Technical Information Bulletin 21

Soft Rot and Blackleg of Potato
Erwinia spp.

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Blackleg

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Soft Rot and Blackleg of Potato

Erwinia spp.

Objectives. Study of this bulletin enables you to:

- explain the economic importance of soft rot and blackleg,
- describe symptoms,
- classify the pathogens,
- describe factors influencing disease development,
- describe disease development (epidemiology),
- discuss possibilities for control,
- describe nature of resistance and guidelines for testing.

Study materials

- Slides showing of symptoms.
- Diseased plants and tubers.

Exercises

- Observe symptoms in the field and store.
- Determine soft rot potential as described in Section 6.
- Inoculate tubers as described in Section 7.

Questionnaire

1 How do the hosts of *Eca, Echr,* and *Ecc* differ?

2 Which of the diseases, tuber soft rot or blackleg, causes greater loss in your country?

3 Where may tuber soft rot initiate?

4 How do blackleg symptoms vary under dry or wet conditions?

5 How do bacteriologists separate the soft rot erwinias into species and subspecies?

6 How does moisture favor the disease?

7 Under which temperatures do *Eca, Echr,* or *Ecc* predominate?

8 What may be the result of infection during emergence when soils are wet and temperatures warm?

9 What is an important source of inoculum?

10 Why does bruising or cutting favor tuber infection?

11 Why is control of soft rot and blackleg difficult?

12 What planting material is usually free from contamination?

13 Why is sprinkler irrigation preferable to flood or furrow irrigation?

14 When harvesting seed potatoes, why should you destroy stems chemically, not mechanically?

15 In storage, why should you avoid temperature fluctuations?

16 How can you determine the soft rot potential of recently harvested tubers?

17 How can you evaluate the resistance to tuber soft rot?

18 How can you compare the soft rot potential of different genotypes?

19 How can you estimate blackleg resistance?

20 What sources of immunity to blackleg have been determined?

Soft Rot and Blackleg of Potato

Erwinia spp.

1 Economic importance
2 Symptoms
3 Classification
4 Factors influencing disease development
5 Epidemiology
6 Control
7 Resistance
8 Additional study

The three bacteria *Erwinia carotovora* ssp. *atroseptica* (Eca), *E. carotovora* ssp. *carotovora* (Ecc), and *E. chrysanthemi* (Echr), known as the **soft rot erwinias**, cause **soft rot** of potato tubers in field and store, and rotting or wilting of stems on growing potato plants —often known as **blackleg**. The pathogens cause problems in potato production worldwide. Practical chemical control is not available, although cultural measures may reduce disease impact.

1 ECONOMIC IMPORTANCE

The soft rot erwinias have a climatic distribution that reflects the diversity of their hosts and growing temperatures. *Eca* is mainly restricted to **temperate** climates and almost exclusively to potatoes. *Echr* affects a wide diversity of **tropical** and **subtropical** crops, including potatoes, many ornamental plants, maize, rice, and pineapple. *Ecc* also attacks a wide diversity of plants and is found in **both** temperate and tropical zones, causing soft rot of potatoes and many fruits and vegetables.

Accurate numbers of losses caused by tuber soft rot and blackleg are not available. Additionally, losses vary from country to country and are influenced by climate and conditions of growth and storage.

Tuber soft rot. Tuber soft rot limits potato storage, especially in tropical environments. Under bad handling and storage conditions, postharvest losses may reach 100 %. In large operations, losses have reached millions of dollars during one storage season. Similar losses can occur during ocean shipments of ware or seed potatoes. Losses worldwide probably reach hundreds of millions of dollars annually.

In warm regions, soft rot of seed tubers before emergence can be serious, especially when they are not sufficiently ventilated during storage or transport.

Blackleg. Under adequate conditions for potato cultivation, in many temperate regions, blackleg incidence is usually lower than 2 %. But even this low percentage can be serious in production of seed tubers.

