University of Idaho
College of Agricultural and Life Sciences

CIS 1132

Late Blight Management Action Plan for Potatoes

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INTRODUCTION

Development and Use of This Management Plan

This action plan was developed in cooperation with the Idaho potato industry in consultation with late blight experts in the Pacific Northwest and other areas of the United States. It is hoped this information will help the Idaho potato industry reduce potential yield and quality losses caused by late blight. This action plan should also help in making informed decisions about disease prevention, fungicide spray programs, and optimizing disease management costs. Additional information about late blight is contained in Pacific Northwest publication PNW 555, *Managing Late Blight on Irrigated Potatoes in the Pacific Northwest*, available at local University of Idaho Extension offices, or on the web at http://info.ag.uidaho.edu/pdf/PNW/PNW0555.pdf.

Occurrence in Idaho

Late blight is the most important disease of potatoes on a worldwide basis. Prior to 1995, only one isolated case of late blight had been reported in Idaho. Late blight appeared in numerous fields throughout southwest Idaho in July 1995, and later spread to south central Idaho. Since then, the disease has occurred in all commercial potato production areas of the state and has been responsible for severe damage during some years.

Spread of Late Blight

Potatoes may be exposed to late blight during the growing season from inoculum produced on infected cull piles, volunteer potato plants, or plants developing from infected seed. Tomato transplants in home gardens may also be a source of late blight. Under the right conditions (see Avoid conditions that favor late blight, p.3), spores from infected plants can be carried for miles in moist air, such as in thunderstorms, and infect healthy plants, thus spreading the disease. Currently, no labeled chemicals will cure the disease once it becomes established in a plant. Because of this, it is critically important that everyone in the potato industry develops a "late blight prevention attitude." Effective best management practices (BMP) are based on prevention and include cultural and chemical management practices that reduce the potential for occurrence, spread, and loss from late blight.

Terms Used in Discussing Late Blight

Inoculum – Structures of late blight pathogen capable of infecting plants. Examples include windborne sporangia and waterborne zoospores.

Lesion – Area on a leaf, stem, or tuber showing symptoms of late blight.

Pathogen – A microscopic organism that causes disease in higher plants, such as potatoes and tomatoes.

Spore – A pathogen structure containing one or more cells capable of reproducing, germinating, and causing infection.

Strain – A population of late blight pathogens with similar traits. A late blight strain is designated using two letters to designate the country where it was first identified (such as US) followed by the number of identification (e.g. US-8 represents the 8th strain identified in the United States). Strains have also been called genotypes by some.

CULTURAL CONTROL BEFORE PLANTING

Learn to recognize late blight symptoms – Early detection is critical for late blight management, so it is essential for all personnel involved in farming operations to be able to recognize and identify late blight symptoms. Both the plant (Figures 1-1, 1-2, 1-3) and tubers (Figure 2) produce distinct symptoms.

Understand conditions favoring development – The late blight pathogen is more likely to spread, and disease is more likely to develop when repeated evening thundershowers occur and/or during periods of high humidity when temperatures are between 55 and 80°F. Even in the absence of rainfall, sprinkler irrigation may provide conditions that favor late blight development.

Eliminate sources of inoculum – The initial sources of late blight inoculum are likely to be plants produced from infected tubers in cull piles, volunteers infected the previous year that have survived the winter, and plants that develop from infected seed tubers. In addition, infected potato and tomato plants grown in home gardens, greenhouses, and nurseries (even those grown outside and transported to Idaho) can serve as sources for late blight inoculum.

Because of the potential danger of these inoculum sources, Idaho State Department of Agriculture regulations mandate daily treatment of waste potatoes and other non-usable material from all potato operations, including seed cutting operations, in a manner that renders foliage unable to allow pathogen growth. These regulations are in effect from April 15 to September 20 in regions west of Raft River, and from May 15 to September 20 in areas east of Raft River.

ISDA-Mandated Daily Treatment

Because of the potential danger of inoculum sources listed above, Idaho State Department of Agriculture (ISDA) regulations mandate daily treatment of waste potatoes and other non-usable material from all potato operations, including seed cutting operations, in a manner that renders foliage unable to allow pathogen growth. These regulations are in effect from:

- April 15 to September 20 in regions west of Raft River, and
- May 15 to September 20 in areas east of Raft River.

Figure 1_1. Late blight lesion on a potato leaf. Gray or brown lesions surrounded by a light green (chlorotic) area are very characteristic of late blight. Lesions that look like this are about one week old.

