



Bacterial Soft Rot and Lenticel Spot on Potato Tubers

WASHINGTON STATE UNIVERSITY EXTENSION FACT SHEET • FS066E

Potato growers in Washington produce, store, process, and market nearly 9 billion pounds of potato tubers each year (Washington State Potato Commission, 2010). Since tubers are nearly 80% water, they are especially susceptible to diseases caused by bacteria. Bacterial soft rot and lenticel spot are two commonly occurring potato diseases in the state. Soft rot is a wet, mushy rot that progresses rapidly, especially when temperatures are warm and conditions are moist. Bacterial lenticel spot is a manifestation of bacterial soft rot which is initiated in tuber lenticels. Lenticels are the pores in the tuber surface that allow for exchange of oxygen and carbon dioxide during cellular respiration of the tuber. Substantial economic losses from these diseases may occur in both processing and fresh market potatoes.

Causes

The bacteria that cause soft rot are referred to as pectolytic bacteria because they produce enzymes that decompose the pectin in plant cell walls, leading to tissue deterioration. Soft rot bacteria generally affect potato tubers following harvest, but some can also cause black leg, a bacterial disease occurring on potato stems in the field. The soft rot bacteria are assigned to several species in the genera *Pectobacterium* and *Dickeya* (both were formerly in the genus *Erwinia*), and include *P. atrosepticum*, *P. carotovorum* subsp. *carotovorum* and subsp. *brasiliensis*, *P. wasabiae*, and *D. dianthicola*. Lenticel spot can also be caused by one or more species of *Pectobacterium*. However, other bacteria such as species of *Bacillus*, *Clostridium* and *Pseudomonas* are also suspected to cause symptoms of lenticel spot.

Wet fields and warm temperatures before harvest, plus a film of moisture on the tuber surface either in storage or transit, greatly favor development of both diseases. Generally, tuber soft rot and lenticel spot caused by *Pectobacterium* and *Dickeya* occur at temperatures above 10°C (50°F) with 10 to 30°C (77 to 86°F) optimal. Additional bacterial pathogens like *Pseudomonas* may prevail at temperatures between 10 and 24°C (50 and 75°F), while *Bacillus* and *Clostridium* are favored by temperatures above 24°C (75°F).

Symptoms

When soft rot develops, tuber flesh decays and becomes cream to tan colored. Often there is a black border between

healthy and rotting tissue (Figure 1). Symptoms can be observed on seed pieces (Figure 2), on tubers in the field, and on potato tubers in storage. In extreme cases, lenticels and other natural openings may exude slimy masses of rotting tissues and bacteria, rendering the tubers unmarketable.



Figure 1. Potato tuber with typical soft rot symptoms (russet potato cultivar; photo courtesy of D. Johnson).

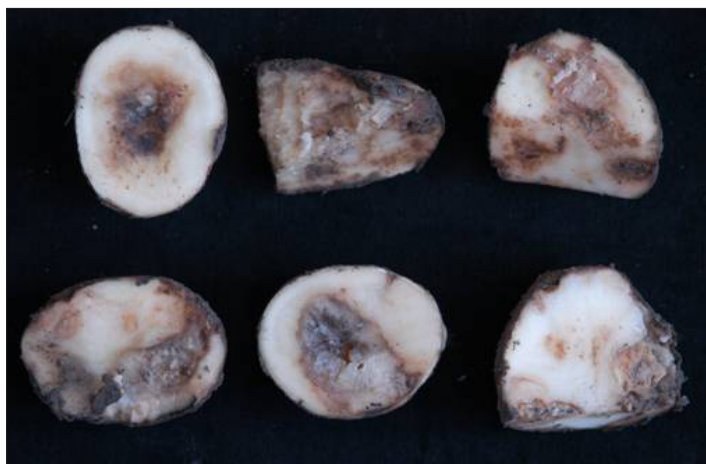


Figure 2. Potato seed pieces with soft rot bacteria oozing from cut surfaces (russet potato cultivar; photo courtesy of D. Johnson).

Lenticel spot symptoms may also be observed in the field, but usually are most noticeable 4 to 10 days after harvest and packaging. Symptoms are characterized by tan to dark brown, circular, water-soaked spots or small lesions surrounding the lenticels on the tuber surface (Figure 3). Infected tissue usually does not extend deeper than about 4 mm into the tuber. Adjacent lesions may coalesce to form larger, irregularly shaped, sunken lesions. Under moist conditions, the lesions enlarge, and can rapidly take on a puffy appearance (Figure 4) due to the production of gases by respiring bacteria in the lenticels. Usually the infected tubers remain firm and marketable, although of reduced quality and appearance. Infections via the lenticels can contribute to eventual soft rot of the entire tuber. However, if conditions remain dry, lenticel spot lesions remain limited, sunken, dry, and hard (Figure 5).

