



Cornell University

Late Blight: Frequently Asked Questions By Gardeners, Growers, & Consumers

Updated 8/26/2009

Prepared by Margaret Tuttle McGrath, Department of Plant Pathology and Plant-Microbe Biology, Cornell University, Long Island Horticultural Research and Extension Center, Riverhead, NY

Note: More answers will be added as new questions are asked.

When you observe the devastation of late blight in your garden or crop, be thankful that you, unlike the Irish people in the mid 1800s, are not dependent on those plants for your sustenance and try to imagine what it was like for those people to watch their plants die with no knowledge of what was happening and no tools to manage it even if they did know.

1. What is late blight?

Late blight is a very destructive and very infectious disease that affects tomato and potato (not sweet potato). It is the same disease that led to the Irish Potato Famine in the 1840s. It is caused by the fungal-like pathogen, *Phytophthora infestans*. Late blight occurs regularly but very sporadically in the Midwest and Northeastern U.S.A. It often develops in major potato production areas because potato tubers have been the main source of initial inoculum for disease development in these regions. The pathogen has not been able to survive outside of living plant tissue. Late blight occurs very sporadically due to aggressive management programs on commercial farms, which limit the quantity of wind-dispersible spores produced by the pathogen on leaves, the fact wind doesn't generally move southward from major potato production areas in the northern part of the region toward areas where there is more tomato production and gardens, and the pathogen strain that has been occurring in potato is not as aggressive on tomato.

2. Are all tomatoes and potatoes in the northeastern US doomed to get late blight this season because of the wet weather?

No. In addition to requiring that there be favorable conditions (cloudy, rainy, and not too hot) and a susceptible plant (tomato, potato, and some related weeds), late blight cannot develop unless the pathogen that causes this disease is also present.

This disease normally occurs sporadically in the Northeast, and rarely in many parts, because the pathogen is usually not present. For late blight to develop in a particular garden or field the pathogen has to be there, which it accomplishes by being brought in on infested potato seed tuber pieces or infected tomato

transplants or blown in as spores (which function like seeds for pathogens) from affected plants in another location.

Some plants may 'escape' late blight if the pathogen does not get on them. However, the chances of this happening this year are very low based on the fact occurrence of late blight is very widespread very early in the summer growing season.

3. What other diseases could be confused for late blight?

There are several diseases that can cause dark spots on leaves and stems of tomato and potato plants. Most of these are smaller than those due to late blight. Botrytis gray mold is the most similar. It is always best to have plant tissue with suspected disease symptoms examined in a plant diagnostic clinic.

4. If I grew my own tomato plants from seed do I need to worry about late blight?

Yes. While the pathogen does not have a means to get into seed and it cannot survive on seed, this year there will be a lot of wind-dispersed spores with so many occurrences of late blight widely distributed in the eastern U.S. this early in the season. These spores can be moved long distances.

5. Are tomatoes grown in greenhouses or high tunnels protected from late blight?

No. In fact at some farms the tomatoes in high tunnels have been more severely affected than those in the field! The pathogen that causes late blight needs only high humidity to infect. Thus it is similar to the pathogens that cause gray mold and leaf mold, which commonly occur in tomatoes grown in these protected environments where humidity typically is higher than outdoors. Leaves need to be wet for other pathogens to infect; additionally, several need splashing water for dispersal, thus Septoria leaf spot, early blight and bacterial speck/spot are uncommon in protected tomatoes. The sides of high tunnels are rolled up on hot days, thus these structures do not provide a barrier that prevents spores of the late blight pathogen from getting to the plants inside. Greenhouses provide better protection, but most have vents and thus are not completely sealed.

6. Can late blight be suppressed in greenhouses and high tunnels by maintaining high temperatures?

High temperature likely will slow disease development since cool temperatures are favorable for most strains of this pathogen. However, excessive heat can be detrimental to tomatoes. Temperature should be kept below 90 F. Pollen can be killed when above 90 F, which affects pollination resulting in small or puffy (flat sided) fruit. Additionally lycopene is destroyed resulting in fruit with poor red

color, streaking, green shoulders, etc. Internode length will increase. Plants will be stressed. And they are more likely to wilt leading to problems like blossom end rot.