Figure 1_2. Leaf and stem lesions are typical of potato late blight.

Figure 1_3. In advanced stages of late blight, leaf lesions will be sparse, as most leaves will be completely destroyed by the pathogen. Stem lesions are commonly seen at this stage of the epidemic.

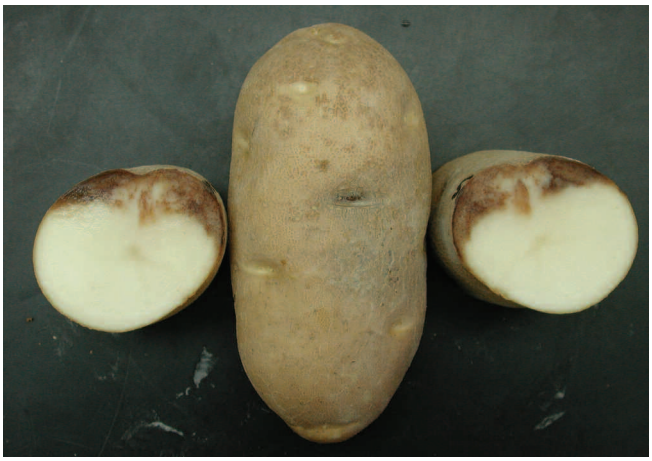

Figure 2. The potato tuber (center) shows infection through an eye. The tuber slices on either side depict the granular, brown dry decay associated with late blight.

Methods for disposing of cull and non-usable material include freezing, chopping, feeding to livestock (non-treated potato tubers), composting, burial, or herbicide spraying. See University of Idaho *Cull and Waste Potato Management* at http://info.ag.uidaho.edu/pdf/CIS/CIS0814.pdf for more detailed information.

Controlling volunteers, late blight – In regions where soil temperatures at 4 to 6 inches deep have not reached 20 to 25°F during the winter, volunteer potato plants may be very common.

- Herbicides. Use cultivation and labeled broadleaf herbicides where possible to suppress growth of volunteer potatoes in rotation crops. Check with your local UI Extension office for herbicides available to use for controlling volunteer potatoes.
- Avoid planting back to back. Avoid planting potatoes in the same field for two or more consecutive growing seasons. Back-to-back growing makes control of volunteers impossible.
- Down wind fields. Potato fields directly downwind from fields that had late blight the previous season may be at a higher risk for late blight because of the potential for spores to move from infected volunteers.
- Year-out plantings. Planting "eliminator" or "year-out" seed is risky due to the possibility of having late-blight-infected tubers, especially if late blight was present during the previous year.
- Certified seed. Purchase only certified seed from seed operations with which you are familiar. The occurrence of late blight in a region does not mean seed tubers are infected, but there is an increased risk.
- Examine seed fields. Examine seed fields during the growing season and/or check inspection records and shipping point inspection reports for information about the seed lots that you are considering for purchase.

Avoid conditions that favor late blight – Weather conditions strongly influence the incidence and severity of late blight. Cool (55 to 80°F), rainy weather, high relative humidity (near 100%), and heavy dew formation favor infection, disease progress, and spore production. Although weather conditions are beyond grower control, careful irrigation management can help reduce the extent of periods favorable for disease development.

- Good water infiltration/drainage. Select fields with good water infiltration and drainage characteristics for planting potatoes. If water collects in some areas of the field, consider making modifications to eliminate standing water. Low spots in a field, areas near the pivot point of a center pivot system, irrigation overlaps, or areas next to windbreaks where shade allows plants to stay wet for longer periods, favor late blight development.
- Vulnerable areas. Areas of fields next to windbreaks, houses, or power lines may be difficult to cover with fungicides applied by air, and these poorly protected locations are often where late blight first occurs. Avoid planting potatoes in areas of fields where plants cannot be adequately protected with fungicide, or areas that are at a higher risk of infection.
- Ground applications. Ground applications of fungicides should be considered in areas not adequately protected by aerial spraying. An option for center pivot systems is to install valves on the first few nozzles of the center tower that can be turned off to avoid keeping this area excessively wet. Or, better yet, leave the first 100 feet near the center of the pivot unplanted.
- Avoid 12-hour sets. Growers who use handlines or wheel-lines artificially encourage late blight development by irrigating using 12-hour sets. This situation ensures more than 12 hours of leaf wetness, far more than the needed 8 to 10 hours, for infection to occur. Reducing set times or beginning early in the morning and allowing foliage to dry before evening may help reduce infection.
- Excessive nitrogen. Excessive nitrogen applications promote heavy vine growth and extend

the period during which relative humidity within the canopy favors spore production and leaf infection. Develop a nitrogen management plan that promotes optimum plant growth and yields without stimulating excessive vine growth (see *Potato Production Systems*, chapter 8 [J. C. Stark and S. L. Love, eds., University of Idaho Extension]).

