

Management of Storage Pathogens
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The first step in limiting tuber quality loss from storage pathogens is to grow a healthy potato crop. Stresses from nutrient deficiency, temperature extremes, moisture extremes, diseases and insects during production can predispose decay potatoes by storage pathogens. Avoiding working wet soils and field with rocks can be critical. Clearly, starting with seed free of seedborne diseases such as ring rot, Ralstonia bacterial wilt, blackleg, *Erwinia (Dickeya) chysanthemi*, late blight, silver scurf, Fusarium dry rot and either root knot or cyst nematode is critical. I urge all growers to become aware of the potential of new low temperature strains of *Ralstonia solanacearum* (Race 3 biovar 2) and *Dickeya chysanthemi* currently not present in MT to potentially cause problems in MT.

Control of Pythium leak, late blight, early blight and silver scurf control starts in the field with selection of disease-free seed, crop rotation and selection of appropriate fungicides applied as needed during the growing season.

Pythium Leak

Pythium leak is caused by the common soil inhabiting oomycete, *Pythium ultimum* var. *ultimum*. This pathogen is found in all soils and enters potatoes only through wounds and is active only at temperatures greater than 50⁰F and temperatures of 69-86⁰F. Typically this is a problem in MT when we have a warm, wet harvest period. For optimal control growers can use an infurrow fungicide spray at planting and an application at flowering plus 14 days and 28 days. A maximum of three applications are allowed per season. These same timings will work for Phytophthora pink rot although this disease is not common in MT. Ridomil Gold MZ, Ridomil Gold /Bravo, or Ridomil Gold/Bravo L, Metastar and Ultra Florish are fungicides that will give control. Growers should avoid where possible harvesting when soil temperatures are above 69⁰F. Be sure skins are well set and avoid harvest injury. Allow tuber injuries to suberize in storage at temperatures less than 60⁰F at high humidity. Avoid free water! If leak occurs in storage increase air movement, cool to less than 50⁰F and turn off humidification as quickly as possible.

Late Blight

If late blight has been identified in a field, early vine kill is the best recourse. Fungicide sprays incorporating the fungicide products Gavel, Forum, Previcur Flex, Tanos, Curzate, Ranman or Revus Top into the last two sprays before vine kill will help reduce tuber infection. The strain of late blight found this year causes stem lesions and is therefore a mating type II- these are resistant to metalaxyl/mefoxam (Ridomil Gold MZ, Ridomil Gold /Bravo, or Ridomil Gold/Bravo L, Metastar and Ultra Florish). Application of copper with vine kill materials will also help reduce tuber infection. Good vine kill is critical to controlling late blight in storage. Allow full 2-3 weeks after vine kill before harvest so infected tuber rot or those that are visibly diseased can be picked out before piling. It will be very difficult to store potatoes with >5% infection.

North Dakota is recommending that growers with late blight consider using phosphorus acid post harvest to reduce tuber infection before or after harvest. Several brands (e.g. Crop-Phite, Fosphite, Phostrol, Resist 57, Topaz) are registered; the label for one, Phostrol, states: "For the suppression of late blight (*Phytophthora infestans*) and pink rot (*Phytophthora erythroseptica*) apply 0.1 gallon of Phostrol per ton of tubers in approximately 0.5 gallons of water as a spray. Complete and even coverage of tubers is critical. This use ratio equates to 12.8 fl. oz. of Phostrol per 0.5 gallon of total spray volume (12.8 fl. oz. + 51.2 fl. oz. water). Apply as a mist directly to tubers as they move into storage. Phostrol, like all other post-harvest products, should be applied to tubers after most soil has been removed by normal handling operations". Phosphorous acid may be best applied on a roller or star table positioned just in front of the piler; we recommend a plastic "tent" around the table to prevent escape of the phosphorous mist and for minimizing worker exposure. In limited data from 2009 this treatment showed also good control of Fusarium dry rot.

Follow suggestions storage temperature and humidity suggestions for Pythium leak above if late blight is present.

Vine Kill/Harvest

Proper vine killing of physiologically mature tubers and allowing the required amount of time (usually minimum of 14 days) to ensure good skin set is critical to minimizing tuber injury where most pathogens gain entry. Soil moisture during this time should be in the 60-75% available moisture range. Tuber injury during harvest can be minimized by ideally harvesting in clod free soils in the 60-75% moisture availability range and when pulp temperatures are in the 50-65°F range. If soils are dry a light irrigation 4 days or so before harvest will help soften clods and will help get hydration of tubers in the proper range.

The next most critical step is operation of the harvester, windrower, loading and piling equipment to minimize bruising. Remember any injury will allow a place for Fusarium, Pythium or soft rot bacteria to enter. A good rule of thumb is there should be no drops of more than 6-8". These pathogens are present in most soils. Remember that sunburn can provide infection sites so picking up windrowed tubers within 30-45 minutes and tarping loads can be important. Disinfection of the storage and all equipment is critical .

