

Diagnosis & Management of Potato Storage Diseases

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U.S. potato losses during storage have averaged about 7.5% over the past several years, according to the *National Potato Council 2004-2005 Potato Statistical Yearbook*. Individual farm losses can be much more severe, with complete losses all too frequent. While a portion of the average yearly losses is due to transpiration and respiration, the more serious losses usually are due to storage diseases.

Storage diseases are not curable, but there are ways to help limit pathogen spread from diseased to healthy potatoes and to keep the problem from getting worse. Appropriate storage management depends, however, on proper identification of the disease responsible for a rot problem. Pathogen identification will also help in making future field management decisions.

The major diseases that plague potatoes in storage include pink rot, *Pythium* leak, late blight, dry rot, soft rot, silver scurf, black dot, and early blight. Some diseases cause more severe damage and progress more rapidly than others, especially when secondary bacterial soft rot creates “hot spots” that can rapidly lead to the breakdown of an entire pile of potatoes in storage.

Selecting tubers for diagnosis

The first step in diagnosing the type of rot either coming out of the field or developing in storage is to select partially rotted potato tubers. “Partially rotted” means that half or more of the tuber is healthy. Careful selection is important because tubers that are completely rotted often have succumbed to secondary soft rot invasion, and ascertaining the initial problem becomes much more difficult, if not impossible. If they are available, take several dozen tubers from each of the affected areas in the storage. Dissect the tubers by cutting them in half and peeling off areas of the skin. Most of the pathogens responsible for tuber decay in storage can take advantage of damaged areas on

tubers such as nicks, cuts, abrasions, broken knobs, or shatter-bruised areas. Look for evidence of these possible disease entry points and examine each tuber’s natural weak points such as the area of stolon attachment, the lenticels, and the eyes.

Unfortunately, many tuber diseases vary in their appearance, and often they do not look exactly like the textbook pictures. Further examination by a disease expert (university scientist or other disease diagnostician) may be necessary. The expert will require intact tubers to perform a proper diagnosis. Collect new samples for this purpose or leave some of the tubers in your samples uncut. Also, provide healthy tubers not expressing any of the symptoms for comparison.

Identifying the disease

Match your observations to the disease descriptions and photographs that follow.

Areas on tubers affected with most of the described diseases are also easily invaded by the ultimate nemesis of the potato storage manager: bacteria that cause bacterial soft rot.



Figure 1. Tuber symptoms of pink rot. Infected tubers first appear cream colored when sliced open. The salmon-pink coloration appears after 15 to 20 minutes at room temperature.

Pink rot

Tubers affected by pink rot, caused by the oomycete *Phytophthora erythroseptica*, often maintain a normal shape, but the outer skin turns dark and the internal flesh when cut has a rubbery, “boiled potato” consistency (fig.1). The internal tissue turns pink after about 15 to 20 minutes of exposure to warm air and approximately 30 to 40 minutes under cool temperatures.

It is easy to confuse the pink rot color reaction with the lighter pink color that occurs due to oxidation when healthy tissue is exposed to air. Look for a distinct line between healthy and infected tissue. Your nose can also help in diagnosing this disease. Pink rot in storage is usually accompanied by a distinctive ammonia odor.

Pythium leak

Pythium leak, caused by *Pythium* spp., is often described as a “shell rot,” but the term “leak” comes from the extremely wet nature of the rotted tissues. One method to confirm the presence of leak is to gently squeeze the rotten tuber and watch for a clear liquid to stream out (fig. 2). This disease also tends to cause a grey/brown/black rot in the interior of the tuber, leaving the outer cortex, or “shell,” of the tuber intact.

Since the leak pathogen typically needs a wound to infect, inspect the tuber for any potential disease entry points.

Late blight

Tubers with late blight, caused by the oomycete *Phytophthora infestans*, tend to have a reddish or tan-brown, dry, granular rot that extends from the skin of the tuber inward an inch or more (fig. 3). Tissues with late blight are firm to the touch, not wet or mushy. The amount of rot development will depend upon the duration of the infection, temperature, and potato variety. Peeling away the skin over the affected areas of the tuber and looking for the characteristic reddish color is a good way to identify this disease, but confirmation by an expert is always recommended.