Grow less susceptible varieties - Most commonly grown potato varieties in Idaho are considered susceptible to late blight (Table 1). A notable exception is Defender, a recently released variety with resistance to both foliar and tuber infection. Early-maturing varieties, such as Russet Norkotah, Shepody, and Frontier Russet seem more prone to yield losses because disease defoliation caused by late blight progresses rapidly, and diseased leaves are not replaced by new growth. Shepody and Ranger Russet are more susceptible to tuber infection. It is important to note that susceptibility to foliar infection is not always directly related to the level of tuber infection (e.g. Umatilla Russet—see Table 1).

Table 1. Relative late blight susceptibility rating of several potato varieties.

Variety	Foliar Rating	Tuber Rating
Alturas	MS	MS
Atlantic	MR	--
Bannock Russet	S	HS
CalWhite	S	S
Chipeta	S	S
Defender	R	R
Gem Russet	S	MS
GemStar Russet	S	S
Hilite	HS	HS
IdaRose	S	S
Ivory Crisp	S	S
Ranger Russet	S	HS
Russet Burbank	S	MS
Russet Norkotah	HS	HS
Shepody	S	HS
Summit Russet	MS	MR
Umatilla Russet	S	MR
Western Russet	S	MS

R = Resistant
MR = Moderately resistant
MS = Moderately susceptible
S = Susceptible
HS = Highly susceptible
-- Data unavailable

CULTURAL CONTROL DURING PLANTING

Recognize that seed handling can be an important factor in disease spread – Several experiments conducted over the last 30 to 40 years have indicated that most of the seed tubers or seed pieces infected with late blight will readily decay from soft rot after planting and are self-eliminating. Yet, seed transmission is an important means of initiating late blight into an area and particularly to a field. Late blight spores can spread from infected tubers to healthy tubers during handling, cutting, and planting operations. These healthy seed pieces can then develop late blight once planted in the field.

Do not mix seed during cutting and planting – Keep seed lots separate to avoid mixing uninfected lots with seed lots potentially infected with late blight. Mixing healthy seed with infected seed will increase the chances of spreading late blight over a larger area. Keep a written record of where each seed lot is planted. During the cutting operation, eliminate and save suspected seed pieces that show a rust brown, firm decay typical of late blight (Figure 2). Send suspicious tubers to a laboratory for positive identification. When possible, store seed at less than 45°F, then warm to 50-55°F and cut just before tubers begin to sprout. Also, to minimize spread between seed lots, always clean and disinfect equipment before cutting a new seed lot. See also the section under chemical control for seed piece treatments that reduce late blight spread.

Do not plant problem areas – Do not plant areas that you suspect may remain wet for extended periods or will be difficult to spray such as near trees or power lines. Consider not planting the area under the first few nozzles of a center pivot system. This will be less than an acre. Research in the Columbia Basin of Washington showed that significantly more tuber blight occurred under the first 100 feet from the center of the pivot. This area is typically overwatered due to the geometry and nozzle sizes used on most center pivots.

EARLY SEASON

Do not let cull potatoes accumulate – Eliminating cull potatoes early in the season is critical because they could potentially carry the late blight pathogen. Potato pieces resulting from seed cutting operations or cull potatoes left after loading or unloading at storage facilities may support the production of late blight spores whether or not the pieces are sprouting. Dispose of them properly.

- Because freezing temperatures generally do not occur in the spring, burial or feeding non-treated potatoes to livestock may be appropriate methods for disposing of cull and waste material.
- Do not allow cull piles to build up at feeding areas.
- Check with the Idaho State Department of Agriculture or local county officials for information on how to properly dispose of cull potatoes in your area.
- Potatoes may sprout and produce plants even when buried to depths greater than two feet, so it is important to continually monitor disposal sites to prevent volunteer plants from developing.
- Remember the Idaho State Department of Agriculture regulations in effect from April 15 to September 20 in regions west of Raft River, and from May 15 to September 20 in areas east of Raft River requiring cull potatoes to be rendered non-viable.

