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Steps For Managing Late Blight In Organically Produced Tomato And Potato

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1. Select less susceptible varieties when possible.

   Potato: There are no truly resistant varieties, but some usually are less severely affected than others. Those described as having some tolerance or resistance include Elba, Kennebec, Allegany, Sebago, Rosa, Defender, Jacqueline Lee, and Ozette. Elba is considered the least susceptible. Some organic growers in the northeast reported that late blight in 2009 appeared to be less severe on some other varieties, notably Island Sunshine.

   Tomato: There are 3 major genes for resistance. *Ph1* (in variety New Yorker) is not effective against pathogen genotypes now present in the US. *Ph2* is effective (in Legend). *Ph3* is more effective (in Plum Regal). Varieties with both genes provide the best suppression. Iron Lady released in 2013 is the first variety with two copies of both genes (one from each parent, homozygous). It is expected to have excellent resistance, better than the varieties released previously with one copy of these genes (heterozygous): Defiant PhR, Mountain Magic and Mountain Merit. Except for New Yorker, control of US-23 was achieved with all of these varieties in an evaluation conducted on Long Island in 2012 (Iron Lady was not available then) (see http://vegetablemdonline.ppath.cornell.edu/NewsArticles/Tomatoes-LB-Resistant.html). Jasper and Matt's Wild Cherry were also effective; their resistance has not been determined. Most varieties with the *Ph2* and *Ph3* genes were also bred to have resistance to early blight and Septoria leaf spot. It is important to understand that resistance genes with the greatest suppressive effect tend to have activity for specific genotypes, and this pathogen has potential to evolve new genotypes able to overcome these genes. Therefore, use an integrated management program to minimize selection pressure on the pathogen to adapt and to increase likelihood of effective control. Obtain current information on genotypes occurring (see reports at http://usablight.org/). There is more information about tomato varieties and late blight in a downloadable pdf file posted under 'Tomato' at

   http://vegetablemdonline.ppath.cornell.edu/NewsArticles/NewsList.htm

2. Potato: Use certified seed potatoes (which means the producer's crop was inspected and met state requirements that include set tolerances for key diseases). Ask whether late blight occurred where they were produced. Inspect them to ensure none have symptoms of tuber blight. Infected tubers used as seed or not destroyed from the previous crop are considered the primary source of initial inoculum for late blight in the northeast.

3. Tomato: use transplants produced in an area where late blight is not developing on plants inside or near the greenhouse. Some genotypes of the late blight pathogen can infect petunia and some solanaceous weeds. Inspect transplants carefully before planting to ensure none have symptoms of late blight. The pathogen cannot survive

on tomato seed. Best choice is transplants produced in the north in a greenhouse that is not next to a field planted to potatoes.

4. Promptly destroy any volunteer potatoes. These can be an important source of the late blight pathogen. Destroy any cull potatoes before the growing season begins.

5 Control volunteer tomato plants and solanaceous weeds, in particular hairy nightshade and bittersweet nightshade. Other weeds and ornamental plants that are also susceptible to some pathogen genotypes include jimson weeds, golden henbane, climbing nightshade, devil's trumpet, Sodom apple, potato vine, apple of Peru, porcupine tomato, mandrake, tree tobacco, petunia, and calibrachoa. The late blight pathogen cannot survive over winter on these plants, even perennial species, because the pathogen only infects leaves and other tissue killed by cold temperatures; but they do serve as a place where the pathogen, once in an area, can multiple unsuppressed when they are not located in a fungicide-treated crop. But note: if both mating types of the late blight pathogen become established in an area, then survival as oospores in affected weed plant tissue will be possible.

