

# SOFT ROT-BLACK LEG



potatoes  
aartappels SA

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# SOFT ROT-BLACK LEG

**Soft rot, black leg and stem rot** is a bacterial disease complex caused by a group of closely related pathogens, namely the pectinolytic enterobacteria. The disease was formerly known as erwinia rot.

The disease complex is regarded as a tuber-borne disease and not a soil-borne disease.

The disease develops and is most likely to occur in wet conditions with high temperatures.

Latent contamination of tubers makes the disease difficult to manage as the symptoms are not visible. Under optimal conditions the disease can spread very quickly.

**Soft rot** can affect seed potatoes, daughter tubers and harvested tubers. Soft rot can occur at any stage, and spreads if a source of contamination is present and conditions are favourable for the development of the disease. There is

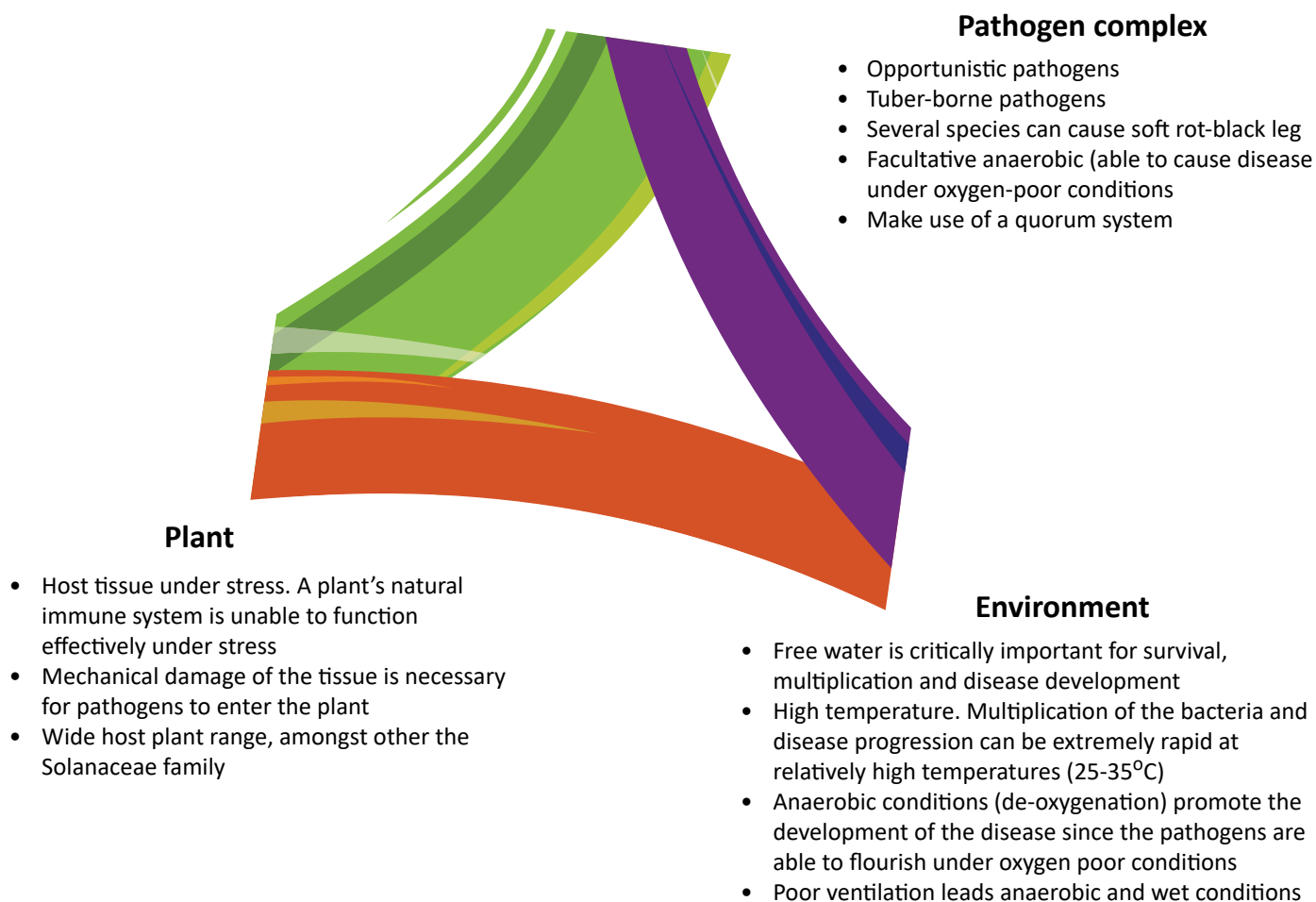
therefore a risk of the soft rot-black leg complex throughout the growing season (on the land, during harvesting, during post-harvest handling and during storage).