Dry rot

Dry rot, caused by the fungus *Fusarium sambucinum* or *F. coeruleum*, typically progresses to tuber decay that is dry, crumbly, and brown in color with collapsed tissue often laced with secondary white- or other-colored fungal growth (fig. 4). While infected tubers eventually shrivel and mummify, the initial stages of dry rot can look very different.

F. sambucinum-infected tuber tissues initially have a wet, dark brown-black appearance. Except for the color changes, infected tuber tissues have the same firm, wet texture as the surrounding healthy tissues. The fungus



Figure 2. Cross section of a tuber affected by *Pythium* leak. Infected areas appear grey-black. When pressure is applied to the tuber, a clear fluid will usually drip or “leak” from the tuber, giving the disease its name.

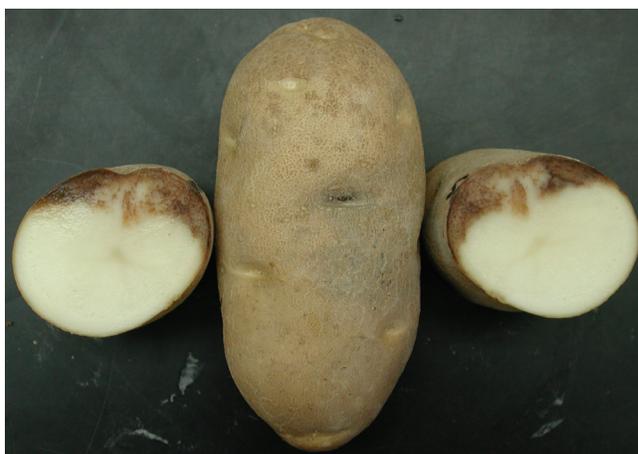


Figure 3. Potato tubers with late blight infection. The tuber in the center shows symptoms of infection through an eye. The tuber slices on either side depict the granular, brown dry decay associated with late blight.



Figure 4. Dry rot caused by *Fusarium sambucinum*. This brown, dry rot is characterized by a nonuniform progression of rot through the potato tuber, usually starting at an injury site.



Figure 5. Dry rot caused by *Fusarium coeruleum*. In contrast to dry rot caused by *F. sambucinum*, this dry rot progresses uniformly throughout the tuber.



Figure 6. Advanced stages of bacterial soft rot occurring prior to tuber harvest. Rot begins at the point of stolon attachment and continues through the central pith tissue of the tuber. These two tubers additionally show rot caused by secondary tuber rot organisms.



Figure 7. Potato tubers infected with silver scurf. Black dot symptoms on tubers can look similar.

Photo courtesy of Brad Geary.

almost appears to be tunneling through the tuber, following the path of least resistance. With time, the disease progresses into the more familiar dry or papery rot stage.

In contrast, early infections caused by *F. coeruleum* appear yellowish-tan. The fungus spreads radially and uniformly outward through the tuber tissues from the point of initiation (fig. 5).

Soft rot

The most serious of all storage diseases is soft rot, caused by the bacterium *Erwinia carotovora*. Symptoms include tan- to brown-colored water-soaked areas of granular, mushy tissue often outlined by brown to black margins (fig. 6). The rotted part of the tuber is clearly differentiated from the healthy part of the tuber, although with time the healthy part will succumb to the bacteria.

Soft-rotted tubers tend to break down easily, thus spreading bacteria to surrounding tubers, resulting in localized pockets of rot or “hot spots.” Spread from tuber to tuber is favored by high temperatures (the bacterium is not very active below 50°F) and anaerobic (low oxygen) conditions. Under these conditions, soft rot bacteria can invade previously healthy tubers, primarily through the lenticels.

Under most storage conditions, there is a danger that soft rot bacteria will invade tubers already infected with any of the previously described diseases. Once a soft rot pocket begins, the intense respiration occurring within the pocket can generate heat that accelerates the rotting process. The combination of high temperatures and wet, decaying tuber tissues laden with soft rot bacteria can result in extremely rapid disease progression.