7. Can plants be saved in a garden once late blight starts to develop?

This depends on amount of symptoms seen, type of symptoms, how early in disease development symptoms were found, environmental conditions, proximity to other gardens or farms where late blight is developing, and management steps being taken.

It is more likely possible to save plants in a garden if when the first symptoms are found:

1. There are very few.
2. They are on the leaves and not stems.
3. The garden has been inspected very thoroughly on a frequent basis (preferably daily) and thus the symptoms are discovered shortly after they formed.
4. Conditions are expected to be hot with no rain or lengthy dew for a prolonged period.
5. There are no nearby places with late blight that could be a source for more spores.
6. Further development of late blight will be slowed by regularly removing affected tissue (daily cut off and bag, preferably during the day when plants are dry and there will be sunshine for several hours afterwards) and applying fungicides (minimum of weekly).

Additionally, success is more likely if fungicides were applied before symptoms were seen (thus there will be fewer initial symptoms) and spray coverage is maximized by using a pressurized pesticide sprayer to plants that are trellised. Removing extra branches will also help.

Realize that even with an ideal situation (all above conditions met) there is no guarantee that success will be achieved. Late blight is a very destructive and difficult to manage disease. Impact can be great considering that tomato fruit and potato tubers that become infected can quickly rot.

Plants can be killed quickly when late blight is not managed. A spot (lesion) can form within 4 days of when a spore lands on a plant (even faster, less than 3 days, with one strain of this pathogen) and a day later be producing spores that can be dispersed by the wind to healthy plant tissue resulting in more spots within a few days. Lesions that develop on stems are especially destructive.

Late blight needs to be aggressively managed not only to try to save plants in the garden but also to avoid having the affected plants serve as a source of

inoculum (wind-dispersed spores) for other gardens and farms. Promptly remove affected plant tissue on a regular basis.

Realize that when symptoms are first seen, all points of infection likely are not yet visible. There is a 'latent' period of a few days between infection and when symptoms are visible. As a result, initially fungicides may appear to be not working when applications are started after symptoms are found. No fungicide can cure tissue that is already affected, and this tissue will produce more inoculum. Thus it can be impossible to stop late blight when there are a lot of symptoms.

Also rogue out any volunteer tomato plants growing from seed of previous year's tomatoes and susceptible weeds like bittersweet nightshade. Given the amount of effort to try to save a garden once late blight starts to develop, especially when it is early in the season, and the chance the crop will be destroyed despite the effort, especially if fungicides are not applied frequently, the best option when late blight occurs might be to replace the plants with something like spinach or lettuce that grows quickly.

8. Can plants be saved in a farm planting once late blight starts to develop?

Yes. Growers are able to effectively control late blight, especially potato growers with experience from being in an area when this disease occurs regularly. It is easier to manage late blight on a farm than in a garden because of the fungicides that can be used. Growers using conventional fungicides can use products able to move within the leaf that the spray lands on. Some fungicides can move into stems and new growth. None of these mobile fungicides are approved for organic production.

Growers also have sprayers that can achieve better coverage of plant tissue than hand sprayers used by gardeners. Thus growers can be more successful than gardeners even when they use the same fungicides. As with a garden, success is affected by whether or not fungicides were applied before symptoms were seen and how severely the crop is initially affected if fungicides were not applied.

Typically growers begin applying a broad-spectrum, contact* fungicide when conditions are favorable for late blight, inspect their crops regularly, and when symptoms are found start applying fungicides with specific activity for late blight. They also manage the usual initial source of the pathogen: affected tubers from the previous year or used as seed. See also answer to previous question.

9. Do I really need to apply fungicides preventively to control late blight?

If fungicides are not applied preventively, there is a risk that when this disease begins to develop, there will be too many symptoms to achieve control.

Fungicides cannot 'cure' a spot that has already developed (disease control in plants is very different from humans). This tissue will soon die, but before it does the pathogen will produce hundreds of spores. The more spores, the greater the odds some will be dispersed to plant tissue that has not received fungicide.