Control alternate hosts – Hairy nightshade can be infected with the late blight pathogen and may contribute to disease spread under some conditions. Apply effective pre- or post-emergence herbicides, such as Eptam, Matrix, or Outlook, during early season to reduce hairy nightshade populations. Although other weed species are not hosts of late blight, they can contribute to conditions that favor the disease by restricting air movement within the canopy. Heavy weed infestations also prevent adequate coverage of potato foliage during fungicide applications. Information available from the University of Idaho can help plan an effective weed control program.

Scout fields regularly – Closely monitor the growing potato crop and submit suspected late blight samples to the University of Idaho for identification. Also,

- Wet. Concentrate scouting in areas of fields that tend to stay wet for long periods, such as center pivot wheel tracks, irrigation overlap areas, and low areas where water collects.
- Center pivots. Especially scout plants under the first tower of center pivots. This area is almost constantly wet, and therefore conducive for late blight development.
- Windward side. The windward sides of fields are usually infected from windborne spores so check these areas first.
- Obstacles. Carefully scout areas that may have escaped a fungicide application because of power lines, trees, or other obstacles.
- Volunteers. Look for early indications of late blight on volunteer potatoes, especially in fields that had late blight the previous year.

Watch late blight forecasts – Two late blight forecasts have been developed at the University of Idaho.

The first utilizes the amount of rainfall in April and May and the number of favorable hours when the temperature is between 50 and 80°F along with relative humidity values above 80 percent. These variables are used to calculate the probability that late blight will be present.

The second forecast calculates the number of hours potato leaves are moist and the average temperature during that time. This forecast generates a "severity value" between 0 and 4 for each day. A running total of severity values is maintained, and late blight is expected one to two weeks after a total of 17 severity values has accumulated.

Find forecasts. Information on these forecasts is published on

- The University of Idaho toll-free hotline (800-791-7195),
- The Pacific Northwest Pest Alert—www.PNWPestAlert.net, and
- The University of Idaho Potato Pathology web page—www.ag.udiaho.edu/potatopath.

MIDSEASON

Irrigation management – Leaves and/or stems need to remain wet for about 8 to 10 hours for late blight spores to germinate and infect a plant. The longer leaves or stems remain wet, the greater the risk of pathogen infection.

Irrigating during or immediately after periods of cool, rainy weather will increase the possibility of late blight infection. Irrigation practices or weather conditions that increase the time leaves are wet will increase the potential for late blight.

Carefully examine irrigation management practices for modifications that will reduce conditions for late blight development (wet leaves) but will still maintain plant health and tuber quality. If large wet spots form in localized areas of a field, repair irrigation system leaks or turn off or plug nozzles in these areas to allow drying.

Sanitation practices – People entering fields should wear boots and clothing that can be disinfected between fields with products such as diluted household bleach mixed 1 part bleach to 9 parts water. Although late blight is more likely to spread from field to field by moist air than by contact with people, it is unwise to take risks. An alternative is to wear disposable boots and pants that can be changed between fields, or clothing that can be reused after washing and drying.

Destroy hot spots –When late blight infestations are found early in small patches in fields, it can be beneficial to disk, burn with a propane burner, or spray these patches with a fast-acting desiccant to remove these local sources of inoculum. The area to be killed needs to extend at least 100 feet beyond any visible symptoms.

While this can be effective, remember that visible late blight lesions show up 3 to 5 days after leaves become infected. If conditions were favorable for disease spread during those 3 to 5 days, killing an infected area after symptoms appeared may not have been done soon enough to prevent further spread of the pathogen. These areas should be carefully monitored for further disease development and also marked and inspected prior to harvest for presence of late blight in the tubers. The late blight pathogen is capable of producing as many as 100,000 spores on a lesion as large as quarter.

LATE SEASON

Avoid excessive irrigation – Potato tubers become infected and disease develops when spores are washed down from infected leaves and stems through cracks in the soil surface. Spores may directly contact tubers exposed through soil cracks, or may "swim" short distances through the soil to infect shallow tubers. In either case, excessive irrigation and soil cracks may increase tuber infection.

Monitor and regulate fertility – Late season fertilizer applications help maintain green vines and promote tuber bulking. However, remember that green and vigorous vines are susceptible to late blight and can also be difficult to kill with desiccants. Also,

- Green vines may also harbor late blight spores that can infect tubers during harvesting.
- Skinned tubers may be more susceptible to infection because damaged areas remain moist for a longer period.

At the end of the season, petiole nitrate levels should normally drop to levels that encourage vine senescence.

