Managing Late Blight in Organic Tomato & Potato Crops

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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.

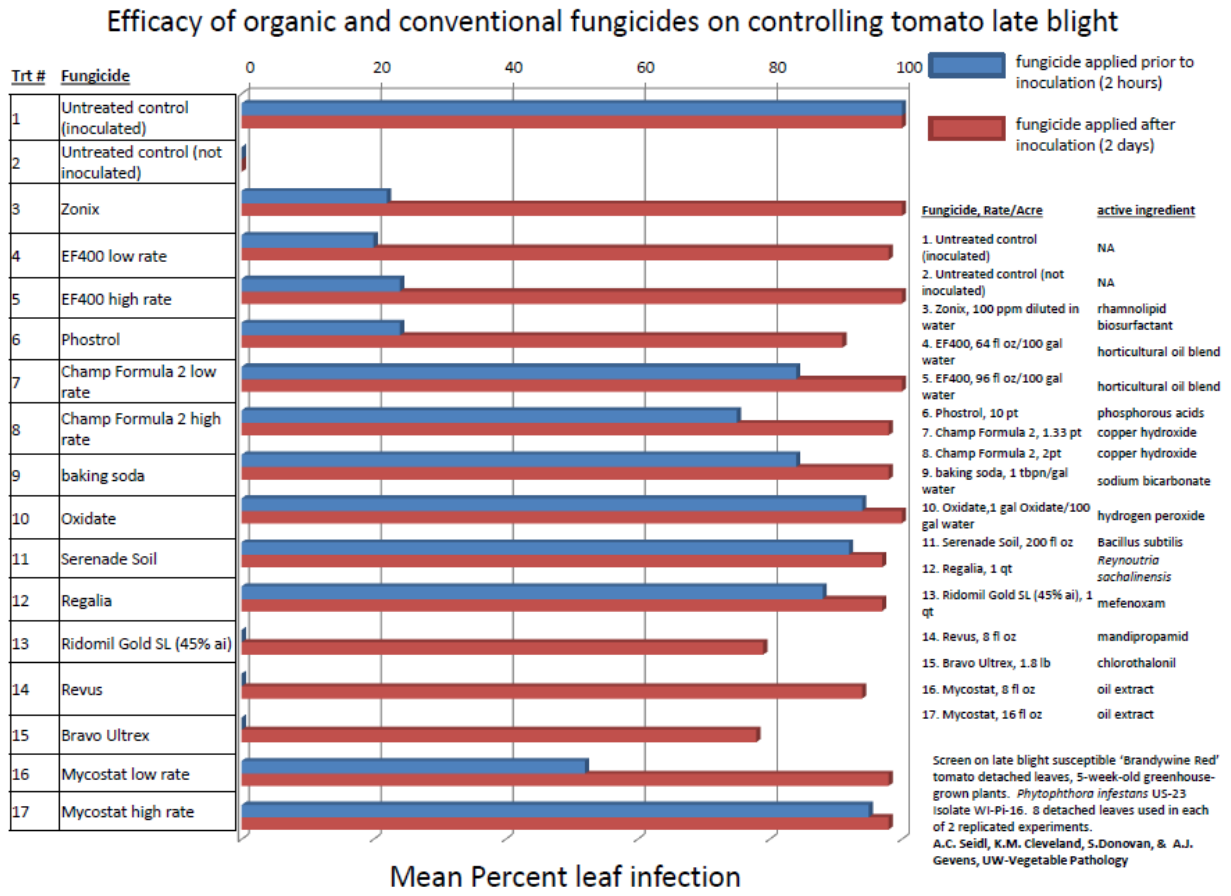

Figure 3. Comparison of common organic and comparative conventional fungicides for the control of tomato late blight (US-23 genotype) when applied before and after pathogen inoculation.

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.