It is difficult to achieve complete coverage of plant tissue with fungicide, especially when a contact* fungicide is used, even with the best farm sprayer. The underside of leaves is an especially difficult area to reach (the pathogen can infect through either surface), which is why growers who can use fungicides able to move through leaves are better able to control late blight.

Only contact* fungicides are available to gardeners. Note that there are precautions that need to be taken when applying fungicides. Read the label to determine what protective equipment is required (e.g. water-proof or chemical-proof gloves, shoes plus socks, long pants, long-sleeved shirt, goggles, respirator).

10. Do I really need to apply fungicides frequently to control late blight?

Yes. Fungicides applied on a plant, even those that get inside of the plant, disappear over time due to being broken down biologically or by sunlight and/or being washed off by rain or irrigation. After about 7 days the concentration (dose) of many fungicides can be too low to be adequately effective.

11. Do I need to be concerned about bees when I spray fungicides?

Chlorothalonil and copper fungicides have been rated 'relatively nontoxic' to bees. Insecticides are a much greater concern generally than fungicides.

Additionally tomato and potato are pollinated mostly by wind and not commonly visited by bees compared to some other crops. To avoid exposing bees to pesticides, apply them during late afternoon or early evening when bees are less active. Applying when there is no wind minimizes the chance of drift to other plants that bees visit more commonly.

12. Can late blight be exacerbated by handling plants, such as during pruning and trellising tomatoes?

Possibly, but the quantity of spores dislodged by the plant movement that occurs during these activities might not be more than what would occur naturally by wind. Human impact on pathogen spread is expected to be much less with late blight than with a pathogen like the one causing bacterial canker, which is in the sap of plants, can be picked up on hands and any tools, can be deposited while handling another plant, and can enter a plant through wounds that occur during

pruning and trellising. Better spray coverage can be achieved when plants are pruned and trellised rather than left to grow on the ground.

13. Should potatoes be harvested early?

Maybe. When to dig depends on late blight severity, management practices, risk of this infection to other plantings, and environmental conditions. Early harvest should be considered if there are other plantings of potato or tomato without late blight in the general vicinity, and fungicides are not being applied for late blight to the affected potato planting. Potato tubers are susceptible. They are more likely to become infected when late blight symptoms are on stems, rather than just on leaves, because rain is more likely to wash spores from stems down to tubers. The pathogen is better able to infect when soil is cool (below 54 F is most favorable) and wet.

Harvesting as a preventive measure is not usually warranted; however, this might be a worthwhile consideration where the crop is not being inspected for symptoms, there is not an action plan that can be immediately implemented when late blight develops, and there is a concern that any affected tubers will not be properly managed. An affected tuber left in the ground or tossed on a compost pile could grow next year into an affected plant that serves as inoculum to start another epidemic!

Tubers are routinely left in the ground for about 2 weeks after the plants die (or the vines are killed mechanically or chemically) in order for the skins to set. During this time tubers already affected by blight might rot. It is also best to harvest when soil is dry, before a significant rainfall, and after foliage affected by late blight has died to avoid exposing tubers to those spores. Avoid bruising and skinning while harvesting which will make tubers more susceptible to infection. Harvest thoroughly: infected tubers are the usual main source of the late blight pathogen.

14. What should be done with affected plants when late blight cannot be controlled?

Affected plants should be promptly destroyed to minimize the potential for them being a source of spores for other plantings. Growers can kill them with a very fast-acting herbicide like diquat (glyphosate is too slow). Burning with a propane flamer is another option. Or plants can be pulled out and put in a garbage bag (suitable for small plantings) or either piled and covered with a tarp or buried deeply. The best time to pull plants is a sunny day because UV radiation can kill spores dislodged in the process, but don't wait several days for this to occur. Leave the bagged plants for a few days in a sunny spot so heat will build up inside and kill the plants before they are put out with trash. Heating will also occur under a tarp. The late blight pathogen cannot survive in dead plant tissue, unless oospores are formed. Oospores are unlikely to be present because

formation requires interaction between individuals of the pathogen (aka isolates) of opposite mating type (equivalent of male and female). All isolates tested so far have been the same mating type. The pathogen can survive in potato tubers because these are living; therefore, destroying affected tubers is extremely important.

