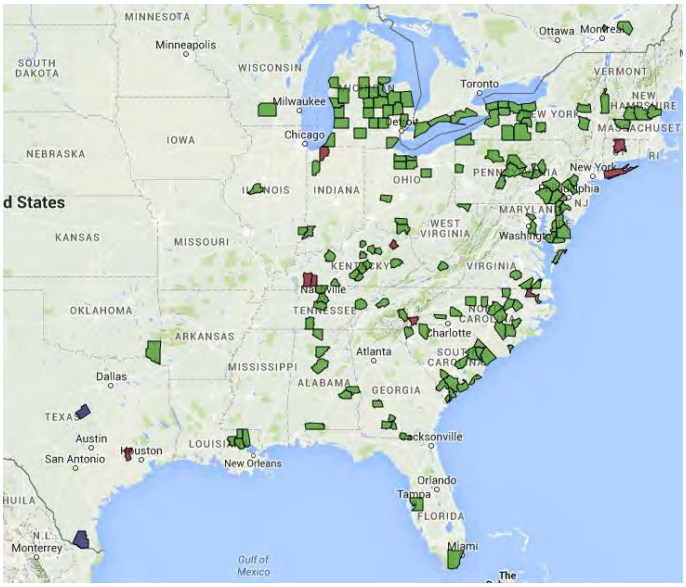
There is not one recommended fungicide program for all late blight susceptible potato (and tomato) fields in Wisconsin. Fungicide selections may vary based on type of inoculum introduction, proximity to infected fields, crop stage, late blight strain, and other diseases that may be in need of management. Please see UWEX Veg Crop Updates article on fungicide

selections from June 5 at link below. Fungicides for organic systems and home garden fungicides can also be found at my website.
http://www.plantpath.wisc.edu/wivegdis/pdf/2015/June%205,%202015.pdf or a listing of 2015 WI potato late blight fungicides:
http://www.plantpath.wisc.edu/wivegdis/pdf/2015/Potato%20Late%20Blight%20Fungicides%202015.pdf

If you suspect/detect late blight, have the disease confirmed (free diagnostics through my lab and the UWEX Plant Disease Diagnostic Clinic) and we can genotype for further information on the nature of the pathogen.

Further details on registered fungicides for WI vegetables can be found in the Univ. of WI Commercial Vegetable Production in WI Guide A3422, http://learningstore.uwex.edu/assets/pdfs/A3422.PDF.

Cucurbit downy mildew updates: Cucurbit downy mildew was identified on melon this past week from Dane County. We have had previous detections of downy mildew on organic winter squash in Dane County (8/21/15), as well as cucumber and cantaloupe from Dane County (7/20/15). In the past week, downy mildew was confirmed in CT, IN, KY, NC, NY, and TX. Prior reports of the disease have been confirmed in AL, DE, FL, GA, IL, IN, KY, LA, MA, MD, MI, NC, NH, NJ, NY, OH, OK, ON Canada, PA, QC Canada, SC, TN, TX, VA, WI, and WV. For more information, visit: http://learningstore.uwex.edu/Assets/pdfs/A3978.pdf. Past newsletters provide fungicide recommendations for downy mildew on cucurbits in WI.



Map of recent (red counties) and past (green counties) reporting cucurbit downy mildew in the U.S. through the http://cdm.ipmpipe.org/ website. The map was sourced at 2:38PM on September 4, 2015. **We need to keep an eye out for this disease on all cucurbits as it has been identified on cucumber, cantaloupe, winter squash, pumpkin, and watermelon in upper Midwestern states.**

Managing Late Blight in Organic Tomato & Potato Crops

Amanda J. Gevens
Extension Plant Pathologist, University of Wisconsin, Madison, WI 53706
Phone: (608) 890-3072, Email: gevens@wisc.edu
Updated September 4, 2015