**Black leg** develops when the bacteria from rotting seed potatoes spread to the haulms. In other words, black leg always occurs in conjunction with soft rot in seed potatoes. Wilting sets in where after a dark brown discolouring of the vascular tissue and pith necrosis develop at the bottom of the haulms.

**Stem rot** is a secondary soft rot of haulms and leaf stems when the haulm is damaged by external factors such as hail, wind, etc. Wounds that consequently develop are infected by the soft rot bacteria.

**Wilting** is characterised by a mildly excentric wilting of the youngest leaves. This symptom spreads in time to the lower leaves. Wilting symptoms can be limited to only one haulm of the plant.

## DEVELOPMENT OF DISEASE



## MANAGE THE RISKS OF SOFT ROT-BLACK STEM

|                    | RISK   | MANAGEMENT   |
|--------------------|--|--|
| PLANTING TIME      | Hot, wet season  | <p>Conditions of high moisture and high temperatures are conducive to soft rot.</p> <ul style="list-style-type: none"> <li>- Excessive irrigation should be avoided.</li> <li>- Avoid planting in fields with poor drainage.</li> <li>- If soft rot occurs repeatedly, consider planting at a cooler time of the year.</li> </ul>  |
| CHOICE OF LAND     | Contaminated soil  | <ul style="list-style-type: none"> <li>- Maintain a rotation programme of at least three years, but preferably longer.</li> <li>- Volunteer plants must be controlled to maintain the effectiveness of the rotation programme.</li> <li>- Ensure that rotation crops are not hosts to soft rot pathogens.</li> <li>- If the preceding crop was affected by soft rot, all plant residues must be destroyed, or the planting must be postponed, since soft rot pathogens are able to survive as saprophytes on dead plant matter.</li> </ul>   |
| CHOICE OF CULTIVAR | Susceptible cultivars                                      | <ul style="list-style-type: none"> <li>- Cultivars differ in terms of their resistance to soft rot pathogens.</li> <li>- Consider planting alternative cultivars in cases where soft rot is a regular occurrence and cannot be managed successfully.</li> </ul>  |
| SEED POTATOES      | Latent contamination of seed potatoes                      | <ul style="list-style-type: none"> <li>- Consider that all seed potatoes can have latent contamination and apply sanitary measures (stores, crates, et.), in order to prevent contamination as much as possible.</li> <li>- If there is evidence that seed potatoes were indeed contaminated, tubers must be harvested as soon as it is ready, since soft rot-black leg becomes more prevalent later in the season.</li> </ul>   |
|                    | Unfavourable conditions during transportation and storage  | <p>Conditions of poor ventilation, high temperatures and free moisture promote the development of soft rot.</p> <ul style="list-style-type: none"> <li>- Ensure sufficient ventilation in the storage shed and truck.</li> <li>- Stack pallets in such a way that air is able to circulate between them.</li> <li>- Do not store or transport wet seed potatoes.</li> <li>- Maintain a moderate temperature (&lt;25°C) during transportation.</li> <li>- Avoid temperature fluctuations, as it causes condensation.</li> <li>- In the event of condensation, seed potatoes should be unpacked and spread out to dry in a well-ventilated area.</li> </ul>    |
| PLANTING           | Contamination of seed potatoes during planting             | <ul style="list-style-type: none"> <li>- The cutting of seed potatoes is not recommended. If cutting is considered necessary, all knives must be disinfected at regular intervals and wounds must be allowed to heal prior to planting. As some cultivars are better suited to cutting than others, confirm the cultivar's characteristics.</li> <li>- If it should happen that a contaminated batch of seed potatoes is planted, clean all implements with a high-pressure hose and allow to dry thoroughly before being used to plant seed potatoes from another source.</li> </ul>  |
|                    | Seed potatoes rot prior to and immediately after emergence | <ul style="list-style-type: none"> <li>- Avoid stress conditions prior to emergence.</li> <li>- Avoid soil that is too wet, especially in hot weather.</li> <li>- Do not plant in fields or parts of fields that have a tendency to be waterlogged.</li> <li>- Do not plant too deep, especially where waterlogged conditions are possible.</li> <li>- Control soil-borne diseases and nematodes that can contaminate tubers.</li> <li>- Avoid planting in extremely hot soils (&gt;30°C). If the soil temperature is cool to moderate, but very wet during planting, soft rot can develop at a later stage if the temperature rises drastically.</li> </ul> |

