

Potato tuber soft rot, blackleg and stem rot

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The bacteria that cause soft rot, blackleg and stem rot are referred to by different names such as soft rot, pectolytic or soft rot *Pectobacteriaceae* (SRP). They are classified under two genera, namely *Pectobacterium* and *Dickeya*. However, because they were previously classified under *Erwinia*, many people still refer to these pathogens as *Erwinia*. The scientific community has adopted the SRP name as the most representative name for the two genera, *Pectobacterium* and *Dickeya*.

In this article, we will also refer to these bacteria as SRP. In potatoes, these bacteria cause blackleg, tuber soft rot and stem rot. Two of these, blackleg and stem rot, are known to occur mainly in the field. The third, potato tuber soft rot, mainly occurs during post-harvest storage.

Members of the *Pectobacterium* and *Dickeya* species are associated with one or more of these three main diseases in potatoes. When they infect a plant or tuber, they produce exactly the same symptoms. Hence, it is important to note that symptoms alone cannot determine whether the infection is caused by *Pectobacterium* or *Dickeya* spp.

Place determines pathogen

However, geography tends to be an indicator of which pathogens are dominant in which areas. For example, in South Africa, through several surveys, we have shown that the biggest problem for potato growers is *P. brasiliense*. However, there are other species of importance such as *P. wasabiae* and a few *Dickeya* species present in the South African potato fields and irrigation water. In the literature, one of the major causes of infection is said to be latently infected seed potato tubers (tubers that appear healthy but harbour SRP).

However, the literature also highlights the complexity and interwoven nature of the factors that lead to infection and the development of symptoms. The big question, therefore, is how does one know whether a given seed lot will lead to any of the SRP infections and symptom development? The answer is very complex and often unpredictable. Some of these intricately linked factors are discussed in this article. But first, the three different symptoms associated with SRP in potatoes are discussed.

Symptoms of potato blackleg

Potato blackleg occurs mainly in the field. As the name indicates, blackleg symptoms include stems that develop an inky black decay and often the stem can become completely rotted at the base. The main cause of this is the planting of latently infected seed tubers. Symptoms begin to develop from rotting seed pieces and extend upwards onto the stems. Stem piths above the inky black lesions of the stem can be decayed and vascular tissue can be discoloured.

During wet weather, decay can be slimy and easily spreads to other plants. For this reason, it is important to completely remove infected plants (and not bury them) as they can

spread the bacteria to healthy plants. During dry weather, the decay is dry and shrivelled, and mostly restricted to above-ground stems and roots of infected plants. Tubers of infected plants can show discolouration of stolons and wet breakdown of the entire pith.

The bacteria can also enter potato tubers through stolons causing sunken lesions at the stem end of the tuber. The flesh of the infected tuber gradually changes from cream to greyish to black. The lenticels of infected tubers are slightly sunken, brownish-black and usually dry. New tubers from infected plants may become soft and slightly discoloured in the vascular tissue at the stem end. In the advanced stages of the infection, the centre of the tuber decays leaving an empty shell.

Blackleg can occur in the field due to latently infected tubers (plant debris of infected plants). However, the combination of conditions and latent infection (bacteria-infected tubers that do not yet show symptoms) is a critical determinant of whether blackleg develops or not. The amount of inoculum on the seed tuber is also an important determinant of whether blackleg develops or not.

Conditions are another factor. When the conditions are favourable,

Table 1: Possible inoculum sources.

Disease	Symptoms	Possible sources
Soft rot	<ul style="list-style-type: none"> • Can occur in small areas such as a single eye or entire tuber can rot. • Tubers become soft, wet, cream or tan rot. • When exposed to air, rotting tissue can turn brown. • Foul-smelling rot. 	<ul style="list-style-type: none"> • Wet storage conditions. • Limited air circulation/ventilation. • Wounds. • Mechanical damage.
Aerial stem rot	<ul style="list-style-type: none"> • Black, cracked stems. • Curling of leaves. • Mushy and hollow stems with mucilaginous slime. • Inky black stem. 	<ul style="list-style-type: none"> • Bacteria in rainwater (splashes from weeds/soil etc.). • Irrigation water. • Insects. • Weather damages (hail, wind etc.). • Secondary infection to fungal and oomycete infections.
Blackleg	<ul style="list-style-type: none"> • Blackleg leaves curl up. • Yellowing of foliage. • Wilting. • Rotting roots and stems. • Inky blackening of stem bases and black lesions. 	<ul style="list-style-type: none"> • Bacteria in seed tubers (inoculum). • Mechanical and handling transfers from infected to uninfected. • Hands. • Equipment. • Bacteria from the soil. • Irrigation water. • Weeds. • Insects.

for example, high temperature and high moisture, the tubers can rot in the soil. Plants tend to be stunted, wilted and have stiff, erect appearance. The foliage becomes chlorotic (yellowing) and leaves tend to roll upward at the margins.

Aerial stem rot

As the name indicates, the infection and disease symptoms occur on aerial parts of the stem. The primary causes of aerial stem rot are stem wounds, created by cultivation, wind-blown sand, insect injury or hail. Early symptoms include irregular black marks that rapidly enlarge and into the soft decaying rot of the stem. The rotting stems appear slimy, mushy, water soaked and black. Similar to blackleg, when conditions are dry, the infected stem desiccates resulting in a dry black shrivelled stem.

