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The Blackleg-Soft Rot Disease Complex in Potatoes

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Blackleg-soft rot of potatoes appears to be a complex of diseases in which several bacterial species may induce various stem, foliar or tuber symptoms. At least four species or subspecies of bacteria are associated with soft rot of tubers in the northern U.S. They include:

- *Erwinia carotovora pv. carotovora* (Ecc)
- *Erwinia carotovora pv. atroseptica* (Eca)
- *Pseudomonas marginalis*
- *Clostridium sp.*

The bacterial soft rots commonly occur in conjunction with other rots such as Fusarium seed piece decay and ring rot. Of particular concern for Idaho are the bacteria causing blackleg (Eca) and soft rot (Ecc). In Idaho, *Fusarium sambucinum* (Fs) has been reported to interact with Eca. Yield reduction is greater when Russet Burbank potato is infected with both Eca and Fs than with either pathogen alone.

Tuber Symptoms

Blackleg — Infection of daughter tubers of a plant with foliar blackleg symptoms generally occurs at the stem end of the tubers. A sunken, dark, moist rot develops that can penetrate to the center of the tuber, giving a dark mushy appearance to the tuber's core. Often, only the tuber's shell remains. These symptoms can occur in the field or in storage.

Soft rot — Tuber symptoms include a soft, white-yellow rot that is clearly delineated from healthy tissue and often has a dark margin. A bacterial slime will ooze out of lesions on the tuber if the "skin" is broken. If the skin is intact, the lesion can be detected by locating a soft area under the skin. The rot may be extensive, sometimes destroying more than half of the tuber tissue. The rot is

Fig. 1. Reduced plant growth caused by blackleg.

Fig. 2. Potato plant wilting caused by blackleg.

odorless at first, but develops a foul odor as secondary organisms invade.

Seed pieces are often destroyed by soft rot, particularly when it develops on the fresh-cut surface and persists beneath the suberized tissue.

Bacterial soft rot symptoms can be confused with other types of soft rots such as water rot and Pythium leak. These diseases often occur as a complex with Fusarium rots.

Foliar Symptoms

Blackleg — Symptoms include soft, inky black, mushy lesions found anywhere on the stem, below as well as above the soil line. Chlorotic leaflets may be severely rolled and wilted. Eventual necrosis and a collapse of the stem will cause death. Young shoots may be invaded and killed before emergence.

Aerial stem rot — Tan, brown or black discoloration that does not originate at the point of attachment to the seed piece occurs on aboveground stems. Stems may be mushy without a color change. Decaying areas may be associated with an injury.

Symptom Development

The development of blackleg and soft rot symptoms is influenced by the tissue that is infected, the growth stage of the host plant and the environmental stress to which the plant is exposed. Early in the growing season, seed pieces may rot; young plants or some of the stems may collapse and die. The bacteria in or on the seed tubers interacts with soil moisture and temperature to determine symptom severity. Under some environmental conditions, symptoms may not be expressed even though the bacterium is present. Foliar symptoms may develop independent of tuber decay.

Soft rot decay in storage is increased by improper handling of the tubers at harvest and by improper storage conditions especially humidity and temperature during the healing or curing period after harvest (see Harvest and Crop Storage).

Rot Development in Tubers

Bruises and other wounds are not necessary for tuber infection to occur. If bruises are present, however, they will hasten infection by providing a suitable environment in which the bacteria can multiply. The following sequence of events probably occurs when bacteria infect tubers:

1. Bacteria enter and survive in the lenticels.
2. Excess moisture causes lenticel cells to enlarge and separate, leaving exposed interior cells and intercellular spaces.
3. Excessive moisture also causes a cellular oxygen deficiency that alters membrane permeability and causes nutrients and water to "leak" from cells into intercellular spaces.
4. The separation of the enlarging cells provides a point of entry for the bacteria and access to the nutrients and water in the intercellular spaces.