15. Can plants with late blight be disposed of by composting?

Yes if done correctly. Considering the potential impact of not composting correctly, especially with potato plants that have tubers, it is prudent for home gardeners to bag and trash the plants (see previous question). Plants should not just be dumped on a compost pile. Either cover with a tarp or bury them so that there is not an opportunity for spore production and dispersal by wind to another planting or farm before the plant tissue completely dies. Based on results from a laboratory study, temperatures above 115 F, which commonly occur in proper compost piles, are adequate to kill even the pathogen's most durable type of spore (oospore) within 2 hours. Oospores are unlikely to be present because formation requires interaction between individuals of the pathogen (aka isolates) of opposite mating type (equivalent of male and female). All isolates tested so far have been the same mating type.

Guidelines have been developed on composting cull potato tubers for commercial operations:

<http://www.umaine.edu/umext/potatoprogram/Fact%20Sheets/Composting%20Cull%20Potatoes.pdf>.

16. Are there any health issues from breathing spores of the late blight pathogen such as could happen when pulling up affected plants?

None known. There is one scientist who has been studying late blight for many years and is a good test case for health issues since he is allergic (asthmatic) by inhalation to flour, as well as components of livestock feed and hay. He has not experienced any health issues from inhaling large quantities of spores over more than 30 years (1973 to 2007), nor has anyone who has worked with him during all those years. No published scientific study has been conducted on this specific issue, however. Anyone concerned about breathing spores could wear a dust mask to reduce exposure.

17. Could the late blight pathogen survive on tomato cages and stakes between seasons?

No. Therefore it is not necessary to discard or even disinfect the cages or stakes to manage this disease. Stakes and cages should be disinfected however, especially if bacterial diseases also developed in the planting. Disinfectants include: quaternary ammonium chloride salts (e.g. Green-Shield), sodium hypochlorite (Clorox or other household chlorine bleach; these are 5.25%; use at

0.5% = 1 part bleach + 9 parts water), and hydrogen dioxide (e.g. OxiDate). Clean off soil and organic matter first because this inactivates disinfectants and can protect pathogens that are inside. This is especially important when using bleach. Soak at least 10 minutes. Disinfectant solution can be reused until it becomes dirty or ineffective (replace Green-Shield after 24 hours; half-life for bleach is only 2 hours).

18. Could the late blight pathogen survive in soil between seasons?

Unlikely except in affected potato tubers. This is an obligate pathogen that is thought to only be able to survive in living plant tissue in the northeastern U.S. It can produce a specialized structure (oospore) that would enable it to survive without living plant tissue, but this requires that the pathogen reproduce sexually which it is not thought to be able to do in the northeastern U.S. So far only one "mating type" has been found in the Northeast. This is the term used for the pathogen's equivalent of male/female. Thus the pathogen has only been able to reproduce asexually. The characteristic white growth that develops on late blight affected tissue contains many asexually-produced spores. Both mating types have been found in Florida.

19. Could the late blight pathogen survive between seasons on perennial weeds that it is able to infect (e.g. bittersweet nightshade and hairy nightshade)?

No. This is an obligate pathogen that needs living plant tissue to survive. It only infects foliar tissue of weeds. Since the pathogen cannot infect roots, it cannot survive on weeds in areas where foliage is killed by cold temperatures. In the Northeast, potato tuber is the only plant tissue it is able to survive in.

20. Could the late blight pathogen survive in or on tomato seed?

No. Fortunately this pathogen is not able to get inside seed and it does not produce a type of spore that is able to survive the dry conditions on the outside of a seed. Thus there is no concern that late blight will develop as a result of growing plants next year from seed that were in tomato fruit affected by late blight. There are other pathogens that can be in or on seed, however, thus there are other reasons to use seed from healthy plants.