Scout fields regularly – Even small amounts of foliage infection may lead to significant tuber infection if conditions are favorable for infection during harvest. Continue scouting on a weekly schedule through vine kill.

Infected areas should be marked and harvested last so infected tubers have time to decompose, or consider not harvesting these areas. If the areas are not harvested, lay the tubers on top of the ground so they are more likely to freeze during winter. If the infected area is harvested, tubers from these areas should be placed near the storage door so that these potatoes can be removed and marketed immediately if tuber decay becomes evident.

Prevent next year's volunteers – Volunteer potatoes are difficult to control so consider using a preharvest sprout suppressant. Preharvest sprout suppressants must be applied while vines are green and actively growing, and must be made at least two weeks before vine kill. Maleic hydrazide (Royal MH-30) may provide 70 to 80 percent control of next year's volunteers when applied at the proper time under good environmental conditions at the full labeled rate. Maleic hydrazide should not be applied to seed potatoes, and has been reported to cause some foliar and tuber injury when applied to stressed crops or if overlap occurs during application. Check the label for specific use recommendations.

Kill vines completely – The late blight pathogen cannot survive and produce spores without a living host—green foliage or stems, or tuber tissue. During harvest, infected vines mixed with tubers in cool, wet conditions may lead to tuber infections that are not visible until later in storage.

Kill vines at least 2 to 3 weeks prior to the anticipated harvest date. This interval minimizes the chance of tubers getting contaminated with late blight spores during harvest and allows previously infected tubers to decompose in the field. Mechanical, chemical, or natural (frost) methods may be used to desiccate vines.

No data are available that indicate one method of vine kill is better than another as long as vines are completely killed. Vine rolling or flailing may be helpful to expose the soil and lower canopy to drying in fields with heavy vine growth. Some vine-killing methods are very sensitive to weather

conditions. Watch weather forecasts, and if necessary, kill vines early if wet conditions are forecast.

CULTURAL CONTROL DURING HARVEST AND STORAGE

Identify level of tuber infection – Sort tubers during harvest, removing as many decayed tubers as possible. Identifying tubers infected with the late blight pathogen can be difficult, especially if tubers are covered with soil. Submit suspect tuber samples to trained personnel for confirmation.

Potato lots with more than 3 percent late blight infection may be very difficult to store. Even very small infection levels can lead to serious losses in marginal storage facilities, so it is important to know what level of infection is present.

Harvest carefully – Avoid harvesting during wet conditions. Tubers can become infected at harvest even with minimal foliar blight in a field if conditions are wet. Harvesting during rain is particularly dangerous. Harvesting when skins are mature, and minimizing skinning, cuts, and shatter bruises will reduce the likelihood of tuber infection.

Any break in the tuber skin provides an ideal place for the late blight and other disease-causing organisms to gain entry into the tubers. Although the late blight pathogen does not need a wound to infect tubers, cut, skinned, and shatter-bruised tubers are more likely to become infected because the protecting skin is damaged and these areas remain wet for an extended time period, giving the late blight spores time to infect the tuber.

Carefully monitor and regulate storage conditions – The ability to provide high volumes of air flow throughout the pile for cooling and drying tubers is critical during the early storage period. Remove vines, loose soil, and anything else that may interfere with air distribution in the pile.

If foliar late blight was present in the field prior to harvest, it is important to ventilate the storage as quickly as possible with a high volume of air. As soon as the first 2 to 3 air ducts are covered, begin supplying air to the pile to dry wet potatoes and to equilibrate the pile temperature.

It may be necessary to continuously run the fans with reduced or no humidity until tubers are completely dry. This drying time should usually require no more than 72 hours. Expect increased pressure bruise and shrinkage losses in potatoes subjected to these storage conditions, especially if they are not marketed early.

Due to the negative impacts of reducing humidity, this difficult decision should involve accounting for the percentage of infected tubers, the wetness of the rot, and market-end use of the remaining healthy tubers.

Begin observing potatoes in storage immediately for rot development (hot spots). If hot spots develop, supply additional air to those areas of the cellar, and plan on removing the potatoes as soon as possible. Holding potatoes at lower temperatures (below 45°F) may lessen development of disease in storage, but this can have a significant impact on the market use of the potatoes. Know the end use of the tubers prior to manipulating storage temperatures.