Disease Description & Status of Disease in WI: Late blight is a potentially destructive disease of tomatoes and potatoes caused by the fungal-like organism, *Phytophthora infestans*. This pathogen is referred to as a 'water mold' since it thrives under wet conditions. Symptoms of tomato or potato late blight include leaf lesions beginning as pale green or olive green areas that quickly enlarge to become brown-black, water-soaked, and oily in appearance (Figure 1). Lesions on leaves can also produce pathogen sporulation which looks like white-gray fuzzy growth (Figure 1, 2). Stems can also exhibit dark brown to black lesions with sporulation. Fruit symptoms begin small, but quickly develop into golden to chocolate brown firm lesions or spots that can appear sunken with distinct rings within them (Figure 2); the pathogen can also sporulate on tomato fruit giving the appearance of white, fuzzy growth. The time from first infection to lesion development and sporulation can be as fast as 7 days, depending upon the weather. In WI, as in several other U.S. regions, late blight has been identified on tomatoes and potatoes in each of the last 6 years. On June 24, 2015, we confirmed late blight on potato in northern Adams County, WI. Since that time, 15 more WI counties have had confirmed late blight on tomatoes and/or potatoes. It is important to protect susceptible crops with fungicides in both conventional and organic production systems.

Figure 1. Symptoms of late blight on potato tuber and leaves. A. Note brown-rust colored firm discolored tuber tissue. B. Late blight lesion on potato leaf. Lesions appear brown and papery when weather turns dry or after fungicide use. C. Underside of leaf showing late blight pathogen producing spores.

Figure 2. Symptoms of tomato late blight on tomato leaves and fruit. A. Entire row of plum tomatoes with dead foliage due to late blight. B. Brown, firm, late blight lesions on 'Roma' tomato fruits. C. Late blight lesion on tomato leaf. Note brown, water-soaked lesion with white pathogen sporulation. D. Close up of brown, firm, late blight lesion on green tomato fruit. E. Sporulating late blight lesion around the stem and shoulders of a ripening tomato fruit.

Management: The strain of *Phytophthora infestans* from all field infections from Wisconsin that have been tested, to date, is US-23. Most of the late blight detected in WI last year, as well as in the rest of the U.S. (in both 2014 and to date in 2015) is type US-23 which is known to be aggressive on potato and tomato, and is of the mating type A1. In our research, we have demonstrated that the US-23 type will infect tomato, potato, hairy nightshade, black nightshade, and petunia; select cultivars of eggplant, pepper, and tomatillo did not become infected. US-23 produces roughly twice as many spores per lesion as other late blight genotypes and has great potential to rapidly reproduce and spread. Some cultivars have resistance to late blight and are listed in Table 1. Note cultivars containing both *Ph-2* and *Ph-3* resistance genes are most resistant (recent release 'Iron Lady' is robustly resistant). Several varieties also exhibit some resistance including 'Pruden's Purple' and 'Matt's Wild Cherry.' Potato cultivars with some resistance to late blight include 'Jacqueline Lee', 'Defender', and 'Satina.'

Dr. Meg McGrath of Cornell University has an outstanding tomato variety document on late blight resistance that I strongly encourage you to read for further information on varietal performance. Her data is very current and useful. The link is: http://www.extension.org/pages/72678/late-blight-management-in-tomato-with-resistant-varieties#.VYq8dkYSyqE

The disease forecasting tool (Blitecast) indicates risk times for late blight activity and can aid in identifying critical times for preventative fungicide applications. To access Blitecast information for Wisconsin, please go to: http://www.plantpath.wisc.edu/wivegdis/index.htm. Once late blight has moved into a region, it is critical that tomato and potato plants be protected. Fungicides must be present on foliage in order to have a protective, disease-limiting effect. Because new growth is not protected and fungicides can wash off, repeat sprays are necessary. Little disease control can be had when fungicide applications are made only after disease onset. A 2007 study compared copper and non-copper containing organic-approved fungicides (such as Sonata, Serenade, and Oxidate) for late blight control on potato. Results from replicated trials showed that the best organic-approved fungicide for potato late blight control was copper (Dorn, et al. 2007. Control of late blight in organic potato production: evaluation of copper-free preparations under field, growth chamber, and laboratory conditions. Eur. Journal of Plant Pathology 119:217-240). Copper containing fungicides have provided some of the best preventative control against late blight in multiple U.S. trials in recent years as well. Table 2, below, lists some of the certified organic copper formulations (please check up on the allowability of specific formulations if you are certified organic).