# MANAGE THE RISKS OF SOFT ROT AND BLACK STEM

|                          | RISK   | MANAGEMENT   |
|--------------------------|--|--|
| CROP MAINTENANCE         | Weakened plants  | <ul style="list-style-type: none"> <li>- See to it that plants absorb enough calcium during tuber initiation. Calcium strengthens the cell walls, thus improving the plant's resistance to soft rot.</li> <li>- Ensure a balanced fertilisation programme. An excess of nitrogen tends to make plants more susceptible to contamination by pathogens.</li> <li>- Control soil-borne pathogens such as fusarium and nematodes, as they cause wounds in underground organs, thus allowing access by soft rot pathogens.</li> <li>- Water-logged conditions are undesirable because soft rot pathogens can cause disease under anaerobic conditions. Plant tissue cannot function optimally under oxygen poor conditions leading to weakened plants and lenticels expand under such conditions, allowing access by soft rot pathogens. The pathogenic cells can survive latently in lenticels, or can lead to soft rot if water-logged conditions persist,</li> <li>- Manage irrigation and avoid fields with a tendency to being water-logged .</li> </ul>                       |
| HARVESTING               | Mechanical damage  | <p>Limit mechanical damage as far as possible during harvesting.</p> <ul style="list-style-type: none"> <li>- Harvest once the groundwater content reaches 65% of available groundwater. This limits clod formation in soil that is too dry, as well as soil smudging if it is too wet.</li> <li>- Do not harvest when the soil and tuber temperature is &lt;10°C. At low temperatures, tubers are more prone to cracking than at higher temperatures,</li> <li>- Cultivars vary in terms of their tendency to crack. In a region where harvesting takes place in winter, cultivars must be thoroughly tested.</li> <li>- Irrigation must be suspended approximately ten days prior to harvesting in order to promote skin setting. A thick, corked skin offers more resistance to cracking.</li> <li>- Ensure that the harvester is set correctly so that the blade is deep enough to sever the roots below the tubers, and that the land speed of the harvester matches the chain speed to allow the tubers to move across a cushion of soil over the chain bars.</li> </ul> |
|                          | Contamination of tubers in the field                           | <ul style="list-style-type: none"> <li>- Soil contaminated with soft rot pathogens cling to tubers during harvesting. Such fields should be harvested and handled separately from those not affected by soft rot.</li> <li>- Clean implements daily with a high-pressure hose to prevent the spreading of the disease to other plantings.</li> </ul>   |
| WASHING AND SORTING      | Pathogens are spread from contaminated tubers to other tubers. | <ul style="list-style-type: none"> <li>- See to it that the wash water is replaced regularly, since dirty wash water not only absorbs disinfectants, but also serves as a growth medium for soft rot pathogens.</li> <li>- Consider using a system whereby disinfectants are applied to washed tubers by means of a low-volume application method.</li> <li>- Limit the mechanical damage of tubers as far as possible during the washing and sorting process. Contact your Potatoes South Africa regional manager and, by means of the Impact Recording Device, identify those places on the washing and sorting line where tubers are exposed to impact. Cover hard surfaces with impact-absorbing material and limit drop heights to less than 50 cm.</li> <li>- Maintain a temperature of &lt;25°C during washing and packing, especially in regions where harvesting takes place in summer. This will help to limit the activity of pathogens.</li> </ul>   |
| PACKING                  | Conditions conducive to soft rot                               | <ul style="list-style-type: none"> <li>- Ensure that tubers are completely dry before packing and keep bags out of the sun.</li> </ul>   |
| STORAGE OF SEED POTATOES | Conditions conducive to soft rot                               | <ul style="list-style-type: none"> <li>- Disinfect the storage shed thoroughly before seed potatoes are delivered.</li> <li>- Store seed potatoes of different lots separately.</li> <li>- Prevent wet seed potatoes by avoiding condensation. Ensure sufficient ventilation and a constant temperature.</li> <li>- In the event of any seed potatoes being contaminated with soft rot, it must be removed as soon as possible along with all plant residues, and the floor thoroughly disinfect.</li> </ul>   |

## THE PATHOGEN COMPLEX

Soft rot, black leg, stem rot and wilting are caused by a group of bacteria known as pectinolytic enterobacteria.

