IDAHO POTATO DISEASES
University of Idaho

Overwinter survival of late blight in Idaho in volunteer and cull potatoes

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Volunteer potatoes

With the recent annual epidemics of late blight late in the 2013, 2014, 2015, 2018 and 2019 growing seasons there has been speculation as to the source of these outbreaks and debate as to the relative importance of overwintering sources of inoculum. *Phytophthora infestans*, the causal agent of late blight overwinters in potato tubers that are intended for planting as seed, but the pathogen may also be harbored in waste or cull potatoes, or in late blight-infected volunteer potatoes left behind in the field during harvest the previous season.

Volunteer potatoes have become an important perennial weed in many potato growing regions. Researchers in Washington have reported that up to 1,122,000 tubers per acre are returned to the soil after harvest. Potato sprouts emerge from overwintered tubers and grow rapidly in the spring. This rapid growth combined with the tubers ability to re-sprout makes them very difficult to control, even with multiple control measures. Studies with field corn (Zea mays) showed that when volunteer potatoes were not controlled corn yields were reduced up to 62%. Volunteer potatoes also act as hosts for a number of important pests and diseases, including late blight, Colorado potato beetle, potato leafroll virus, and nematodes such as *Paratrichodorus allius* (the nematode that transmits tobacco rattle virus, the causal agent of corky ringspot disease).

Potato tubers are susceptible to cold injury and in the past tubers left in the soil after harvest would be killed by the freezing soil temperatures of the Idaho winters. Tuber death resulting from cold injury is usually as a result of the freezing of intracellular water in the tuber tissue. However, tuber tissue is able to supercool below its freezing point without causing cell death and when the tubers are re-warmed, they will still be viable. The formation and growth of ice crystals within a supercooled liquid must be preceded by a process known as nucleation. As with most plant tissues, potato tuber tissues can supercool several degrees due to a lack of nucleating substances necessary for ice crystal initiation or barriers to ice crystal growth present in the tissue. Previous research has determined that the freezing point of potato tuber tissue is between 30 and 28°F, but under controlled conditions where ice crystal nucleation is prevented, tubers are able to supercool to 20°F. In the soil, tubers are in contact with organic matter, water, microbes and minerals that may act as ice crystal nucleation sites and thus may affect the amount of supercooling that a tuber undergoes. Field trials carried out in Washington state showed that when soil temperatures at tuber depth reached 27°F or lower, extensive tuber death occurred.

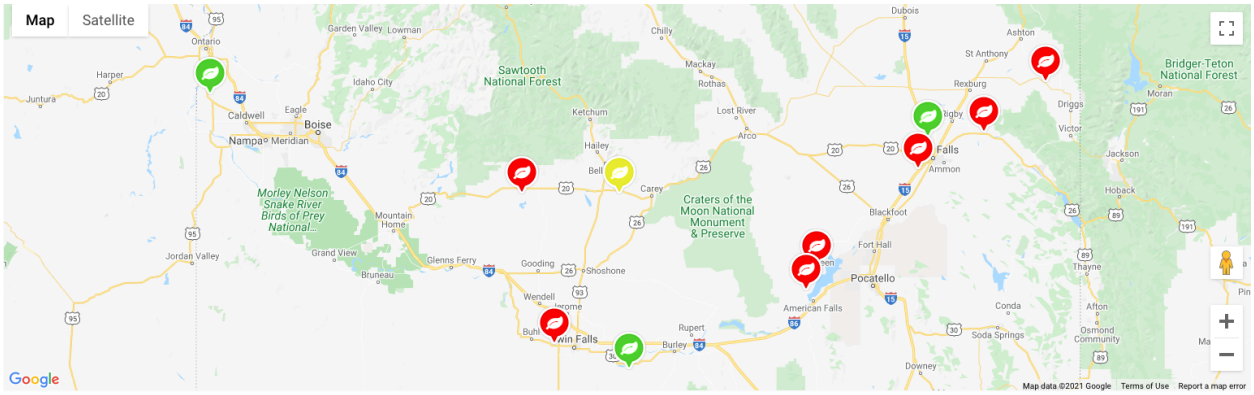
Many interacting variables including meteorological factors such as climatic change and increasing tolerance of *P. infestans* to colder temperatures represent a serious situation for the potato industry in the Pacific Northwest (PNW). Winters in Idaho and the PNW are also becoming warmer which may favor survival of volunteer potatoes and cull potatoes over winter. With the recent trend for warmer winters, more volunteers and cull pile potatoes are surviving the winter and acting as sources of disease inoculum in the spring. Studies have shown that mycelia of newer genotypes of *P. infestans* (e.g., US-8 and US-23) are becoming more tolerant to colder temperatures and are tolerant to 27°F for up to three days continuous exposure. Our studies have shown that the tubers of most cultivars appear to breakdown after exposure to 27°F for about one day. Thus, the monitoring of winter soil temperatures may enable growers to

accurately estimate the potential for survival of volunteer plants over winter and thus the help to estimate the risk of an epidemic of late blight initiated from volunteer potatoes or cull piles. We have developed a model that predicts the likelihood of tuber survival over the winter based on soil temperatures at 2 and 4 inches between November 1st and March 31st (www.cropalerts.org/volunteer-survival/)