2 SYMPTOMS

According to the environment, *Eca, Ecc,* and *Echr* cause different types of symptoms:

on tubers – soft rot
– latent infection

on stems – blackleg
– aerial stem rot

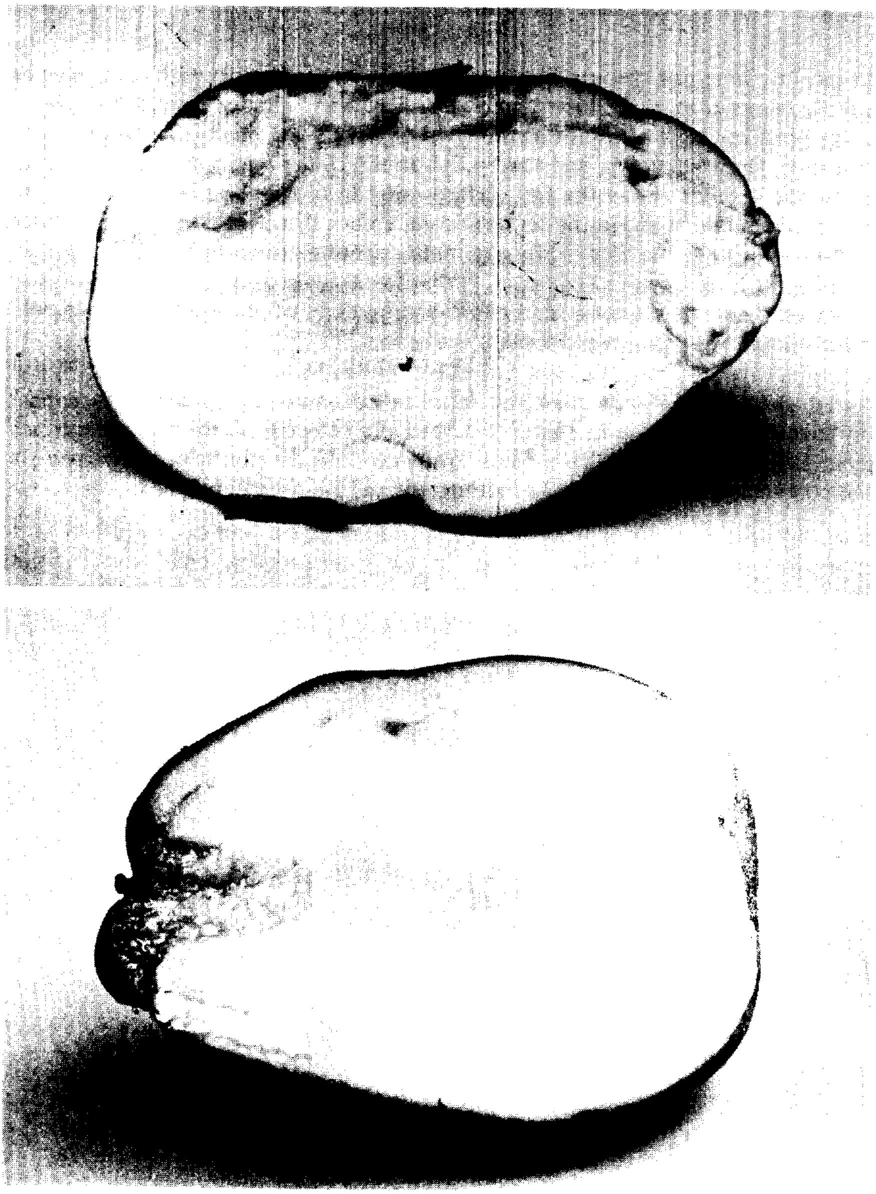
Tuber soft rot. Tuber soft rot is characterized by maceration of the parenchymatous tissue that ends in a wet, grainy, white or brown rot. The unpleasant odor that frequently accompanies the rot is caused by secondary organisms, which are particularly active at 25 °C and above.