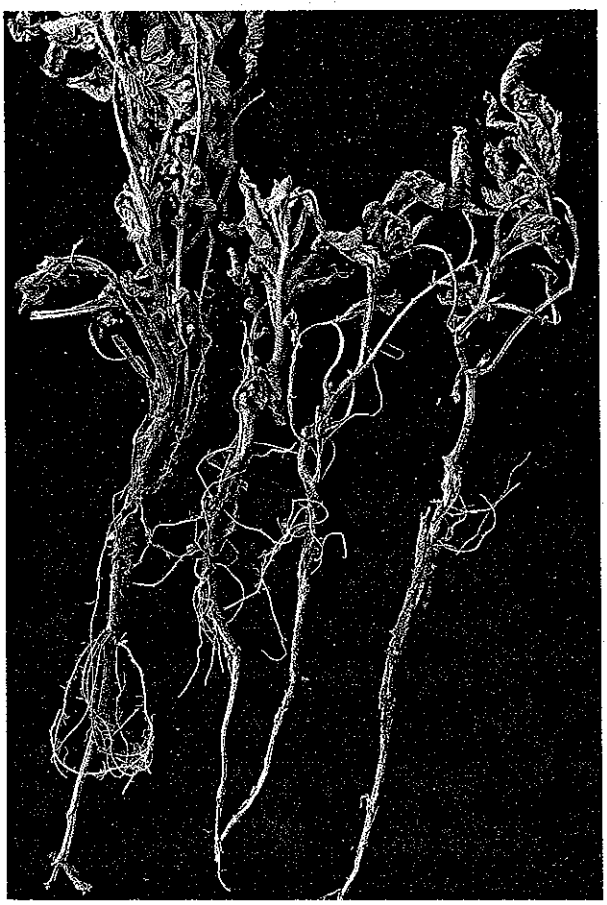

Fig. 3. External symptoms of blackleg.

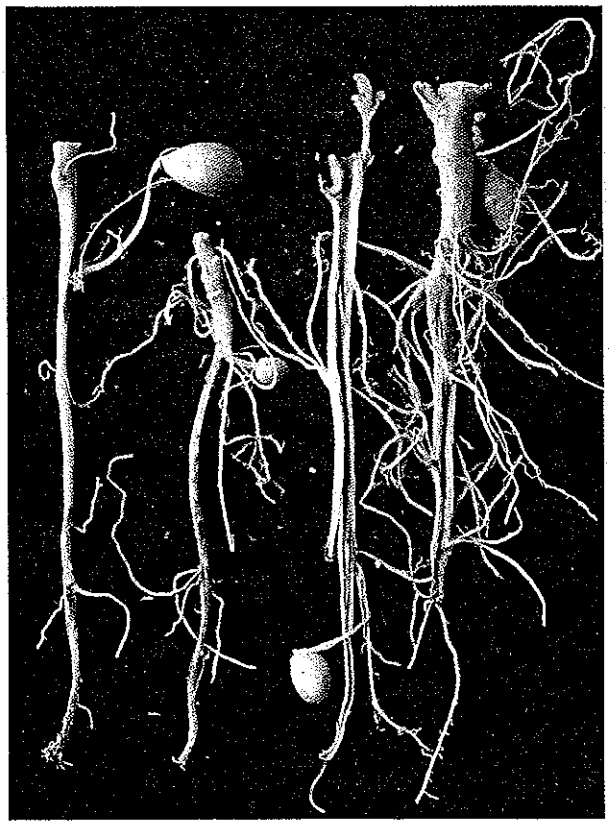

Fig. 4. Internal symptoms of blackleg.

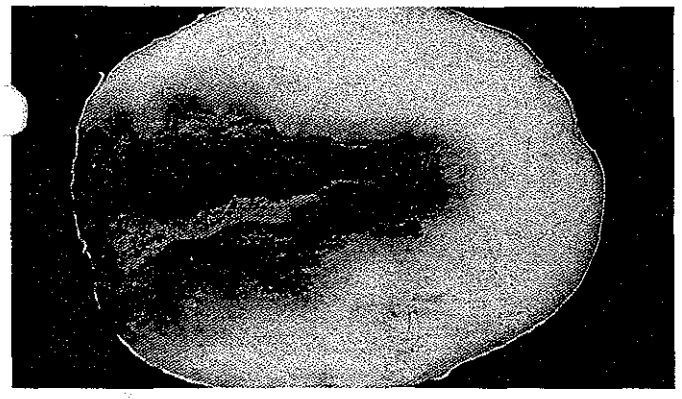

Fig. 5. Tuber symptoms of blackleg.