- If tubers were exposed to temperatures below 27°F for more than 120 h between 1 November through 31 March at 4- and 2-inch depth, then the risk of tuber survival is considered low (indicated by a green marker pin).
- If tubers were exposed to temperatures below 27°F for less than 120 h at 4-inch depth and greater than 120 h at 2-inch depth, then there was a moderate risk of tuber survival (indicated by a yellow marker pin).
- If tubers were exposed to temperatures below 27 °F for less than 120 h at 4-inch depth and less than 120 h at 2-inch depth, then there was a high risk of tuber survival (indicated by an orange marker pin)."

The data for this model is collected automatically from automated weather stations in the the Agrimet weather network (http://www.usbr.gov/pn/agrimet/index.html) and University of Idaho run weather stations (https://cropalerts.org/risk-monitoring/). After the model is run, data is posted on a Google map with colored markers indicating the locations of the weather stations (Fig. 1). When users click on the markers, they will be given further data on soil temperatures for that station.

Figure 1. Volunteer survival map showing the weather stations used to collect soil temperature data for the volunteer survival model. The marker color indicates the risk of volunteer survival (red = high risk; yellow = moderate; green = low).



This winter in Idaho most areas in the Snake River Valley experienced soil thermal conditions that placed them in the high-risk category for volunteer survival. Even with the severe sub-zero air temperatures we had only three of the locations where the model was run this winter (2020/2021) had minimum monthly soil temperatures below 27 °F (Table 1). This situation should alert growers to the high risk of potato volunteers surviving the winter and all growers should therefore be implementing their IPM scouting programs early in 2021 and considering volunteer elimination programs in adjacent non-potato crops if possible. Growers in Southeast Idaho counties (Bingham, Bonnerville, Madison, Power Co.) where there have been previous late blight outbreak and where conditions were conducive for over winter survival should remain vigilant for signs of late blight on volunteer potatoes.

Table 1. Minimum monthly soil temperatures (°F) at 4 inches below the soil surface for winter 2020/2021 at select locations.

Month	Location									
	American Falls	Tetonia	Aberdeen	Golden Valley	Ririe	Twin Falls	Picabo	Fairfield	Parma	Osgood
November	30	31	35	27	33	38	31	33	28	24
December	25	30	32	22	29	34	27	28	26	18
January	26	31	32	27	26	35	29	32	26	22
February	29	32	32	30	29	36	31	34	26	24
March	32	32	33	30	30	36	30	34	27	25

Cull Potatoes

As mentioned above, late blight can also survive the winter in cull potatoes. Cull potatoes are those potatoes unusable for the fresh market, processing, or dehydration because they don't meet minimum size, grade, or quality standards, or potatoes disposed of for some other reason such as overproduction or waste (slivers) from seed production.

It is difficult to estimate the probability that late blight infected potato stems or foliage will emerge from culled potato tubers. Several factors can influence the fate of the infected tuber. If the infection is severe, then the tuber may rot and prevent sprout development. The tuber infection however may be localized and optimal in terms of inoculum load and therefore it is possible that a developing sprout or the tuber itself could become infected to initiate an epidemic. Under optimal environmental conditions (cool, wet, weather) the disease can then spread within individual plants, between plants and neighboring crops. Research has shown that the temperature within discarded cull piles may influence core tuber tissue temperatures affecting the survival of tuber tissue and thus *P. infestans* mycelia in infected tubers. Consequently, the risk of initiation of an epidemic of late blight from cull piles is closely related to the temperature experience of overwintered potato culls. Although the potatoes at the top and bottom of a cull pile may freeze over the winter when ambient air temperatures fall below freezing, research has shown that the temperature in the middle of the pile remained stable regardless of cull pile size (1-15 ton). Since cull piles in excess of 1 ton may enhance the survival of tubers and thus the P. *infestans* mycelia even in the coldest winters it is important to follow cull and waste potato management guidelines.