Rotting may initiate in lenticels or wounds and spread rapidly through the tuber. In dry conditions, however, the rot may remain confined to small, dry, dark, sunken parts. If diseased seed tubers are planted, *missing hills* (or *blanking*) appear in the field, when the tubers rot before emergence.

Extension of rotting from the stem, along the stolon, can result in soft rot of progeny tubers. Occasionally the whole tuber rots, but usually the rot remains restricted to a conical, dark-colored area at the stolon end. Also, tubers formed on apparently healthy plants may rot before harvest when conditions favor infection by erwinias from external sources.

Tuber latent infection. In many cases, at harvest, apparently healthy tubers are latently infected. Such tubers do not show symptoms but carry bacteria on the surface, inside suberized lenticels and wounds, or the vascular system. Later, these bacteria can infect the tuber tissue.

Blackleg. Although blackleg and tuber soft rot are usually described separately, blackleg is often an extension of tuber soft rot. However, it also occurs in potatoes grown from true potato seed, where no seed tuber is present.



Tuber soft rot is characterized by maceration of the parenchymatous tissue (above). Extension of rotting from the stem, along the stolon, usually remains restricted to an area at the stolon end (below).

In recently emerged sprouts, blackleg results in stunted plants with pale green or yellow leaves that curl upward and wilt. The plant rapidly dies. Older plants show black or brown lesions at the stem base. In dry weather, leaves become chlorotic, the stem splits, and the haulm dries. Under wet conditions, a black, slimy rot extends above the soil surface and can progress rapidly up the stem. Transverse sections above the lesions reveal a dark discoloration of the vascular system, which may be blocked by a gummy deposit causing the wilt.

Affected plants may appear at random or in groups where soil drainage is deficient. Often only one stem per plant is affected.

Aerial stem rot. Aerial stem rot (also called bacterial top rot) may appear on succulent or damaged stems, that become infected above the soil surface from external sources. Water-soaked brown lesions develop and can extend via petioles and veins to leaflets. As rotting spreads, the foliage may fall.

Older blackleg-infected plants show black or brown lesions at the stem base.

3 CLASSIFICATION

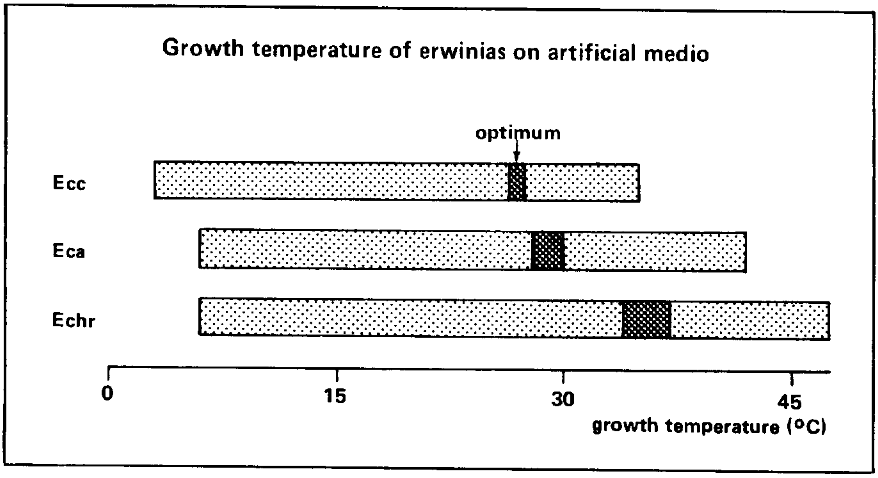
The soft rot erwinias belong to the family *Enterobacteriaceae,* do not form spores, are gram negative, rod-shaped, and facultative anaerobes. All have flagella and a size of 0.5-1.0 by 1.0-3.0 μm. They are distinguished from other members of the family by their ability to produce large quantities of pectic enzymes and to macerate parenchymatous tissue.