Fig. 6. Stages of soft rot development in tubers.

5. In this suitable environment, bacteria reproduce and release pectolytic enzymes that destroy the pectate-rich, middle lamella which serves to bind the cells together.
6. Tissue disintegration (rot) occurs.

Wounds also provide a point of entry for bacteria. Within the crushed cells of a wound, the bacteria find the necessary nutrients and free moisture for infection, multiplication and intercellular movement in the tuber. Tubers may also rot because of bacterial entry into the vascular (water-conducting) tissues at the stem end.

Symptom Development in Foliage

1. Bacteria in or on the seed piece.
2. Bacteria move intercellularly up the stem, causing the tissue to disintegrate.
3. The dark, mushy stem symptom may develop or chlorosis and wilting of the apical leaflets may be the first symptoms followed by additional chlorosis, wilting and death of leaves and stems.
4. Isolated foliar and/or stem lesions and leaflet chlorosis, rolling and wilting may occur in plants adjacent to the systemically infected one. This probably occurs from aerosol or insect dispersal of bacteria from plant to plant.

Bacterial Survival

Generally, *Erwinia* species survive in cool, moist soil and in infected plant debris and tubers in the field. Until recently, *Erwinia* species were not considered capable of overwintering in soils in the northern U.S. Special culturing techniques, however, have shown that the bacteria can overwinter in soil from Wisconsin and Oregon. In recent Colorado studies, these bacteria were found in surface water. In Idaho, there is evidence that *Erwinia* spp. are present in well water, and surface water has been found to be naturally contaminated with Ecc. Thus, irrigation water may be a source of soft rot Erwinias.

The primary means of *Erwinia* spp. survival and the major source of inoculum is in seed tubers. Thus, bacteria can readily be spread during cutting and handling operations. They survive in the lenticels, and the resident bacteria establish an intimate and stable relationship with the tuber. Vigorous scrubbing under running water will not remove all of the bacteria. Seed pieces are capable of carrying large numbers of bacteria into the soil. These bacteria multiply and persist on the root surface of the host plant and perhaps some weeds. As new tubers develop they become contaminated with bacteria in soil water that enters into lenticels, growth cracks or injuries.

Transmission of Bacteria Among Tubers and Plants

Transmission of soft rot and blackleg bacteria among tubers and plants can occur in several ways depending on the location of plants, time of year, movement of free water, level of tissue contamination and availability of vectors. The primary ways in which transmission can occur among tubers and plants are: (1) Tuber to tuber contact, (2) tuber and plant contact with contaminated surfaces such as in storage or handling, (3) seed cutting, (4) seed piece to the developing plant or (5) seed piece to daughter tubers. Additional transmission may occur via insects and aerosols (rain, sprinklers and humidified ventilating systems).

Tuber-Bacteria Interactions in Storage

Tubers have different susceptibilities to soft rot bacteria, depending on variety, extent of wounds, rate of wound healing and maturity or physiological condition at harvest. The potential for rot development in potatoes can be determined by subjecting tubers to moisture and temperature stress in a mist chamber. The rot potential index (RPI) determined by this method considers the proportion of tubers with rot and the severity of decay in individual tubers. Investigations in 1980 showed that the potential for rot is highest in the period after harvest and declines as the storage period progresses. Significant populations can persist throughout storage, however.

During storage, populations of bacteria on tubers decline rather dramatically. In western Canada, when 90 percent of the tubers in storage were contaminated with *Erwinia* spp. at the beginning of the storage period, only 33 percent were contaminated 5 months later. Investigations in Idaho indicate that the populations of soft rot bacteria in or on tubers declined about 40 percent from early December to early January. If tuber bacterial populations are high in the spring, the tubers must have been heavily contaminated when placed into storage.