21. Could tomatoes and potatoes become affected by blight after they are harvested?

Yes. Tomatoes and potatoes can be infected but appear healthy. Additionally, the pathogen can spread in a moist environment from affected to healthy tomatoes and potatoes. Produce from affected plants should be checked regularly and not kept long to avoid losses. Consumers should be aware that the shelf life may be shortened.

22. Could marketing affected tomatoes and potatoes be a means of spreading the late blight pathogen?

Yes, especially if the affected produce is discarded on a compost or cull pile near tomato or potato plants. This is primarily a concern with potatoes. Consumers should be instructed to put affected tissue into the trash rather than the compost.

23. Are the unaffected parts of blighted tomatoes and potatoes safe to eat?

Yes the unaffected parts probably are safe to eat. Tomato sections without blight symptoms likely do not pose a health risk to the consumer. They may not look appetizing and will have an off flavor. However, no published scientific study on this specific issue was found to confirm this conclusion. On the other hand, there also have been no reports of a health problem possibly associated with consuming tomatoes or potatoes affected by late blight to warrant such a study. One study documented no association with birth defects. Late blight has been affecting tomato and potato plants for a long time, and there have been years when several crops were affected due to lack of adequately effective control measures. Thus there might have been enough consumption over the years for any problem to be revealed. Additionally, there is a story that someone ate blighted potatoes many years ago to dispel the myth that blight was associated with typhoid.

The conclusion that unaffected tissue is safe to consume if diseased sections are adequately removed is based on several points. This pathogen does not produce a toxin that can make people sick, as a few plant pathogens can do. Plant pathogens cannot infect people. No food safety issues have been found with other diseases that affect tomato fruit or potato tubers. Late blight appears to be like other more common diseases, e.g. anthracnose on tomato fruit and pink rot of potato (which incidentally is caused by *Phytophthora erythroseptica*, a pathogen related to that causing late blight), in that these do not appear to affect plant tissue beyond the area of infection. Many home gardeners likely often cut off diseased tissue rather than throw out the entire fruit or tuber having found the healthy appearing part of these to taste fine. To date, this practice has not been associated with any human health issues. Diseases like late blight and anthracnose are not considered a health concern for commercial tomato processing. Fruit are sorted to remove affected ones, but this is because of the impact on fruit quality. For home canning, only disease-free, preferably vine-ripened, firm tomatoes are recommended in the USDA Complete Guide to Home Canning because fungal pathogens may raise tissue pH (which has been supported by recent studies) and thereby allow growth of potentially harmful microorganisms, such as Salmonella.

Deterioration can occur quickly after infection; therefore, affected tomatoes and potatoes should be salvaged and consumed right away.

24. Is it safe to eat tomato fruit with visible fungicide residue?

Yes, but advisable to wash fruit to reduce exposure. Fungicides are the main tool for controlling late blight. Regardless of whether pesticides have been applied, all fresh produce should be washed before consuming to remove dust and other contaminants, which could include organisms that cause food-borne illness.

It is not uncommon for a residue to be visible. Many pesticide spray solutions are cloudy. Many are formulated with ingredients that help improve product efficacy, including 'stickers' that help keep the pesticide on plant tissue to extend the period of time that it is there to protect the plant from infection by pathogens. Residue present at the time of purchase means the fruit has had protection through the marketing process when it also could have been exposed to the late blight pathogen in addition to field exposure.

Instructions on pesticide labels are developed to achieve control without leaving a toxic level of crop residue. Labels are legal documents, thus growers and other pesticide applicators must follow these instructions. Pesticide registration decisions in the U.S. are done by the EPA (Environmental Protection Agency). Products must be reviewed by EPA before they can be sold. New products are evaluated and old ones are re-evaluated every 15 years by EPA to ensure there will be no 'unreasonable adverse effects on humans, the environment and non-target species'. A major component of the registration process for pesticides is determining human toxicity and the amount of residue present when a product is applied the maximum amount according to the label (highest rate and maximum number of applications). Product efficacy is not a component of the decision.

25. Why is there residue on organic tomatoes? Is it safe?

Growers producing organically also need to protect their crops from late blight this year for which there are fungicides that have been approved for organic production. Yes tomatoes with residue are safe. See also previous question.