Bacteriologists separate them into species and subspecies (ssp.) based mainly on temperature required for growth on artificial media and characteristic biochemical properties.

The scientific names are often abbreviated:

Erwinia carotovora ssp. *atroseptica*	=	*Eca*
Erwinia carotovora ssp. *carotovora*	=	*Ecc*
Erwinia chrysanthemi	=	*Echr*

For identification and classification, also serological techniques may be used. Most strains (genotypes belonging to the same species) of *Eca* belong to one of three serological groups. *Ecc* strains represent more than 40 serological groups. For *Echr,* four serological groups have been defined. (For further information on characterization of the soft rot erwinias see Cother & Sivasithamparam, 1983.)



Bacteriologists separate the soft rot erwinias based on growth temperature. *Eca* is mainly restricted to temperate climates, *Ecc* attacks plants in temperate and tropical zones, *Echr* affects tropical and subtropical crops.

4 FACTORS INFLUENCING DISEASE DEVELOPMENT

Whenever a crop originates from seed tubers, blackleg is preceded by tuber soft rot, although soft rot does not necessarily result in blackleg. The mechanisms that initiate blackleg are not understood. In general, the same factors that lead to soft rot also favor blackleg:

- moisture,
- temperature.

Moisture. A film of water on the tuber surface provides anaerobic conditions for rapid growth of the bacteria and is necessary for initiation of soft rot. Hence, high soil moisture favors disease. Similarly, soft rot increases when stored tubers are wet, or when tubers are stored under high relative humidity or deficient ventilation which result in condensation on the tuber surface.

Temperature. The temperature determines species of *Erwinia* involved and speed of disease development. At low temperatures, *Eca* predominates in both tuber soft rot and stem diseases. With increasing temperature, *Ecc* and *Ech* become involved.

Temperature (°C)	16	20		25
Soft rot	*Eca*	*Eca/Ecc*	*Eca/Ecc/Echr*	*Ecc/Echr*
Stem diseases	*Eca*	*Eca*	*Eca/Ecc*	*Ecc/Echr*

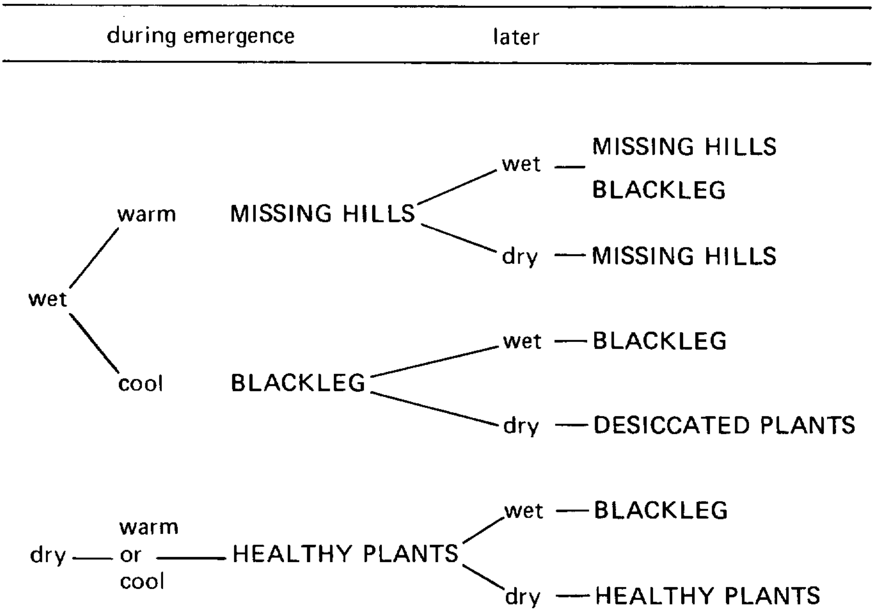
Interaction between soil moisture and temperature determines disease incidence and symptom expression.