Other pathogens can quickly take advantage and invade tissue and, like soft rot, this will lead to a foul smell. Dense canopies, warm conditions and long periods of leaf wetness favour stem rot development. This is because a dense canopy creates a

microclimate that limits air circulation leading to high humidity and high moisture. Stem rot frequently occurs in fields with overhead irrigation.

Potato tuber soft rot

The decay of potato tubers caused by SRP occurs mainly during post-harvest storage. Symptoms include wet, rotted, tan or cream-coloured tuber rot. After exposure to the air, the cream colour becomes dark brown to black. Often a slimy, watery substance oozes out of infected tissue. Rot normally begins on the surface and proceeds inward. In the beginning, the rot is odourless but proceeds to develop into a foul smell as other secondary bacteria start to feed off the rotting tissue.

Bacteria infect tubers mainly during harvest, handling and washing, as well as when using poorly sanitised equipment such as containers. Soft rot can be exacerbated by wounding, infection by other pathogens (which leads to some form of wounding) and harvesting immature tubers. Immature potato tubers are susceptible to harvest-related injury. Keeping tubers

in warm (over 27°C), poorly aerated storage (low oxygen) and high moisture favour soft rot.

Favourable infection conditions

Bacteria are almost always present on potato tubers, whether seed or table tubers. However, conditions in the field or during storage play a critical role in the development of blackleg or soft rot. These include high moisture content, high temperature and anaerobic (lack of oxygen) conditions. When tubers are starved of oxygen (in waterlogged soils) or in dry but compacted soils, they tend to become enlarged and are more prone to develop tuber soft rot symptoms.

Although most studies show that the main source of blackleg inoculum is latently infected potato tubers, it can also be caused by contaminated irrigation water, insects and coinfection with other pathogens. Mechanical damage (which can occur during harvesting or grading), wounding and free water on tuber surfaces can also lead to tuber soft rot. Furthermore, symptoms could be due to other pathogens that coinfect

Table 2: Management techniques.

Growth stage	Symptoms	Management
Pre-plant	Soft rot present in seed tubers	<ul style="list-style-type: none"> • Use bacteria-free or low levels of soft rot. • Remove infected tubers. • Sterilise all equipment if cutting seed (e.g., knives, hands, bags and boxes) to prevent spread from healthy tubers. • Chlorine-based disinfection or sterilising equipment is recommended. • Application of fungicides to prevent other diseases. • Crop rotations. • Avoid irrigation with surface water.
Planting		<ul style="list-style-type: none"> • Avoid planting in waterlogged soils. • Improve drainage where waterlogging occurs. • Avoid planting moist seed tubers.
During growing	Typically, non-emergence, wilting of plants, yellowing or chlorosis, blackened cracks of stems, water-soaked blacked stem bases.	<ul style="list-style-type: none"> • Avoid overwatering. • Reduce nitrogen inputs (leads to large bushy crops that lead to high leaf wetness). • Remove weeds (some may harbour soft rot bacteria). • Remove plants with blackleg symptoms.
During harvest	Mechanical damage	<ul style="list-style-type: none"> • Ensure tubers are mature at harvest. • Minimise mechanical damage/avoid tuber injury. • Disinfect containers/bins before placing tubers. • Avoid harvesting during wet conditions. • Dry tubers as soon as possible and remove excess soil. • Remove infested plants/debris by burning or landfilling. • Minimise dust in storage areas as it can spread the bacteria. • Use clean water to wash potatoes. • Post-harvest curing.

potato tubers with soft rot bacteria (discussed under other microbes).

Other microbes that cause tuber rot

Apart from soft rot bacteria, other bacteria in the soil can cause tuber soft rot, either independently or in conjunction with soft rot pathogens. These include certain bacterial species such as *Pseudomonas* spp., *Bacillus* spp. and *Clostridium* spp. Some of these microbes cause rot of potatoes but the symptoms are slightly different from those of SRP. For instance, the late blight pathogen (*Phytophthora infestans*) and the cause of pink rot, *Phytophthora erythroseptica*, can also cause symptoms of reddish-brown rot in potato tubers and some members of *Pythium* spp.

Controlling SRP infection

Planting certified seed potatoes is one of the main ways that can reduce incidences of SRP infection and symptoms. Although most

certification schemes do not test for SRP, certified seeds eliminate other pathogens that can cause wounding, allowing the proliferation of SRP. In some cases, it has been found that the cultivar or variety planted can make a difference, however, potato plant and tuber resistance to SRP is limited.

Some weeds, particularly those within the *Solanaceae* family, can harbour the soft rot pathogen and transfer it to the potato crop. Thus, it is important to remove weeds and practice good crop rotation with non-host plants to reduce the abundance of this pathogen. Good sanitation and disinfection are important during mechanical handling of seed, e.g., when cutting use well sanitised equipment to reduce the spread of the pathogen.

Treating seed tubers with fungicide does not affect bacteria but reduces incidences of fungal infections which can subsequently increase bacterial

infection. Removal of infected plants is important because plant debris with bacteria can be a source of inoculum.

Delaying harvesting to increase the maturity of potato tubers and reduce pathogen entry points. Ensuring good sanitary handling of potato tubers (sanitising of equipment, knives, containers, etc.) will ensure the limited spread of bacteria. Minimise bruising by avoiding harvesting during wet conditions. Suberising of potato tubers is recommended as it ensures wound healing and limits the entry of pathogens. Remove as much soil as possible from tubers before storage. After washing, dry potatoes well and store them in a well-ventilated cool place. Remove infected potatoes from storage. 📧

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