Control

To control blackleg and soft rot, the bacteria must be excluded from potatoes, or the tuber or seed piece must be altered structurally or physiologically to reduce susceptibility. The following practices are recommended:

1. Plant certified seed known to be free of high levels of blackleg and tuber soft rot in the previous growing and storage season or that have shown low rot potential through testing.
2. Plant certified seed that is recently derived from a pathogen-tested generation program. Keep seed lots separated and plant the most pathogen-free first.
3. Thoroughly clean handling, cutting and planting equipment between each seed lot to reduce contamination. Give particular attention to cleaning seed cutters. Use **hot** water with a detergent or steam to remove soil and debris. Then apply an approved disinfectant, being sure to keep surfaces wet with the disinfectant for at least 10 minutes.
4. Warm tubers before cutting (50° to 60°F for 5 to 7 days to reduce bruising). Treat cut seed tubers with an approved fungicide that is effective against Fusarium spp. and permit them to be suberized before planting (3 to 6 days at 50° to 60°F with high humidity and moving air). After a suberizing period, lower the temperature to 40°F for 6 to 10 days, but preferably 14 days or more, to further reduce soft rot. Begin warming tubers 7 to 10 days before planting.
5. Use cup-type planters instead of pick-type planters.
6. Plant in well-drained soil.
7. Avoid excessive irrigation to prevent anaerobic soil conditions that favor seed piece decay and subsequent stem invasion.
8. Remove cull piles, discarded vegetables and plant refuse to avoid inoculum sources from which insects can transmit the bacteria.
9. Avoid washing seed potatoes since this can spread the bacteria.
10. Fertilize adequately with nitrogen, but not to excess.
11. Remove and destroy infected plants as soon as they appear.
12. Avoid excessive moisture before harvest to reduce lenticel infection.
13. Protect harvested tubers from solar radiation and desiccation.
14. Do not wash tubers going into storage because this will induce anaerobic conditions that encourage soft rotting.

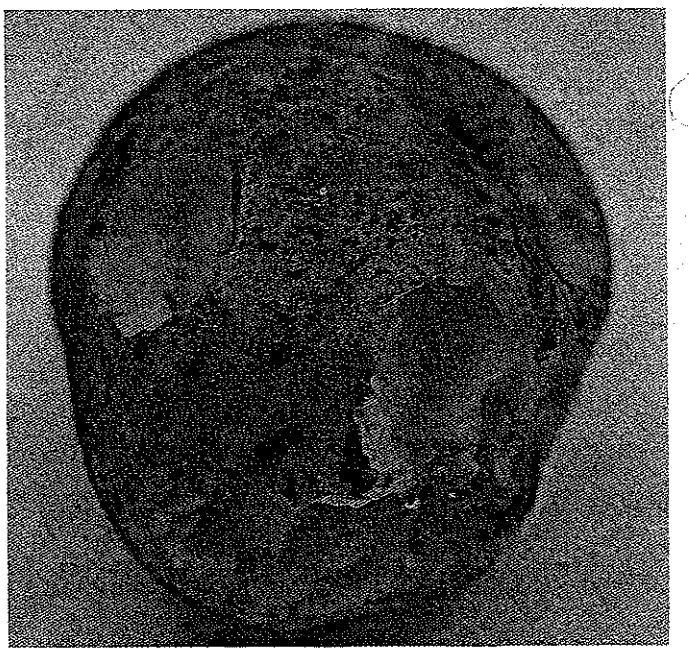

Fig. 7. Tuber after removal from the mist chamber. The areas removed from the tuber were decayed by bacteria. This is the method to determine the Rot Potential Index (RPI).

Harvest and Crop Storage

1. Begin harvest only after the vines are dead and tubers are mature. Harvest potatoes when the tuber pulp temperature is above 45°F but less than 68°F. This will reduce bruises, which can be points of entry for soft rot bacteria and dry rot fungi and will reduce development of the bacteria as well.
2. Operate harvest and storage handling equipment so that bruising is minimized. Clean and disinfect the equipment between seed lots and harvest lots in order of quality, with the most pathogen-free first. Clean and disinfect storage areas before harvest.
3. Operate fans and humidifiers in storage during the first 6 to 8 weeks to maximize the wound-healing process. Maintain temperature at 55°F for 10 to 14 days and then gradually lower to the appropriate storage temperature with the relative humidity above 95 percent. Avoid condensation (dripping) in storages which can induce blackleg and soft rot bacteria to begin multiplying and cause tuber soft rot.

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