In the past few years, we've been investigating efficacy of non-copper organic fungicides and have demonstrated good control of tomato late blight with EF-400 under laboratory conditions. Dr. William Kirk of Michigan State University has conducted field trials with EF-400 plus ExCit (now BacStop) on potatoes and corroborated our laboratory efficacy results. Good field control of potato late blight was demonstrated with weekly applications of EF-400 + ExCit for 8 weeks. Further information on these organic products can be found at: http://anjonag.com/crop-management/ef400-fungicide/

We tested several organic fungicides (and made a few conventional comparisons) (Figure 3 below). Zonix (a rhamnolipid from Jeneil Biosurfactant Company) and EF400 (formerly US Agritech, now Anjon Ag) performed well when applied before inoculation (prior to disease onset). However, recent field tests with Zonix from other states (PA and NC, specifically) have documented poor control of late blight when used in an open field setting with multiple cycles of the pathogen (typical for 'real world' late blight). EF400 has continued to perform well. Fungicides have the best chance of effectively managing disease when applied before disease starts – this is true for all fungicides, conventional and organic. While Oxidate didn't perform well, keep in mind that it is a contact antisporulant and will kill spores on contact, but will not provide lasting control as a protectant. It has a place to manage spore load, but can't be relied upon solely to prevent late blight.

Late blight can be managed in an organic system, but control measures need to be proactive and sustained. In the circumstance when late blight gets out of control, early harvest and crop destruct options must be considered to limit development of inoculum that could pose heightened risk for area producers. This is a community disease – management by all growers of susceptible crops is necessary.

Table 1. Tomato cultivars tested for late blight resistance against the US-22, US-23, and US-24 clonal lineages of *Phytophthora infestans* and their resistance/susceptibility response.

Cultivar[v]	Selection Parameter[w]	AUDPC Lesion Length[x]			AUDPC Pathogen Growth[y]		
		US-22	US-23	US-24	US-22	US-23	US-24
Wapsipinicon	Field observation	80.5a[z]	116.2a	12.6a	72.5a	155.0bcd	0.0a
Mountain Magic	*Ph-2* and *Ph-3*	96.1ab	67.1a	49.8ab	73.8a	22.5a	27.5ab
Matt's Wild Cherry	Seed company	87.6ab	128.7ab	22.2ab	70.0a	118.8ab	10.0a
Pruden's Purple	Other research	177.0abc	153.0ab	48.4ab	180.0ab	136.3abc	20.0ab
Legend	*Ph-2*	213.6cd	161.5abc	79.2abc	271.3bc	201bcde	96.3abcd
Plum Regal	*Ph-3*	243.9cde	137.5ab	110.6bc	206.3b	147.5bcd	106.3abcd
Juliet	Seed company	180.0bc	214.0bcd	108.2abc	228.8b	246.3cdef	150.0cd
Roma	Field observation	257.3cde	251.8cd	81.7abc	272.5bc	261.3def	48.8abc
Slava	Other research	249.3cde	277.1d	100.5abc	271.3bc	293.8ef	136.3bcd
Green Zebra	Other research	321.0e	295.5d	114.9bc	365.0c	322.5f	152.5cd
Brandywine Red	Susceptible control	293.7de	304.1d	160.9c	268.8bc	285.0ef	205.0d

[v] Mountain Magic, Plum Regal, and Juliet are hybrids. Legend was bred to contain *Ph-2* resistance, but is open pollinated, so is considered an heirloom by some. The remaining cultivars are heirlooms.
[w] Cultivars were selected based on anecdotal field observations from 2009, claims by seed companies of late blight resistance, field trials using other *P. infestans* clonal lineages (12, 32) or the presence of resistance genes *Ph-2* and/or *Ph-3*.
[x] Lesion length was measured at 0, 5, 7, and 9 days after inoculation and area under the disease progress curve (AUDPC) was calculated.
[y] Percent leaf coverage of pathogen growth was determined at 0, 5, 7, and 9 days after inoculation and area under the disease progress curve (AUDPC) was calculated.
[z] Values in each column followed by the same letter are not significantly different (Tukey test, P=0.05).