Copper probably is the main fungicide being used for managing late blight organically. The residue is often bluish. This reportedly is one of the easiest fungicide residues to remove from produce. Additionally, it is only on the fruit surface since it is strictly a contact fungicide and cannot get inside of the fruit as can occur with some conventional fungicides. Copper fungicides are now undergoing the routine re-registration process with EPA that occurs every 15 years for all pesticides. There are no human toxicity concerns associated with produce treated with copper fungicides and, while there is a defined concentration range for these fungicides that can be used for an application, there are no restrictions on the total amount that can be applied to a crop over a season.

Copper is a natural element that is an essential trace mineral for humans and all other organisms that need oxygen (aka aerobic). Many vital human bodily functions are dependent upon copper. It is needed for development and performance of several human systems (nervous, cardiovascular, immune, and reproductive systems plus skin and bone). It plays a role in protecting against cancer and heart disease. The National Research Council recommends 1.5 to 3 mg of copper per day for adults to avoid copper deficiency; an RDA has not been established. There are few toxic effects from copper. Daily intake of copper exceeding 20 milligrams can cause vomiting. However, individuals with Wilson's disease, an inherited genetic disorder, need to watch their copper consumption because their bodies are unable to properly excrete copper and it can accumulate to levels that lead to liver disease and mental retardation.

26. What crops can be grown immediately after tomatoes or potatoes are lost to late blight?

The only crops you wouldn't want to plant are tomatoes or potatoes, which typically it will be too late for anyway. Since the pathogen has a limited host range and cannot survive as a saprophyte on dead plant tissue, it does not matter what is planted immediately after crops lost to late blight. Crops most likely to be successful planted in mid to late summer are those that quickly produce something edible and grow well in cool, fall weather. Spinach, lettuce and other leafy greens are good options. Where harvesting of individual leaves can be done, these crops can begin yielding produce quite quickly. Peas also do well under cool temperatures, but might not produce many pods before a killing frost.

27. Are there resistant varieties?

There are some potato varieties described as having some resistance. These include Elba, Kennebec, Allegany, Sebago, Rosa, Defender, Jacqueline Lee, and Ozette. Elba is considered the most resistant. There are some tomato varieties in the final stages of development expected to be available perhaps as soon as 2010. Mountain Magic is one variety with resistance to early blight and Septoria leaf spot (diseases that occur commonly) as well as late blight.

28. What is the most important thing gardeners and growers can do to prevent another late blight epidemic next year?

Destroy potato tubers that appear to be affected by late blight and also volunteer potatoes that grow next year. The late blight pathogen cannot survive in infested plant debris but it can survive in tubers because only the latter is living tissue. Infected tubers can be destroyed by proper composting, deep burial, or freezing. Freezing can be accomplished by spreading tubers on the soil surface in an area where it get sufficiently cold over winter. Tubers in a pile can be protected from freezing.

29. What has been the impact of the late blight epidemic in 2009?

Major impact has been on home gardeners since they don't know this disease and most don't apply fungicides. Late blight occurs very sporadically and is generally confined to the major potato production areas. Some commercial crops also have been destroyed by late blight and others sustained a lot of loss, especially those being produced organically. This was partly due to outbreaks where growers lack experience with the disease. But many crops, organic as well as conventional, receiving a good fungicide program have been saved. For these growers the impact is increased costs for disease scouting and fungicides plus application expenses, in particular for products that target the late blight pathogen which they don't usually need, as well as a lot of stress. Area impacted by this epidemic began with the Mid-Atlantic and Northeastern states. By mid-summer late blight also had been reported in OH, IN, IL, MI, and WI. Prior to this there had been reports of late blight in FL, GA, SC, and NC.

* Contact fungicides remain on the surface of the plant tissue where they are deposited whereas translaminar fungicides can move in and through a leaf. A very few fungicides are systemic and can move in the plant to stems and new growth. In contrast, most human drugs are put inside the body and are able to move to where they are needed and they have a curative effect. Plant medicine is very different from human medicine.