Disease cycle

Soft rot bacteria originate from many sources, including contaminated seed tubers (Secor and Johnson, 2009), decaying seed pieces and plants in the field, infested field soil, and contaminated water and harvesting equipment.



Figure 3. Symptoms of lenticel spot from bacterial infection at the tuber lenticels after washing (yellow potato cultivar; photo courtesy of B. Gundersen).



Figure 4. Puffy appearance of lenticels due to bacterial infection and respiration (yellow potato cultivar; photo courtesy of B. Gundersen).



Figure 5. Hard rot symptoms surrounding tuber lenticels (russet potato cultivar; photo courtesy of D. Johnson).

Wounds and natural openings such as stem ends, eyes, and lenticels are common points of entry for pectolytic bacteria into potato tubers. High numbers of soft rot bacteria are generally needed for infection. The bacteria usually originate in the field, and spread rapidly in storage if not kept in check. Plant-pathogenic bacteria are capable of surviving for long periods (days and months as well as years) as dried bacterial slime from infected tuber and plant liquids. Dried bacterial slime can be present on surfaces in storage facilities and on equipment such as truck beds. Lenticel infections also occur in the field before harvest, but can spread in packing shed environments when tubers are washed.

Oxygen depletion and a build-up of carbon dioxide around tubers are important factors that promote soft rot development (Perombelon and Kelman, 1980). *Pectobacterium* and *Dickeya* species are facultative anaerobes (organisms that normally live in the presence of atmospheric oxygen, but are capable of living without oxygen). If tubers in soil or storage are covered with a thin film of water, depletion of oxygen and build-up of carbon dioxide result. Oxygen depletion reduces the tuber's natural resistance to pectolytic bacteria. The build-up of carbon dioxide also causes lenticels to enlarge (Figure 6), and helps facilitate the entry of pectolytic bacteria into the tuber.

Many potato production practices can lead to excess moisture accumulation on tubers, including soil flooding, washing tubers, spraying tubers with fungicides diluted in water as the tubers are loaded into storage, inadequate drying of tubers, and poor ventilation in storage and/or transit. All of these, separately or collectively, can contribute to the development of tuber soft rot and/or lenticel spot.

Management strategies

Management of these bacterial diseases is centered on irrigation practices in the field before harvest, proper handling of the potato crop during harvest, and careful sorting, storage, and transit of tubers (Davidson, 1948; DeBoer, 2008; Gudmestad, 2008). Commercial storage of potatoes involves several phases: 1) drying of surface moisture; 2) wound healing at 85 to 95% relative humidity with storage temperature below 25°C (77°F); 3) consecutive cooling; 4)



Figure 6. Enlarged lenticels on a tuber, resulting from exposure of the tuber to excessively wet soil conditions (russet potato cultivar; photo courtesy of D. Johnson).

holding; and 5) reconditioning, during which phase the tubers are slowly warmed (Knowles and Plissey, 2008). Moisture condensation and accumulation of carbon dioxide must be managed by mechanical ventilation during all of the storage phases. The following points are important in helping to reduce the severity of soft rot and lenticel spot on potato tubers:

1. Irrigation should be closely monitored before harvest to avoid excessive soil moisture. During the tuber maturation stage, available soil moisture can be permitted to decline to 70% before being replaced by irrigation. This level of moisture will promote skin set. Available soil moisture in excess of 90% can lead to soft rot, however. Excessively dry conditions (i.e., less than 65% available soil moisture) should be avoided.
2. Irrigation practices two weeks before harvest are believed to have a large effect on the development of bacterial lenticel infections. Many fields for fresh packing in the Columbia Basin of Washington and Oregon are over-watered prior to harvest when water is applied to the field before digging to help carry dirt up the harvester chain and thereby reduce bruising of tubers. However, the extra water can form a seal on the soil surface, resulting in an increase in carbon dioxide levels around respiring tubers. Oxygen is then depleted in the air immediately around the tubers, and the natural resistance of the tubers to bacterial infection decreases. If pathogenic bacteria gain access to tubers via enlarged lenticels, the rapidly increasing bacterial populations can lead to infection and colonization of the lenticels and surrounding tissues.
3. Only mature tubers should be harvested. Tubers that are left in the soil for an adequate time after vine death to allow sufficient skin set are less subject to wounding and, consequently, less likely to be candidates for bacterial infections. Tubers harvested from green vines are more susceptible to postharvest soft rot. If possible, tubers should be harvested when soil temperatures are between

50 and 65°F. Tubers from low-lying areas of fields should not be stored or marketed if there is significant water-logging from late season irrigation or heavy rains just prior to or during harvest.