Minimize volunteer potatoes – Small tubers left in the field are potential volunteers the next year, and, if infected, may produce late blight-infected plants. The number of tubers left in the field may be reduced by using a narrower pitch chain on the harvester. However, this may also increase the soil and vine load in the harvester, which must then be removed before placing potatoes into storage so as not to hamper air circulation. Use shallow tillage practices that leave tubers on the surface or within the top two inches of soil to encourage freezing during the winter.

CHEMICAL CONTROL

Seed Piece Treatments

Several experiments conducted over the last 30 to 40 years have indicated that most of the seed tubers or seed pieces infected with late blight will readily decay from soft rot after planting, making them self-eliminating. Yet, seed transmission is an important means of initiating late blight in a field and to an area. Late blight spores can spread from infected tubers to healthy tubers during handling, cutting, and planting operations. These healthy seed pieces can then develop late blight after planting.

Seed piece fungicide treatments that have activity against late blight have been shown to be effective in minimizing seed-to-seed pathogen spread. Use a seed piece treatment that is labeled for control of late blight. Evolve is a combination of thiophanate-methyl, mancozeb, and cymoxanil (the active ingredient in Curzate) and is the most effective seed treatment in preventing tuber-to-tuber spread of the late blight pathogen in seed cutting operations.

Growers who suspect or know they will receive seed that contains some late blight are strongly encouraged first not to purchase the seed. But if you do purchase the seed, use seed piece treatments that have activity against late blight. Growers using seed lots with known or strongly suspected late blight infestation should also place the affected fields on a regular fungicide spray program early in the growing season. Keep in mind that no seed piece treatment can "rescue" a badly infested seed lot.

Fungicide Types and Selection

For a list of fungicides labeled for use on potatoes for controlling late blight, go to www.ag.uidaho.edu/potatopath. The fungicide selected is not as important as application coverage and timing as discussed below. However, the use of copper or tin fungicides alone is not recommended for controlling late blight.

Fungicide Resistance

University of Idaho Extension personnel track and document the late blight strains that occur in Idaho. Strains of the late blight pathogen are identified by the country where the strain was first identified, and by the chronological order of description in that country. For example, the US-8 strain is the eighth strain characterized in the United States.

Any other strains of the late blight pathogen that resemble the US-8 strain are given the US-8 designation regardless of where in the world they are found. Most late blight strains found in Idaho since 1995 have been the US-8 and US-11 strains.

Both of these strains are resistant to the fungicide mefenoxam (Ridomil). Therefore, mefenoxam-based products, such as Ridomil Gold Bravo, Ridomil Gold MZ, and Ridomil Gold Copper are not recommended for use in controlling late blight.

Mefenoxam-based products are very effective for controlling pink rot in some areas of the state and for controlling Pythium leak when applied according to label directions. (Many fields in eastern Idaho have mefenoxam-resistant isolates of the pink rot pathogen.)

The companion fungicides in Ridomil Gold pre-packs, such as Bravo (chlorothalonil) or mancozeb, are protectant fungicides effective for controlling late blight. When applying Ridomil Gold pre-packs for control of pink rot and Pythium leak, consider the companion fungicide in the pre-pack to be part of your protectant spray program for late blight.

Remember that chlorothalonil, triphenyltin hydroxide and the EBDC fungicides have limits on the amount of active ingredient that can be applied per acre each season. **Carefully follow label directions to be certain that you are not applying more active ingredient per season than is allowed.**

Alternating fungicide classes should be part of any program and will help prevent these use limits from being approached. Fungicides with a narrow mode of action should be tank-mixed with a broad spectrum fungicide. **Carefully follow label directions to be certain fungicides are applied in the appropriate manner.**

Consider These Factors When Selecting an Application Method

To ensure thorough and complete fungicide coverage in the potato canopy, a fungicide may need to be applied up to two weeks prior to potatoes being exposed to late blight.

Fungicide label directions – Product choice influences application method because some products have limitations on how they may be applied. Fungicides may be applied by ground, aircraft, or chemigation. Check the label for application restrictions and how the fungicide may be applied, and follow the label directions.

Field size, shape, tillage practices, and obstacles – Choosing an application method depends on many factors including field size and shape, location of obstacles, irrigation system, and tillage practices. For example, fields with power lines, houses, or tall trees along the edges may not be good candidates for aerial applications. Likewise, fields with basin tillage pose some problems for ground application. Chemigation is most applicable with center pivot irrigation.

Timing/availability of equipment – Another factor to consider is whether a fungicide can be applied in a timely manner. A successful late blight management program must include having a fungicide applied to the potato crop before late blight spores enter a field. If you plan on using air or ground application methods, be certain the equipment will be available when needed.