In South Africa, soft rot-black leg is mainly caused by *Pectobacterium carotovorum* subsp. *brasiliensis*, which is a highly aggressive pathogen. *Pbc* subsp. *carotovorum* is the second most important, while *Dickeya dadantii* and *P. wasabiae* have been identified in a small percentage of isolates. *Pbc* subsp. *atrosepticum*, which commonly occurs in Europe, has not yet been isolated in South Africa.

The conditions for optimal functioning vary among the different species.

Different species can occur simultaneously. Scientists speculate that environmental conditions would then determine which species will be dominant in a particular situation.

In South Africa and many other potato producing countries, tests on soft rot enterobacteria for certification purposes are conducted by way of conventional pathological methods. In Scotland and the Netherlands the PCR method is used.

Important characteristics of pectinolytic enterobacteria:

- It secretes certain enzymes (pectinolytic enzymes) that digest the cell walls of the host tissue.
- The enzymes are not able to digest the cuticles, meaning that a wound must be present for the enzymes to invade the plant tissue. The enzymes need free water to survive and multiply, but can survive either with or without oxygen (are facultative anaerobes).
- As opportunistic pathogens, it attacks tissue when the plant's natural defence mechanisms are weakened
- Has a wide host range.
- Can survive pathogenically on living tissue or as saprophytes on dead host tissue.
- Multiplies quickly at relatively high temperatures of 25 – 35°C.

## SPREAD OF PECTOBACTERIUM AND DICKEYA

**Potato tubers.** The soft rot-black leg complex is considered a tuber-borne disease rather than a soil-borne disease. Symptomless latent contamination of tubers plays a very important role in the spread of the disease complex in potato fields and during post-harvest handling.

**Seed potatoes.** The South African Seed Potato Certification Scheme has a zero tolerance for soft rot enterobacteria in *in vitro* plantlets and mini-tubers (Generation 0). Generation 1-8 seed potatoes are not tested for the presence of the pathogens.

**Soil.** Although the pathogens do not form resistant spores to be able to survive for long periods in the soil, once a rotting tuber has decayed, the cells can enter the groundwater and go on to contaminate other tubers, as well as roots and stems.

**Water** is an effective medium for the spread of the disease. Surface water from rivers and storage dams where water is reused poses a particular risk. Recirculating the washing water used in the washing of table potatoes is one of the major ways in which soft rot pathogens are spread.

**Implements** spread the pathogen during harvesting, planting and processing, provided there is sufficient moisture present.

**Animals** walking across contaminated fields can also spread *Pectobacterium* through mud clinging to their hooves.

**Wind** can spread the bacteria suspended in water droplets.

**Dust.** Research has shown that soft rot pathogens suspended in water droplets can survive only for approximately ten minutes after the water has dried up. *There is little likelihood, therefore, of the pathogens being spread through dust.*

**Insects** feeding on contaminated plants can spread the pathogen from one plant to another.

**Within the plant,** pathogenic cells move through the vascular tissue from one organ to another, for example from a contaminated tuber, through stolons, to daughter tubers.

***Pectobacterium* has a wide host range:**

Maize

The Solanaceae family (tomato, tobacco, pepper, paprika, etc.)

Onions

The Crucifers (cabbage, cauliflower, broccoli, mustard, canola, etc.)

Cucurbits (pumpkin, squash, watermelon, cantaloupe, etc.)

Other vegetables such as beet, carrot, etc.

Ornamental plants such as arum lily, flower bulbs, etc.

Chicory

Weeds, especially those belonging to the Solanaceae family.