Table 2. List of OMRI approved copper fungicides. Please note that this list is not comprehensive, but rather represents those most commonly used and likely available copper formulations. Check with your certifying agency if you have any questions or concerns with product selection.

Copper product (OMRI approved)	**Manufacturer**
Champ WG	NuFarm Americas, Inc.
COC WP	Albaugh, Inc.
Cueva Fungicide Concentrate	W Neudorff GmbH KG
Cueva Fungicide Ready-To-Use	W Neudorff GmbH KG
Nordox® 75 WG	Nordox AS
Nu Cop® 50 WP	Albaugh, Inc.
PHT Copper Sulfur Dust	J.R. Simplot Company
Basic Copper 53	Albaugh, Inc.
Copper Sulfate Crystals	Chem One, Ltd.
Quimag Quimicos Aguila Copper Sulfate Crystal	Fabrica de Sulfato El Aguila, S.A. de C.V.

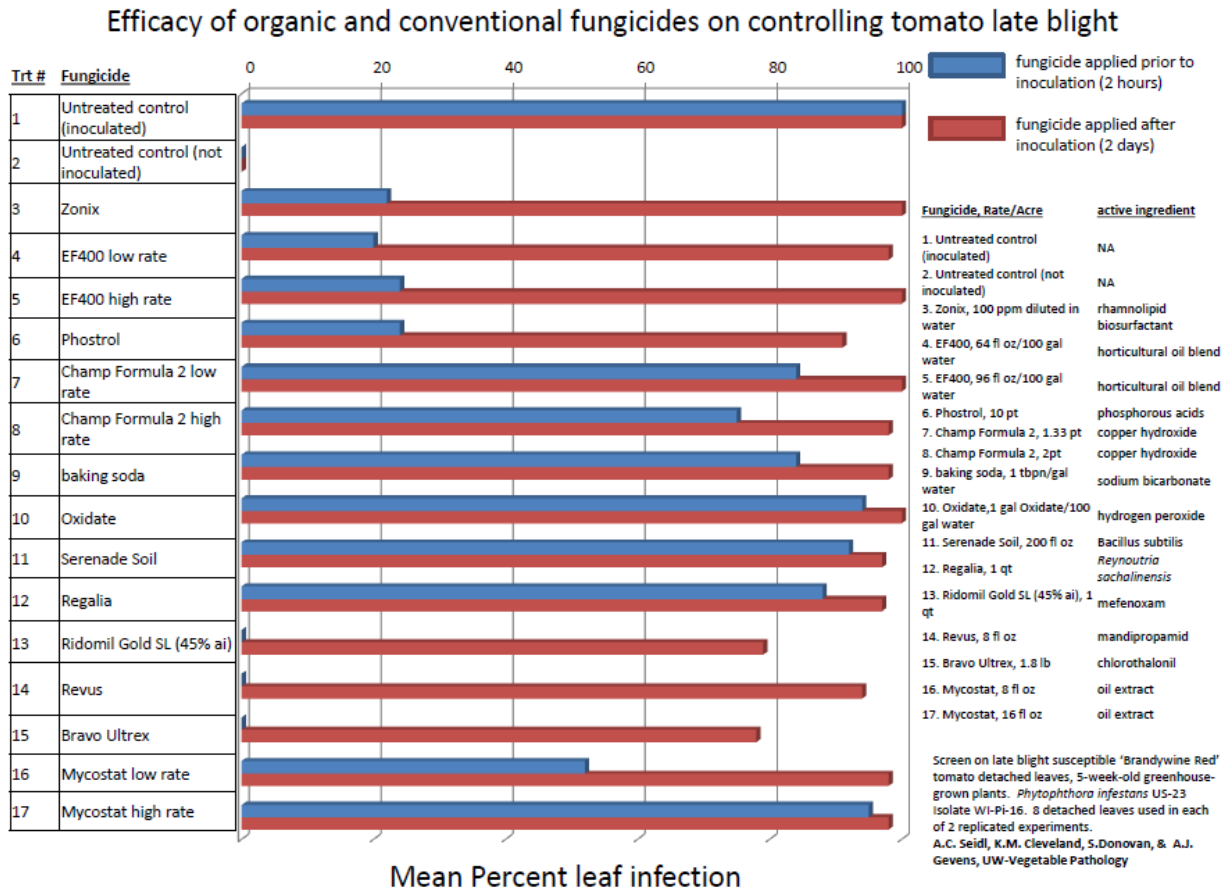


Figure 3. Comparison of common organic and comparative conventional fungicides for the control of tomato late blight (US-23 genotype) when applied before and after pathogen inoculation.