Need for redistribution – To ensure thorough and complete fungicide coverage of the potato canopy, fungicides may need to be applied up to

2 weeks prior to potatoes being exposed to late blight. This 2-week period allows fungicides to be redistributed throughout the canopy by subsequent irrigations. Application method, frequency, and amount of water applied all influence fungicide redistribution in the canopy. More redistribution is required following air application, less for ground, and least is required for chemigation. However, all methods of application work when used properly.

Equipment must provide complete coverage and be timely – No matter which application method is used, the crop must be completely covered with no skips or areas untreated, and fungicides must be applied at the appropriate interval for the disease pressure in your area.

Application Methods

Ground application – Applications using a ground sprayer tend to be very effective in controlling late blight because the water volumes and pressures used provide good leaf coverage and penetration of fungicide into the canopy. Research at the University of Wisconsin found that hollow cone and extended range flat fan nozzles were superior to flood-jet nozzles. Recalibrate the sprayer often, and replace nozzles that are under or over applying by more than 10 percent of the boom average. Raise the boom height as the crop grows to maintain the proper overlap in the spray pattern.

Disadvantages. The main disadvantages of ground applications are the time required to cover large acreage, incompatibility with certain irrigation systems, and basin tillage. Multiple trips through the field with a ground sprayer will also increase soil compaction, especially on heavy soils. During 1996, the University of Idaho documented a 1 to 3 percent reduction in yield due to sprayer traffic in two fields in the Treasure Valley. This yield effect should be factored into the cost of ground application when comparing with air and sprinkler application methods. Ground application also damages reservoir tillage basins causing water to run down rows creating ponds or gullies in some areas.

Air application – Air applications deposit most of the fungicide on top of the crop canopy, and the material must then be redistributed into the lower canopy by irrigation water or precipitation to provide protection. A minimum of 5 gallons of water per acre is required for adequate coverage. Research has shown that 5 gallons of water per acre is as effective as using 10 gallons. It is important to remember that nozzle calibration is just as important for air applications as it is for ground applications.

Disadvantages. One of the biggest problems with aerial application is untreated strips caused by inadequate overlap between passes. If possible, a field could be sprayed in an east-west direction one time and north-south the next. Some aircraft now have GPS systems, which can help eliminate missed strips. Availability of planes for timely applications has occasionally been a problem in parts of Idaho. Work with the aerial applicator to identify field areas that cannot be treated due to obstacles (trees, power lines, houses, etc.). Treat these areas with a ground applicator to ensure proper coverage.

Chemigation – An advantage of using a sprinkler system for applying a fungicide is the system is already in place so you do not need to wait for equipment. A 1998 survey in Idaho showed that potato fields where late blight was controlled with chemigation had disease severity ratings slightly lower than fields where ground or aerial application methods were used. The survey does not, however, consider the number of fungicide applications or products used. An important point to note, though, is that all methods adequately controlled late blight.

For any type of irrigation system, make sure the field is the same size as the system (i.e. no potatoes outside the water coverage area). The uniformity of fungicide application is very dependent on the uniformity of water distribution. Corners of fields irrigated with center pivot systems usually do not receive adequate fungicide coverage and should be sprayed with a ground applicator. For solid-set or set-and-move systems, inject the fungicide during the last portion of the irrigation set, or make a separate application between irrigations. Make sure the fungicide has been evenly applied throughout the line and has been flushed out of the end nozzles before shutting off the system.

Disadvantages. One of the main disadvantages of using a center pivot to apply fungicides is the huge volume of water applied with the chemical. This results in relatively lower fungicide residues in the upper canopy compared to aerial application. Therefore, it is important to adjust the revolution time to the fastest setting in order to apply the least amount of water to the foliage. Always use the highest labeled rate when applying a fungicide through a sprinkler system.

Research from the Columbia Basin of Oregon and Washington indicates that an alternating program of aerial application and chemigation application is an effective method of establishing higher residues and obtaining product redistribution at a reduced cost over using air alone.

When to Apply Fungicide

Initial applications – For optimum protection, potato fields should be sprayed with a protectant fungicide before row closure (plants touching between rows) followed by a second application in 7 to 10 days. Weather can be unsettled early in the season when vine growth is rapid and susceptible to late blight. The need for additional applications will depend on weather conditions and occurrence of late blight. These early applications treat the stems and lower canopy where late blight often begins once the vines close the rows and conditions within the canopy become more favorable for late blight.