In **wet soils**, warm temperatures **during emergence** accelerate disease development. Rotting of the seed tubers before sprout emergence results in missing hills. If the initial temperature is cool (lower than optimum for the pathogen), sprouts may emerge and show blackleg symptoms. **Later**, wet or dry conditions lead to either more blackleg, or plant desiccation, respectively.

In **dry soils during emergence**, plants are healthy whether temperature is warm or cool. However later, blackleg may appear if soils become wet, while plants remain healthy if soils continue to be dry.

Other factors. The incidence of tuber soft rot and blackleg is correlated with the number of latent bacteria per tuber. Plants grown from large tubers develop blackleg symptoms more frequently than those grown from small tubers. However, blanking is more frequent with small tubers. Tuber damage caused by careless harvesting, rough handling, insects, nematodes, fungi, cutting of seed tubers, physiological disorders, such as frost, over-heating, or growth cracking can favor soft rot.

Interaction between soil moisture (wet/dry) and temperature (warm/cool)



Interaction between soil moisture and temperature determines disease incidence and symptom expression.

5 EPIDEMIOLOGY

Soft rot erwinias may disseminate in field and store.

Field. Latently infected seed tubers are an important source of inoculum. They often decay and liberate the bacteria into soil water through which they move to contaminate the progeny tubers.

Reports on survival of erwinias in the soil are controversial. In temperate zones, the bacteria can survive the winter on plant residues, but survival was not observed when potatoes were rotated with a nonhost crop.

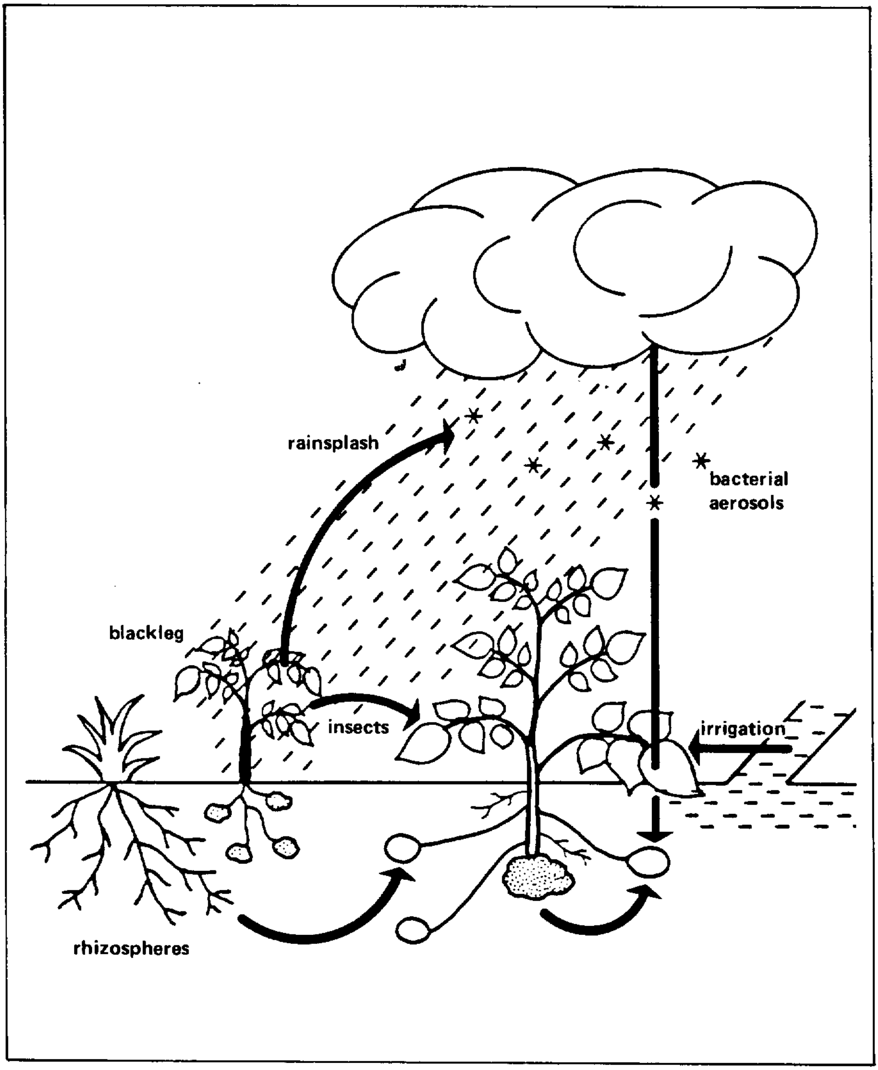
In warmer climates where one potato crop can follow another, or where only short rotation cycles are applied, the bacteria pass easily from one crop to the next, especially if the soil is poorly drained.