Disinfecting Storages and Equipment

One of the most important steps in marketing top quality seed potatoes is to be sure that soil or old potato residues are thoroughly removed from storages and equipment before the new crop is harvested. This can be critical in reducing potential for Ring Rot, Soft Rot and Silver Scurf. The first step is to thoroughly wash storage wall and floors, duct tubing, bins and other equipment with a through high pressure wash with hot, soapy water to remove mud, potato slime etc. This step is critical since organic matter and soil will inhibit the action of most disinfectants and bacterial pathogens such as Ring Rot and Soft rot survive as biofilms that can be protected by dirt or rooted plant material from disinfectants.

The second step is to use a good disinfectant and allow surfaces to have at least a 10-15 minute exposure to the disinfectant (5 minutes for live steam). Table 1. below lists different disinfectant materials and their pros and cons.

Table 1. Disinfectants used for sanitizing potato handling equipment and storage facilities

| Material | Effectiveness | | Inactivation | | Comments |
|-------------------------------|---------------------|---------------------|------------------|------------------------------------|--|
| | Wet bacterial slime | Dry bacterial slime | Organic matter | Hard water | |
| Quaternary Ammonium compounds | Excellent | Excellent | slight | no | Slightly corrosive, many brands available, good wetting properties |
| Sodium hypochlorite (Bleach) | Excellent | Excellent | yes | No- may be in water with high iron | Corrosive, use at 1 part 5.25% bleach to 50-200 parts water- at high dilutions add 0.6 parts white vinegar to the solution. Best activity at pH 6-7.5 . Use within 2 days of mixing solution |
| Iodine compounds | Excellent | Excellent | slight | No- may be in water with high iron | Corrosive, becomes ineffective when yellow-brown color is lost |
| Phenolic compounds | Excellent | Excellent | slight | no | Non-corrosive. Provide residual activity- will say contains phenol on label |
| Chlorine dioxide | Excellent | Excellent | Less than bleach | no | Corrosive, broad activity |
| Copper compounds | Good | Good | no | Yes | Corrosive, residual activity |

Harvester Considerations

Perhaps the largest percentage of bruise damage occurs during harvest. The most common harvester problems are:

1. Blade- the digger blade should be positioned such that the soil and tubers are delivered up onto the primary chain rather than delivering tubers to the nose of the primary chain. The back side of the blade should be even with the top of the primary chain.
2. Primary chain- use belted chain if possible and be sure that this chain is run at capacity and that soil and tubers are carried to the top of the primary. It is ok if soil and tubers are just separating at the top of the primary. Be sure that all chain has good rubber covering and it is not cracked. If harvesting a variety like Umatilla that is very susceptible to Fusarium dry rot do everything possible to have the soil in good condition, avoid use of shakers or clod hopper as this can cause more bruising than the soil clods – pick them out on the sorting line.

3. Secondary chain- use belted chain if possible-be sure all chain is rubber covered. Adjust speed so that tubers are falling on tubers not chain!

Post Harvest Products

The use of post harvest disease control products such as BioSave, Purogene, Jet-Oxide, Oxidate etc is becoming more common and post harvest fungicides such as azoxystrobin and difenoconazole, now being used on fruits, are likely to be registered for use on potatoes in the next year or so. Good coverage is critical and water volumes of approximately 2 qt/ ton will give good coverage with proper nozzle selection. BioSave is a living organism (*Pseudomonas syringae* Isolate EC10) and controls soft rot, silver scurf and Fusarium dry rot by occupying infection niches and producing micro amounts of antibiotics in these niches. Products such as Purogene, Jet-Oxide, Oxidate etc have only a surface sterilizing effect and provide no residual activity. These products cannot be used with BioSave since they will kill the biocontrol bacteria. Data on direct application looks better than use through the aeration system of storages.

Handling into Storage

Unloading from trucks all the way through piling can be other sources of bruising. Again no drops more than 6-8" and have potatoes hitting potatoes not steel. Where larger drops are unavoidable install slides. Build the pile in a stair-step manner to avoid tubers rolling down the face of the pile. One person should be designated to run the piler and should be trained in the importance of bruise avoidance. This should be his/her only job-there should be no distractions!

Storage- Environmental Considerations

After binning with minimal bruising, allowing for a curing period of 7-10 days with temperatures in the 50-60⁰F and 95% relative humidity range with plenty of outside air (> 25 cfm/ton) will reduce many decay problems. This is because the tuber will produce cork cells (suberization) at the site of injuries and most pathogens cannot invade this new tissue. Following this curing period, temperatures should be reduced to levels unfavorable for pathogens (generally in the 38-42⁰F range). Run fans to be sure no condensation moisture is present on the potatoes and use outside air when possible to ensure CO₂ levels remain below 5000 ppm. Temperatures and odor should be monitored as increases in temperature or off odors are the first sign of problems.

Finally avoid bruising when unloading storages and loading customer's trucks. If possible, warm tubers to 50-55⁰F before handling.