Early fungicide applications are recommended because of the chances of infections starting from local sources such as volunteers, cull piles, or seed and because controlling late blight early in the season will prevent weekly applications throughout the season if a field becomes infected early.

Additional Applications – Rigorously scout for late blight and pay careful attention to weather conditions favoring late blight development, i.e. weather that is cooler and wetter than normal. After the first two fungicide applications, if late blight is found in the area or weather conditions are conducive for disease development, then continue to spray a protectant fungicide on a regular schedule.

A preventative attitude is very important when dealing with late blight. Attempting to "rescue" a field after late blight occurs is likely to fail. There are no "curative" fungicides (including the limited systemic products such as Curzate, Previcur, and Acrobat) that will effectively stop a late blight epidemic. It is vital to stay ahead of the late blight pathogen with a protectant fungicide spray program. A regular fungicide program can provide the necessary control of late blight (Figure 3).

Recommendations on spray application frequency will be issued regularly throughout the growing season. Protectant fungicides must be applied at intervals that maintain coverage on new leaves, especially when environmental conditions are conducive for late blight development.

Late season applications – Continue fungicide applications at intervals based on weather conditions and recommendations. Protectant fungicides may need to be applied even after vine desiccation until all green vines are completely dead if late blight was present in the region or field. Research from the Columbia Basin has shown that late season applications of mancozeb can be effective in reducing tuber blight when foliage is infected. Applying a fungicide as a tank mix with a vine-killing agent is not recommended. Early vine killing may be the best option for fields with out-of-control late blight infestations.

Recommendations to reduce late blight tuber rot – Season-long control of the late blight pathogen on plants (leaves and stems) is extremely important for reducing tuber infection. Tuber blight can occur even when only small percentages of foliar blight are observed in the field. Follow the recommendations above to reduce chances of tuber infection during harvest.

Post-Harvest – Disinfestants such as chlorine dioxide, hydrogen peroxide/peroxyacetic acid mixtures (HPPA), and ozone are labeled for post-harvest control of late blight. However, University of Idaho research has not shown consistent results using these products. Phosphonates (phosphorous acid or phosphite-based products) have been shown to be effective in keeping healthy tubers from being infected at harvest. Application of post-harvest disinfestants or fungicides should be done using 0.5 gallons of water per ton of tubers, and tubers should be rolling when they pass under the spray bar to ensure adequate coverage of tuber surfaces.

Figure 3. Research plots show potato plants protected by weekly fungicide applications (left, front) compared to plants not receiving any fungicide applications (right, front). Weekly fungicide applications can provide protection against late blight when spray programs are started before late blight is present.

MORE HELP WITH LATE BLIGHT IN POTATOES

Hotlines with current status

- University of Idaho hotline: 800-791-7195
- Washington State University hotline: 800-984-7400
- Oregon State University hotline: 800-705-3377

Web help

- Pacific Northwest Pest Alert: *www.PNWPestAlert.net*
- University of Idaho Potato Pathology web: *www.ag.uidaho.edu/potatopath*
- Idaho Center of Potato Research: *www.ag.uidaho.edu/potato*
- Fungicides labeled for use on potatoes to control late blight: *www.ag.uidaho.edu/potatopath*

Publications

CIS 814, Cull and Waste Potato Management: *http://info.ag.uidaho.edu/pdf/CIS/CIS0814.pdf*

CIS 1130, Managing Fungicide Resistance: *http://info.ag.uidaho.edu/pdf/CIS/CIS1130.pdf*

CIS 1131, Diagnosis & Management of Potato Storage Diseases: *http://info.ag.uidaho.edu/pdf/CIS/CIS1131.pdf*

PNW 555, Managing Late Blight on Irrigated Potatoes in the Pacific Northwest: *http://info.ag.uidaho.edu/pdf/PNW/PNW0555.pdf*

Potato Production Systems, Jeffrey C. Stark and Stephen L. Love, eds. 2003. University of Idaho Extension

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PESTICIDES DISCLAIMER

ALWAYS read and follow the instructions printed on the pesticide label. The pesticide recommendations in this UI publication do not substitute for instructions on the label. Due to constantly changing pesticide laws and labels, some pesticides may have been cancelled or had certain uses prohibited. Use pesticides with care. Do not use a pesticide unless both the pest and the plant, animal, or other application site are specifically listed on the label. Store pesticides in their original containers and keep them out of the reach of children, pets, and livestock. Trade names are used to simplify the information; no endorsement or discrimination is intended.

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