4. High air and soil temperatures can also promote the build-up of soft rot bacteria and increase tuber infections. In the Columbia Basin, if a producer chooses to water fields prior to harvest in August, care should be given to irrigate in the late afternoon to reduce the duration the soil surface is sealed by the irrigation water. Tubers should then be dug early the next morning when temperatures are relatively cool. For example, a grower could begin digging at 2 am and finish by 9 am. Some potato growers in western Washington have reported a benefit from harvesting before the heat of the day if late summer temperatures are warm in that region of the state.
5. If soft rot is present at harvest, the tubers should be graded as they are washed and packaged or moved into storage. Storage conditions should be managed to promote wound healing for 10 to 14 days, and then the storage facility should be managed to prevent the accumulation of carbon dioxide and condensation. Tubers should never be washed immediately before being placed into storage. A film of moisture left on the tuber surface greatly promotes the development of soft rot in the storage pile. Storage piles should be routinely monitored for wet spots, which are indications of soft rot, and tubers removed immediately from any such spots.
6. Before tubers are removed from storage, they should be warmed before handling to minimize bruising and prevent condensation on the tuber surfaces. If tubers are washed before processing or packing for market, they should not be submerged in flumes or dump tanks any longer than absolutely necessary. Bacteria in suspension in the water will be absorbed through the lenticels and any wounds.
7. If a fluming system must be used to transport tubers in water, the system should be cleaned and sanitized frequently. The flume water must be changed regularly, too. During fluming, tubers should not be submerged more than 1 or 2 inches or washed with high pressure nozzles because water pressure can force bacteria into lenticels and exacerbate disease problems.
8. Clean, chlorinated water or water treated with an effective biocide should only be used for washing fresh-market potatoes on the packing line. Dirt in wash water will deactivate biocides. Wash water should not be re-circulated. Information on disinfectants approved for use on potatoes in Washington can be found on Washington State University's Pesticide Information Center OnLine (PICOL) website: <http://cru66.cahe.wsu.edu/LabelTolerance>.
9. All equipment should be cleaned and sanitized to prevent the spread of bacterial pathogens.

10. It is very important that washed tubers are dried well before packaging. If a film of moisture is left on the tuber surface, the moisture may lead to development of bacterial soft rot or lenticel spot during shipping and marketing, especially when the tubers are boxed or put into plastic bags. Some of the excess moisture on tubers comes off when tubers are moved on the conveyor belt after washing. However, forced, hot air directed at tubers on the belt after washing is usually needed to adequately dry the tubers.
11. Adequate ventilation is required during both storage and transit of tubers. Ventilated bags or shipping containers help to maintain complete drying.
12. The incidence of tubers with lenticel spot generally appears to be greater for thin-skinned, specialty type potato cultivars (red and yellow potatoes) in the Pacific Northwest, suggesting that potatoes of these cultivars are more susceptible to bacterial soft rot and lenticel spot than other types of cultivars. Special care should be taken for these cultivars by following the suggestions listed above for growing and handling tubers.
13. There are various reports from different parts of the world in which the resistance of potato cultivars to soft rot bacteria is ranked. In one study at the University of Wisconsin-Madison (Tzeng et al., 1990), Butte, Russet Burbank, and Norgold Russet potato tubers ranked as the most resistant; Redsen, Norchip, Norland, and Belchip tubers ranked as the most susceptible; and tubers of Rhinered, Red La Soda, Superior, Pontiac, Atlantic, and Nooksack were intermediate in resistance. Another study from Wisconsin (Marquez-Villavicencio, 2011) compared soft rot on different potato cultivars caused by different *Pectobacterium* types, and found that *P. carotovorum* subsp. *brasiliensis* and subsp. *carotovorum* did not differ in aggressiveness on the cultivars evaluated, and were more virulent on tubers than *P. atrosepticum*. The study also reported considerable variability in potato tuber responses to these bacteria. Tuber size, maturity, and field location had significant effects on the susceptibility of tubers to soft rot, with larger, more mature tubers generally being more susceptible to infection than smaller, less mature tubers.

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