## INOCULUM LEVEL AND DISEASE DEVELOPMENT

The more pathogen cells that are initially present on seed potatoes and table potatoes, the quicker the disease will develop and the more intense it will be. Research in Scotland has found that the risk of soft rot-black leg is low where seed potatoes with a low inoculum level are planted

under unfavourable growing conditions. The risk of disease development increases as the inoculum level rises, and seed potatoes with high inoculum levels are at risk of soft rot, even where the conditions are conducive to production.

## DISTINGUISH BETWEEN SOFT ROT-BLACK LEG AND BACTERIAL WILT

The first symptom of bacterial wilt disease (caused by *Ralstonia solanacearum*) and soft rot-black leg is green wilting of one or more leaves on a plant. If seed tubers of such plants are cut, however, it is relatively easy to distinguish between the two

diseases. Tubers infected with *R. solanacearum*, often show ring symptoms (1 and 2) because the bacterial cells occur in vascular tissue. *R. solanacearum* does not cause wet rot of stems (3).



# SYMPTOMS

## Leaves

Young leaves that wilt during the hottest time of the day are often the first sign of the presence of soft rot-black leg.

Wilted leaves are found on one or more haulms of the plant. Initially the leaves are able to recover overnight or during cooler times of the day.

Leaves wilt when the vascular tissue (xylem vessels) becomes blocked by bacteria originating from rotting tubers and is thus deprived of water.

If the disease develops further the older leaves also start to wilt and the entire stem dries out. Closer inspection will reveal rotting at the base of the affected stems.

## Stems/haulms

Close inspection of the stems on which wilted leaves occur will reveal rotting at the base of the infected stems. If the stems are dissected lengthwise, vascular discolouration and medullary pith necrosis are often visible.

Typical symptoms of black leg are associated with wilting and die-back (necrosis) of leaves.

Black wet rot starts at the base of one or more stems of a seed potato and is associated with vascular discolouration. As the rot spreads, the symptoms of black leg can be seen ever higher on the stem. The cortex of the stalk decays and becomes hollow and dark in colour.

Black leg occurs when masses of bacterial cells spread from rotting tubers to haulms.

Since soft rot can affect tubers at any stage of the growing season, the black leg that is preceded by soft rot can also occur at any stage. If the disease occurs early in the season, plants are normally stunted and a low yield can be expected. Where the disease occurs late in the season, the damage is less severe. Tubers from infected plants that are harvested, will probably be infected.

## Tubers

There are often no symptoms of latent contamination of the tubers. The bacterial cells are found in lenticels, vascular tissue or wounds. If conditions are unfavourable for the development of the disease, the cells will survive without causing soft rot.

Where lenticels are contaminated and the conditions are favourable for soft rot, small watery spots form around the lenticels and are the first sign of soft rot. The affected areas are usually visible as sunken brown spots. As the rot spreads, these spots melt together and form a slimy wet rot that is cream to brown in colour. The border between rotting and healthy tissue often appears dark brown or black.

Should conditions become unfavourable for the development of disease, the rotting tissue can dry out and form light coloured, dry spots.

Contamination can occur in deeper-lying wound or vascular tissue, from where the rot spreads. In such cases, the skin may be unaffected while the deeper-lying tissue rots, which causes the rotten areas to become sunken. When an affected tuber is handled it breaks up and releases the watery, slimy mass.

Soft rot is initially odourless, but as a result of secondary contamination, it is usually associated with an unpleasant odour. This unpleasant odour is usually an accurate indication of soft rot in seed potatoes under storage.

Where vascular tissue is contaminated but conditions are not really optimal for soft rot, discolouration of the vascular tissue at the stalk end of tubers is usually the only symptom of contamination.

Soft rot in tubers often leads to leaf wilting and black leg, as the bacteria spread from the tuber to the haulms – initially only through the vascular tissue, but later to the rest of the haulm tissue.

Where tubers rot completely at a very early stage, there is often no possibility of black leg.



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## SYMPTOMS OF SOFT ROT AND BLACK STEM

(For description of symptom development, see page 7)



Plant with wilted leaves. Not all the plant leaves are wilted. (1)

A plant with a few wilted leaves. Note the black wet rot where the stem was attached to the already disintegrated seed tuber. (2)

Black rot has spread into the stems. Note the pith necrosis in

the petioles. A foul odour was present. (3 and 4)

Tuber with soft rot. Note the enlarged lenticels from where the tuber was infected. (5 and 6)

Tuber with soft rot. Note the darkly coloured boundary between rotting and healthy tissue. (7)

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