6. Regularly inspect potato, tomato, and tomatillo crops, which are also susceptible, for symptoms of late blight. Local extension office provides diagnostic service. Many images of symptoms are available on the internet to assist with identification. Mine are posted along with additional information at:

   http://www.longislandhort.cornell.edu/vegpath/photos/index.htm

7. Stay informed about late blight occurrences. Sign up to receive alerts at http://usablight.org/, and routinely check the occurrence map maintained there. Check local extension newsletters each week. During cloudy conditions spores of the late blight pathogen can survive being dispersed in wind currents potentially long distances because they are protected from the killing effects of UV radiation. Rain is an effective way spores are moved out of wind currents down on to healthy plants, potentially far from the affected plants that were their source. Typical dispersal distance is up to about 30 miles, but much further is possible.

8. Use forecast programs to determine when conditions have been and likely will be favorable for late blight development. There is a Decision Support System (http://usablight.org/dss) that provides recommendation on when fungicide applications are warranted based on data from local weather stations as well as management practices already used, including resistant varieties and fungicides already applied. There is also a late blight forecast model at http://uspest.org/risk/tom_pot_map. These programs assume the pathogen is present.

9. When there is a risk of late blight occurring and fungicide applications are going to be used as a component of management, apply approved fungicides on a regular preventive schedule. Limited evaluations conducted to date of individual organic products suggest that copper is the most effective. Actinovate was also effective in an efficacy trial. Some growers have reported success with copper + Regalia alternated with copper + Actinovate. Use the Decision Support System to determine when applications are needed. Late blight is difficult to control, and can be impossible when fungicides are not applied before disease onset. Thorough spray coverage is critical. See section at end if any fungicide will be used.

10. If symptoms of late blight are found in isolated areas in a planting, affected plant tissue should be immediately destroyed. It is best to do this in the middle of a sunny day after the leaves have dried when there will be fewer spores and those dislodged in

the process will likely be exposed to UV radiation, which will kill them. Affected plants could be cut or pulled, then, depending on quantity, put in garbage bags, buried in the ground, or put in a pile and covered with a tarp. Heat that develops from sunlight hitting the tarp will quicken death of plant tissue and the pathogen. For the same reason, garbage bags with affected plants should be left in the sun for a few days before disposal. Another option, especially with large quantities of tissue, is to use a propane flamer. Flamers are a good way to quickly kill foliage, but are not suitable where tomatoes are grown with straw or plastic mulch. Affected plants (but not potato tubers) can be composted if done correctly to achieve killing temperatures and plants are placed inside the pile, rather than on the top of the pile where they will continue producing spores for a few days until tissue dies.

Inspect plants daily thereafter for a week in order to find any additional affected plants that develop symptoms. Apply organic fungicides until vine kill with potatoes and final harvest with tomatoes. It is not possible to control late blight by solely relying on removing affected tissue. Even when rain is not occurring, high humidity and dew over night can provide a sufficient moisture period for infection. Especially when conditions are favorable or a highly aggressive genotype is present, it may not be possible to control late blight with the best organic fungicide. Monitor disease development and be prepared to destroy all foliage if late blight isn't controlled (see step 13 below).

Aggressive management will minimize the opportunity for both mating types if present in an area to infect the same plant tissue (chance event for spores to land on same plant), grow together, and produce oospores through sexual reproduction.

Potato: tubers in an affected area could be dug. They should be held in a dark, dry, warm (at least 65F) place for a week, then inspected for symptoms of tuber blight before marketing.

Potato: do not re-hill potatoes that remain in the field in an effort to protect the tubers because the pathogen can be easily spread on equipment, and the root pruning that will occur may stop plant growth for several days.

11. Promptly inform neighbors growing susceptible crops and also state extension staff when you find late blight so that others can be informed and take action to protect their plants. Due to the potential for spores to move from your plants to others, which could be destroyed if not protected, late blight needs to be treated as a 'community disease' for which communication is an important management tool.

12. Work in affected fields last. Between fields, clean and disinfest equipment with a product and rate allowed by your certifier. The NOP national list allows chlorine materials (calcium and sodium hypochlorite, chlorine dioxide), hydrogen peroxide, and peracetic acid.