Cull and Waste Potato Management Options

Potato production and processing operations may accumulate cull piles at any time during the year, but several periods are especially critical. In the spring during cutting and planting, potato waste material may accumulate as seed pieces or tubers are discarded due to size or disease problems. At harvest, potatoes that do not make the grade due to size, disease, or defects are sorted out and discarded prior to placement of the crop in storage. Disposal of cull potatoes discarded from storage or from in-coming seed lots during the spring pose a challenge for the industry. Depending on the timing of disposal, there is a real chance that these culls will not be thoroughly frozen to prevent new growth. Therefore, potatoes which are discarded during the winter and spring as culls should be disposed of in a way that will ensure they do not sprout and grow to provide unprotected foliage which could be a source of late blight to threaten the new season's crop. The method of disposal will generally depend on the individual situation (location, amount of potatoes, etc.) as well as the time of year. Disposal of potatoes in the winter months when waste potatoes can be reliably expected to freeze can greatly simplify the process, while disposal in the warmer months can greatly add to the challenge of proper disposal.

Disposal of cull potatoes by spreading them on fields that will not be used for potato production is a very good option for cull potato management. However, its important to avoid fields that will be planted with potatoes in the following season as cull potatoes can introduce nematodes, weed seeds and other soilborne diseases to the field. Once applied to the field every effort to crush, cut and destroy the tubers should be attempted. These methods include running heavy machinery over the tubers or a cutting tool that does not bury the tubers. Crushing and chopping cull potatoes into smaller pieces makes the tuber tissue more susceptible to rot and desiccation, which is desirable. Weather conditions during the winter will also lead to desiccation of tubers, which will make spring field tillage easier. Avoid tilling until cull potatoes have had substantial time to freeze and desiccate. Premature tilling could bury live tubers deep enough in the soil to insulate them from further exposure to killing temperatures allowing them to survive the winter as volunteer potatoes.

It is extremely important not to pile waste potatoes too high during field disposal. As described above, this practice will often serve merely to insulate the potatoes underneath from freezing. Spread cull potatoes on top of the soil surface no more than two potato layers deep (approximately 6 inches). If spreading tubers is not an option and the amount is small e.g. up to 1000 cwt, growers may opt to dispose of tubers by piling them into **temporary** cull piles. Culls should be piled close to areas where they can be closely monitored to insure that there will be no unprotected sprouting and foliar growth. These culls should be covered with black plastic sheets to increase the temperature of the respiring tubers and accelerate the rate of breakdown. Whenever cull potatoes are discarded the area should be periodically monitored to assure that any unprotected foliage does not occur. The pile should also not be near areas where the public congregate or reside, surface water or wetlands as concerns about any nuisance odors or leachate could arise. The additional issue with a cull pile is that the volume of potatoes is concentrated so the concern for nitrogen leaching is significant.

Cull potatoes are a significant fertilizer source that needs to be accounted for when calculating the fertility requirements of the crop following cull potato application. Fields that will be planted with grain or forage are particularly good candidates for using cull potatoes as a partial fertilizer source.

Other options for cull potato management in the warmer months of the year include burial, composting, and livestock feed. For further information refer to the University of Idaho bulletin CIS 814, *Cull and Waste Potato Management*.