Soft rot pockets generally spread downward in the pile, in response to gravity. A runaway soft rot problem can lead to the breakdown of an entire storage in a matter of a few days. Other bacteria, such as *Clostridium*, *Pseudomonas*, and *Bacillus*, can also cause tuber soft rot, but these have not been very well researched and are only poorly understood at present.

Silver scurf

Although not a disease that causes the internal tuber tissues to rot, silver scurf, caused by the fungus *Helminthosporium solani*, causes grey to silvery blotches on the surface of the tuber (fig. 7). Affected skin has a silvery sheen, appears thicker, and can be unappealing to consumers.

This disease has two distinct phases. One phase occurs while the tubers are still in the field and consists of infected areas on or near the stem end of the tuber called “primary lesions.” Probably more important from a cosmetic standpoint are the “secondary lesions”

that result from infections that develop while the tubers are in storage. Secondary lesions may occur anywhere on the tuber and can be so numerous as to cover virtually the entire tuber surface. In storage, infected tubers lose water at a higher rate than healthy tubers due to the pathogen's disruption of the periderm.

Black dot

Black dot, caused by the fungus *Colletotrichum coccodes*, causes unappealing lesions that look very similar to those of silver scurf, especially in the early stages of disease development. As the infection progresses, the lesions usually become more prominent and thicker than those associated with silver scurf. Within the lesions, small black sclerotia may be visible with the aid of a magnifying lens (fig. 8).

Early blight

Early blight in tubers is characterized by shallow, gray to black, dry lesions (fig. 9). Early blight can be caused by the fungus *Alternaria solani* or the fungus *Alternaria alternata*. (Tuber lesions caused by *A. alternata* are also called black pit.) Lesion margins may appear water-soaked and have a yellow color. Tuber early blight is often associated with wounding. This disease is seen most often when tubers with immature skins are harvested from sandy soils.



Figure 8. Potato tuber infected with black dot.

Photo courtesy of Dennis Johnson.



Figure 9. Tuber early blight symptoms are characterized by shallow, dry, gray to black lesions with margins that may appear water-soaked.

Managing storage diseases

Disease prevention

Storage management can be greatly simplified by taking steps to prevent diseases from occurring in the first place. A fungicide program and cultural practices to manage diseases like late blight, pink rot, and early blight in the field will reduce the percentage of diseased tubers placed into storage.

Avoidance of physical damage to tubers is one of the best management tools available. All the disease organisms discussed here are able to gain entry through wounds inflicted on tubers during the rigors of harvest and handling.

Some fungicides and disinfectants can be applied to tubers as they are being placed into storage to protect against late blight, pink rot, dry rot, and silver scurf development. Contact university personnel for the latest recommendations for registered and effective post-harvest products.

Management between storage seasons

Some pathogens, such as the silver scurf pathogen, may survive from one season to the next in the storage facilities themselves. Storages and handling equipment should be cleaned and sanitized or “disinfected” after the storage is emptied and before handling and storing the new crop. Disinfection of storages and handling equipment is a three-step process.

1. **Remove dirt and debris.** All the disinfectants approved for use in potato storages are rapidly tied up and rendered ineffective by dirt and organic matter. The next two steps of the process will be much more effective if the debris from last year’s crop is removed.
2. **Wash with soap and water.** This step is often accomplished with a pressure washer and a detergent solution. Warm or hot water will be more effective than cold water. Steam washers are also a good choice but will not actually disinfect storage surfaces or equipment because the duration of the exposure to steam is too short. Water and detergent help to dissolve and remove dried tuber sap and bacterial slimes that are deposited on storage surfaces and equipment, and detergents have some disinfection capability. Cleaned surfaces allow the disinfectant, used in the next step, to work properly.
3. **Disinfect.** Use an appropriate and registered disinfectant and make sure that the surfaces to be disinfected remain wet with the disinfection solution for *at least 10 minutes*. Use sufficient sprayer pressure and volume to effectively clean all surfaces.