13. When late blight starts to become severe the crop foliage should be destroyed to eliminate the planting being a source of spores for other tomato or potato plantings on the farm or other farms. Additionally, destroying foliage in a potato crop will protect the tubers from infection. This is an obligate pathogen that needs living host tissue to survive. Propane flamers are a good way to quickly kill foliage, but are not suitable where tomatoes are grown with straw or plastic mulch. Flail chopping is another option. To initiate plant death with trellised tomatoes, go through the planting and cut all main stems at the base, then come back through and cut stems further up in the canopy plus trellising line to enable plant removal. Disturb foliage as little as possible to minimize the amount of spores dislodged. It is best to do this work in the middle of a sunny, preferably calm day after any moisture on leaves has dried to

minimize the quantity of spores and also their likelihood of survival in the process. Bagging affected tissue or burying is recommended where feasible with small plantings. Piling plants and covering with a tarp is another option.

Applying an organic fungicide to protect remaining potato stems from late blight is not recommended because conditions are much less likely to be favorable for infection once all the foliage is removed.

The late blight pathogen is not able to survive in plant debris unless the pathogen produces oospores, therefore it is not necessary to physically remove affected plant tissue from a field.

13. Potato: harvest tubers after foliage has died but before significant rainfall is predicted. Waiting two weeks to harvest after vine kill is considered to provide an adequate time for spores to die. Rain can wash spores down to tubers. And tubers should not be harvested when wet. Infection is more likely to occur when soil temperatures are cool (below 54F). Avoid bruising and skinning while harvesting. Harvest separately and last any areas that are low or had more severe symptoms of late blight. As described above under 9, tubers from an affected field should not be marketed until checked for blight. Prompt marketing is recommended. If stored, cool down quickly and provide good ventilation in storage. Check stored tubers frequently for symptoms.

14. Potato: destroy any tubers that could be affected. This is the primary way the pathogen currently can survive over winter. Recommended methods include chopping, burial, burning, spreading on fields where they will freeze completely over winter, or feeding to livestock.

15. Tomato: the late blight pathogen cannot survive on stakes, therefore it is not necessary to trash or even disinfect the stakes to manage this disease. Stakes should be disinfected however, especially if bacterial diseases also developed in the planting.

16. Potato: inform customers that tubers from a crop with late blight should be consumed soon as they could have a shortened shelf life and that any tubers not consumed need to be put in the trash rather than composted to avoid providing the pathogen a means to survive over winter. Consider marketing tubers from an affected crop in small allotments to minimize the time consumers will be holding the tubers since they do not have proper storage conditions to slow late blight development.

    Tomato: Fruit from an affected field can develop symptoms after harvest and thus should be inspected just before marketing. Customers should be aware of the potential that fruit could have a shortened shelf life when picked from an affected field. It may be wise to recommend that any fruit that rot be put in the trash rather than on a compost pile since there is a possibility that the pathogen could produce spores before the fruit completely rotted.

High tunnels and greenhouses do not always protect tomatoes from late blight. While often less severe, the disease can still develop because the pathogen does not need leaf wetness for infection and its spores can be dispersed by wind through open vents when the disease is developing on field-grown crops in the region. Relative humidity of at least 90% is favorable. Use cultural practices to minimize humidity and monitor with a sensor.

Additional Information About Copper and Other Fungicides.

OMRI-listed fungicides labeled for late blight include Actinovate, Companion, Sonata, Serenade, Sporatec, Regalia, OxiDate, and copper. Check to make sure product is registered in the state and check with your organic certifying agency to determine what products, including specific copper formulations, are approved. In some states products that are exempt from EPA registration because of their ingredients, such as Sporatec, do not need to be registered in the state (this is the case in NY but not in ME). There is limited data from replicated experiments on efficacy for late blight of products approved for organic production. Copper has provided some control where other products have failed in efficacy trials. Actinovate has also exhibited efficacy. Effective control of late blight with copper has been achieved by some organic growers; however, copper is not considered inherently highly effective by pathologists studying late blight management. Lack of highly effective organic products, combined with the fact that established spots, being uncontrollable with fungicides, will continue to produce spores, plus the explosive nature of late blight on susceptible varieties, is why a preventive spray program is recommended including by organic growers in areas where late blight occurs regularly. It is especially important to use a preventive schedule with products such as Regalia and Companion that act by affecting plants' natural defense mechanisms. The need to apply copper preventively to improve the likelihood of effective control of late blight can be avoided by growing resistant varieties and inspecting plants regularly for symptoms to determine when to start treatment.