Frequently asked questions

Where did this late blight come from?
It is uncertain as to where this late blight came from in 2015. We know late blight can potentially come from late blight-infected potato seed. Other potential sources may be infected tomato transplants or airborne spores from the region. At this time, national reports of late blight have come from FL, CA, NC, TX, and now WI. The website: http://www.usablight.org/ indicates location of positive reports of late blight in the U.S. and provides further information on disease characteristics and management.

Where can I find more information on tomato and potato late blight symptoms and management?
http://www.extension.org/article/18351
http://www.extension.org/article/18361
http://www.attra.org/attra-pub/lateblight.html
http://www.plantpath.wisc.edu/wivegdis/

How do I destroy and/or dispose of my late blight-infected tomato plants?
There are several methods of destroying infected plants: 1) pull up plants by the roots, bag, leave in the sun for a few days for plant and pathogen to die, and put out for trash pickup. This method is OK for a few plants. 2) For many infected plants, plants can be cut at the base and allowed to die in place. Once plants are dead, you can go in and remove stakes, strings, and plastic and dead plant material can be incorporated into the soil. Shallow incorporation of debris is recommended to avoid creating a warm, sheltered environment which would keep the plant tissue and pathogen alive for extended periods of time beneath the soil surface. 3) Plants can be flame-killed with a propane or other torch; and 4) infected

plants can be pulled and placed in a small pile covered over with a dark colored plastic tarp and left in the sun. This will create heat in the pile from the sun beating on the plastic tarp and plants will die within a few days. The winter will provide an excellent freeze kill for exposed infected plants. Do not compost late blight infected plant material, as many piles may have warm centers that can allow plant material and the pathogen to remain viable. The goal is to kill the plants and this will kill the pathogen.

Are tomato fruits from late blight infected tomato plants safe to eat?
Healthy-appearing fruit from late-blight-infected tomato plants are safe for human consumption. If they have been infected, but aren't yet showing symptoms, they won't keep in storage. There are some concerns about canning infected fruit because bacteria can enter late-blight infected fruit and impact quality. UW-Extension food science extension specialist, Dr. Barbara Ingham recommends avoiding canning tomatoes that exhibit late blight infection. Further information can be found at: http://fyi.uwex.edu/news/2009/08/26/tomatoes-and-potatoes-infected-with-late-blight-are-they-safe-for-eating-or-preserving/

How fast will late blight infected plants die?
This depends upon how many points of infection the plant received, the cultivar (some cultivars are more susceptible than others), the history of use of protectant fungicides (such as copper), and on the weather. Hot, dry, sunny weather typically holds back late blight; whereas cool, rainy, overcast weather will cause late blight to progress rapidly killing the plant in 7 to 10 days.

I have tomato or potato late blight in my garden – will I get it next year if I plant tomatoes again?
The strain of the late blight pathogen that we currently have in WI cannot survive outside of living plant tissue. Our strain or 'type' of late blight is ***probably*** US-23 which is known to be an A1 mating type. What does this mean? Much like we have male and female 'mating types' in our human population, the late blight pathogen requires an A1 and A2 mating type to be present together to form persistent, overwintering, long term spores (oospores). Oospores can persist in soil for many years. However, without a compatible mating type in WI (we do not have any A2 strains at this time), there are no oospores produced and there is no risk of this season's late blight residing in the soil over winter. To reiterate, the late blight pathogen that we currently have in WI will not overwinter in the soil on its own. It requires living plants or plant parts to remain viable and infective. Therefore, it is critical to kill infected tomato plants and plant parts such as fruit. Potato tubers can also serve as a source of overwintering inoculum and should also be destroyed if found to be infected with the late blight pathogen.

Can late blight be seedborne in tomatoes?
Generally, the late blight pathogen is not considered a seedborne pathogen in tomato.