Many fungal spores have tough, resilient cell walls, and bacteria in storages often occur in the form of dried slime. Ten minutes provides the necessary time for the disinfectant to penetrate the fungal cell wall or dissolve the bacterial slime and kill the pathogen.

Management during storage

Identify the major storage disease problem prior to making any changes to storage management procedures. Be aware that changes in storage management can impact other potato quality attributes, such as fry color and tuber sugar concentrations.

There are three basic tools of storage management: temperature, humidity, and airflow. Balanced use of these tools is the key to managing potato diseases in storage.

Cooling period. If potatoes are harvested with pulp temperatures above 60°F, cool them to at least 60°F within the first 2 to 3 days after harvest and maximize the duration of fresh-air intake. This is especially important for tubers with late blight, pink rot, *Pythium* leak, and soft rot because warmer temperatures promote faster decay.

Supply a high volume of air to the potatoes to decrease tuber temperature and to help dry out rotted or wet potatoes. Set-point temperatures may need to be decreased in a stair-step manner to optimize the duration of fresh air intake per day. Start operating the ventilation system as soon as the first two to three ducts are covered during loading. Continue to decrease storage temperatures to the desired curing temperature.

Some special circumstances such as colder-than-recommended pulp temperatures or excessive disease may require the advice of an expert. For instance, rapidly warming cool potatoes may cause condensation to form on the surface of the potato and elevate the potential for disease progression.

Curing period. Proper management of the storage facility during the wound healing or “curing period” is critical. The curing period is important for proper healing of cuts and bruises, reducing pathogen spread, and keeping shrinkage losses at a minimum. Wound healing requires oxygen, high humidity, and favorable temperatures.

The recommended storage regime for wound healing and curing is typically 50 to 55°F for 2 to 3 weeks with good ventilation and a relative humidity of 95% and above. Even these relatively cool temperatures will promote rapid breakdown when storage diseases such as pink rot and *Pythium* leak are present. Therefore temperatures during curing may need to be lowered to 50°F if disease incidence and severity are high (more

than 5% wet rot). However, curing temperatures below 50°F may delay wound healing and are generally not recommended.

Use continuous ventilation to dry out wet potatoes. If “hot spots” begin to develop during curing, supply high airflow to the area to help prevent additional pathogen spread. Airflow must be sufficient to remove water given off by the decaying tubers. Supplemental ventilation can be supplied by auxiliary fans on top of the pile or in the ducts below troublespots.

Holding period. After the required curing period, reduce the storage temperature from the curing to the holding temperature as quickly as possible but generally no faster than 0.5°F per day. Limiting the amount of time diseased tubers are held at warmer temperatures will decrease the rate of disease progression. A slower ramping rate may be more appropriate for potatoes to be processed where sugar concentrations and fry color are a concern.

Although lower holding temperatures typically decrease the rate of disease progression, any storage decision involving temperature adjustments must take into consideration the end-use of the potato. Processing potatoes typically need to be stored at higher temperatures (44° to 55°F) than seed and fresh market potatoes (37° to 45°F) and therefore the luxury of low storage temperatures is not available. Continuous fan operation and high airflow may still be necessary to dry out wet or problem potatoes, especially those with soft rot, pink rot, or *Pythium* leak. Continuous ventilation will also reduce the chance for condensation to occur in the storage facility. Keep in mind that low holding temperatures, while an effective management tool for many situations, are no guarantee that disease progression will stop.

Depending upon the nature and percentage of rot in the storage, the pile may need additional drying ventilation with reduced-humidity air. However, reduced humidity results in additional shrinkage and also delays wound healing, which can increase the incidence of dry rot. Decreasing relative humidity in storage to 85% or less can also decrease the secondary spread of the silver scurf pathogen. Still, evaluate other management strategies before reducing relative humidity.

Final thoughts

The three basic storage management tools available are temperature, humidity, and airflow. Properly identifying the disease responsible for a storage problem allows the optimal use of these tools to limit pathogen spread and disease development in storage. Keep in mind that any deviation from normal storage practices can reduce the quality of your stored potatoes. *Under some conditions, early marketing may be the only option available to preserve the value of your crop.*

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Further Readings

All but the potato disease compendium are available from

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