Before using any fungicides read the label. Note that the 'signal word' for most copper fungicides is 'danger'. The signal word assigned to a pesticide is based on how harmful it might be if swallowed, inhaled, or exposed to skin or eyes of the person handling it. Danger is assigned when the pesticide is highly hazardous by at least one of these routes of entry into a person. The other signal words used for pesticides are 'warning' for moderately hazardous chemicals and 'caution' for slightly hazardous chemicals. The signal word is caution for Cueva, a new fungicide with the active ingredient copper octanoate rather than the more common ingredient, copper hydroxide. In the precautionary statement on pesticide labels is a section on 'hazards to humans', which explains how the product could affect someone exposed to it. This is followed by the 'personal protective equipment' (PPE) that is needed when mixing and applying the pesticide. Hazards for copper fungicides are: 'Corrosive. Causes irreversible eye damage. May cause skin sensitization reactions in certain individuals. Do not get in eyes or on clothing. Harmful if swallowed or absorbed through the skin. Avoid contact with skin.' Also 'avoid breathing dust.' for some formulations. PPE that applicators and other handlers must wear when using copper is: long-sleeved shirt and long pants, chemical-resistant and waterproof gloves, shoes plus socks, and protective eyewear. First aid information is also provided on labels for accidental exposure; know this in advance to avoid delay in treatment. There are also important 'Agricultural Use Requirements' described on labels. This includes the 'restricted-entry interval' (REI), which is 24 or 48 hours for most copper fungicides, what PPE is required for anyone who enters and will contact anything treated before the end of this interval, which for copper is the same as for applicators, and what precautions must be followed after an application, which for

copper includes having an eye flush container at the WPS decontamination site for workers entering the field for 7 days after treatment. The REI is 48 hours for new fungicides with copper hydroxide, such as Badge. Older products with this ingredient are expected to have the same REI following re-registration. The REI is only 4 hours for Cueva. Note that fruit cannot be harvested during the REI. EPA's Worker Protection Standard for Agricultural Pesticides (WPS) is a regulation that must be complied with on farms where any pesticide is used, including those approved for organic production. Under this regulation, all agricultural workers on the farm must receive pesticide safety training, decontamination supplies, notification of pesticide applications, access in a central location to a log of pesticide applications plus information about these pesticides, any required personal protective equipment, and emergency medical assistance when needed. Restricted-entry intervals must be adhered to. Also, pesticide safety posters must be displayed.

Labels also specify how often the product can be applied. Most copper fungicides are labeled for use every 5 or 7 to 10 days. These labels will change in the near future following re-registration of copper fungicides in the US. Changes will include more explicit use descriptions plus a defined minimum retreatment interval of 5 days and maximum annual rate of 25 lbs metallic copper per acre for potato (these limits are specified in EPA Reregistration Eligibility Decision (RED) for coppers). Applying copper more frequently than every 5 days is not considered necessary, even following rain, because these products are formulated with adjuvants that help keep them on foliage. Labels always should be checked on new product containers for changes such as this before using. It is especially critical where copper is being applied frequently to test soil regularly to ensure this is not resulting in an unacceptable accumulation of copper. Before starting a fungicide program with copper, it is advisable to check with the certifier about limits in addition to those on the label, such as number of applications.

Calibrate sprayers before needed to ensure rate applied will be neither above nor below labeled rate.

When using any pesticide note that it is a violation of Federal law to use the product in a manner inconsistent with its labeling.

Some of this information on management was provided by Dr. Steve Johnson, University of Maine Cooperative Extension

Please Note: The specific directions on fungicide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Confirm state registration and organic approval with certifier. Any reference to commercial products, trade or brand names, is for information only; no endorsement is intended.