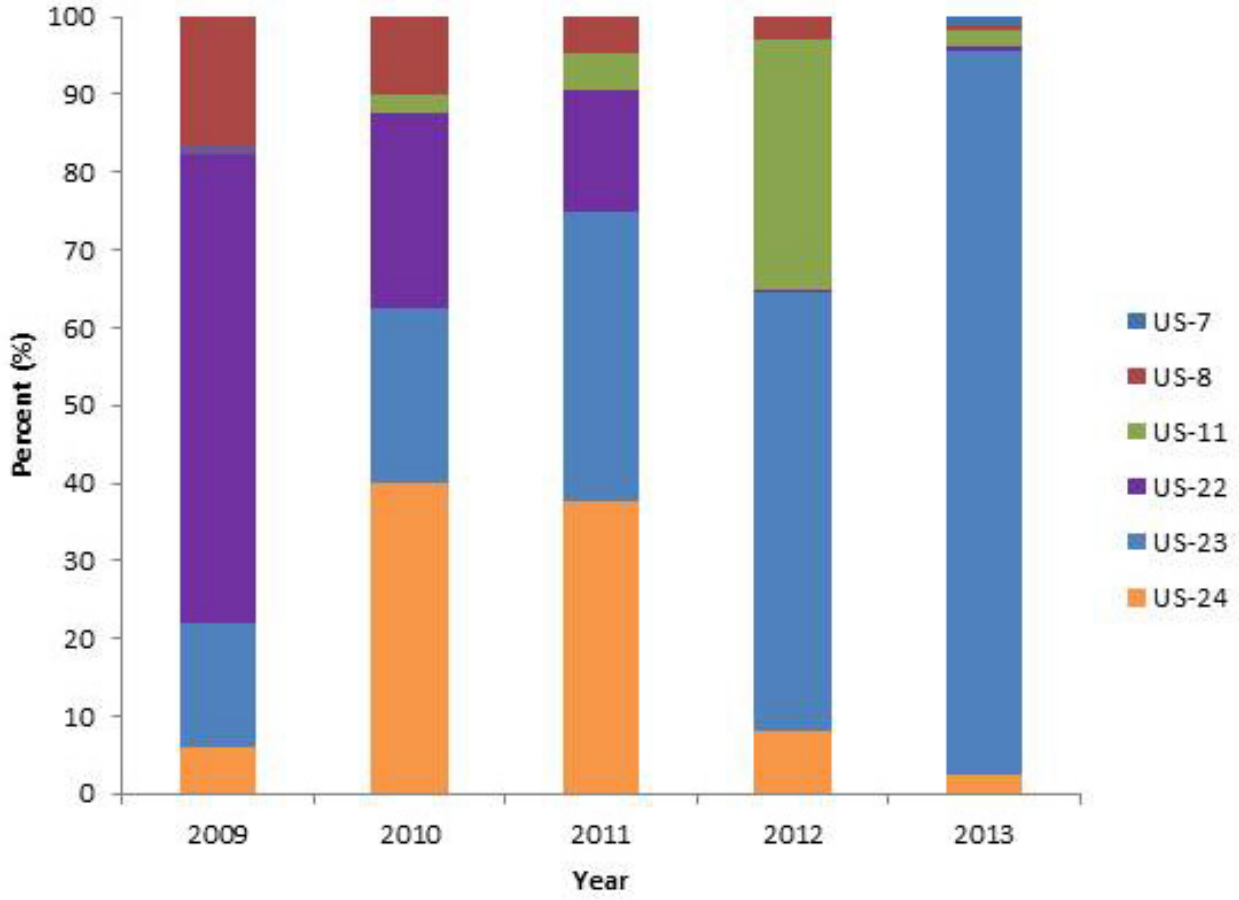
Other sources of late blight inoculum

Traditionally, the late blight pathogen *P. infestans* has not survived overwinter in the Idaho climate. Most outbreaks have occurred when the pathogen came into the state on infected seed. The dry, desert-like climate of Idaho is not conducive to late blight epidemic formation. In addition to the fact that research has shown that there is a less than 1% chance of a late blight epidemic starting from infected seed, the pathogen needs cool, wet conditions to sporulate and spread to surrounding healthy plants. This has meant that in a typical year where summer temperatures could reach the high 90's °F and rainfall amounts were less than 1 inch a late blight outbreak would be rare. Any late blight outbreaks that did occur were likely to be late in the season and limited to a few fields which may have had a micro-climate which favored disease development, such as shading or over irrigation.

Until 2009, the predominant strain of *P. infestans* found in Idaho was the genotype US 8. In most of the rest of the US, this strain has been superseded by a new genotype US 23 (Fig. 2). In 2013, there was a small outbreak of late blight in south east Idaho. Isolates from that outbreak were genotyped and determined to be US23. In August 2014, the cool wet weather with daily

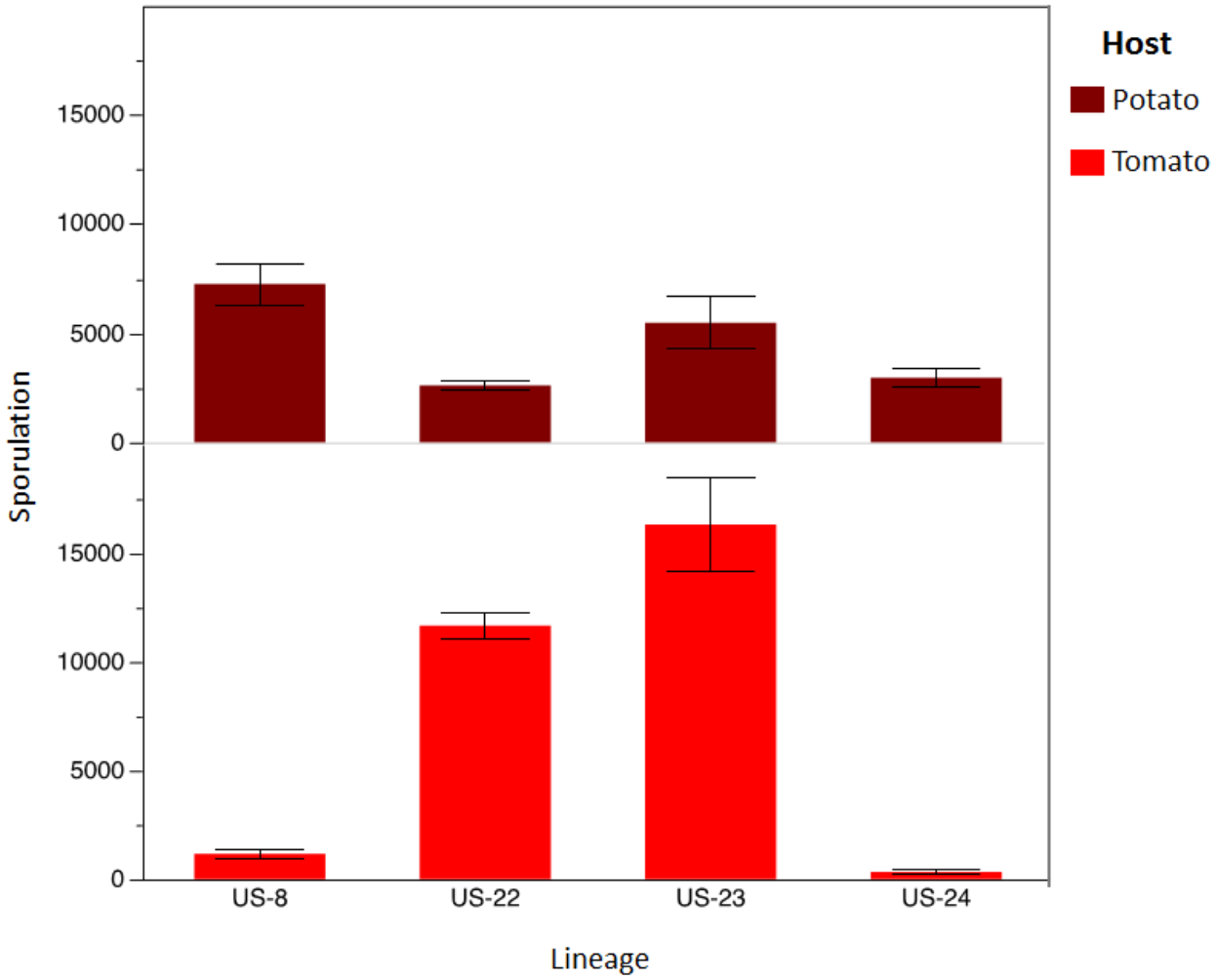
rain showers and temperatures in the 50's – 70's °F were perfect for a disease epidemic to occur. The first occurrence of late blight was reported on August 12th and this was followed by further outbreaks throughout the counties from Madison south to Power. Testing of isolates from infected fields in these counties showed that they were all of the genotype US23.

Figure 2. Displacement of *Phytophthora infestans* clonal lineages over time. (From USAblight.org)



Research has shown that these newer genotypes of P. *infestans* are equally pathogenic on tomato and potato (Fig. 3). Epidemiological studies carried out in the Northeastern US and Midwest have shown that recent epidemics of late blight have started on tomatoes growing in home owners gardens and spread to surrounding potato fields. These infected tomato plants tend to be bought from big box stores and taken home to be planted out in the garden. As most of these tomato transplants are produced by the same companies for big box stores and then shipped all over the US there is the potential for this to be a new source of inoculum for an outbreak of late blight in Idaho if the conditions are conducive for disease development.

Figure 3. Pathogenicity of recent *Phytophthora infestans* genotypes on potato and tomato. From Fry et al., APSnet Features 2012 (http://bit.ly/1ELtEzJ)



Summary of the best late blight prevention options for spring 2021

With the chances of volunteer and cull potato survival over the winter of 2020/2021 being high growers should adopt the following practices to minimize the risks of a late blight outbreak this spring.

- Minimize cull piles during seed cutting and treating.
- Use a seed treatment with mancozeb, or if using a liquid seed treatment apply a mancozeb dust treatment after the liquid.
- Start scouting for volunteer potato emergence early in the season and around the time of emergence in potato fields planted in your area.
- If potato fields are bordering home owners gardens where tomatoes are being grown and conditions are conducive for late blight (i.e. cool wet weather) be vigilant and scout the borders of the field for late blight symptoms.

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