Volunteer potato plants and rhizospheres of other crops and weeds carry the inoculum. The bacteria also survive at places where rotten potatoes and vegetables are deposited.

The bacteria can be disseminated in the potato field by irrigation water, insects, rain, or bacterial aerosols (bacteria-contaminated water droplets carried by the wind). In these forms, the bacteria can reach crops grown from cuttings or seed tubers that were initially free of pathogens.

Under wet conditions, the bacteria multiply in leaf debris on the soil surface, from were they are carried by the water to infect progeny tubers.

Store. During storage, handling, and grading, bacteria easily spread from diseased to healthy tubers. Bruising or cutting favors infection —even in the absence of water— since wounds provide sites for entry, survival, and multiplication of the bacteria. Rotting tubers release moisture containing the bacteria, initiating rotting of a conical-shaped region of stored tubers below.



Epidemiology. Soft rot erwinias may disseminate in field and store.

6 CONTROL

Control of soft rot and blackleg is difficult because the pathogens

- are often protected within suberized lenticels or the vascular system, and therefore not affected by liquid disinfectants;
- are widely dispersed in the environment, particularly *Ecc*.

Nevertheless, integration of the following control measures may reduce losses:

Seed tuber health. Use erwinia-free planting material especially at the beginning of a seed production scheme. True potato seed is usually free from contamination as are stem cuttings and plantlets micropropagated from erwinia-free parent material. Remember that these materials may rapidly become contaminated during multiplication in the field.

Crop rotation. Rotate with nonhost crops to prevent, or at least reduce, incidence of the bacteria in the soil.

Drainage. Plant in well-drained soil. Irrigate properly; sprinkler irrigation is preferable to flood or furrow irrigation, which can result in accumulation of excess water.

Roguing and seed certification. Eliminate diseased plants and tubers to reduce infection sources. Seed certification ensures that heavily infected crops are not used for seed production.

Early harvest. Harvest seed potatoes as soon as possible to reduce exposure to the pathogens. Destroy stems chemically, not mechanically, to avoid production of bacterial aerosols and dissemination of pathogens.

Handling care. During harvest and subsequent handling avoid tuber damage.

Storage care. Before storage, dry tubers as quickly as possible. Forced draught ventilation helps to prevent formation of water on the tuber surface. Avoid temperature fluctuations to reduce condensation. Potatoes stored in diffused light are more resistant to soft rot than potatoes stored in the dark.

The **soft rot potential** of recently harvested tubers may be determined as follows:

- Randomly chose samples of 25 tubers. Test 5 or more samples, according to the quantity of tubers to be analyzed.
- Incubate the tubers during 4 days at 20-25 °C and 100 % relative humidity either in a mist chamber or by individually wrapping them in wet paper towels and then enclosing them in plastic bags.

The number of tubers rotting in a sample of 25, and the weight of rotting tissue per tuber indicate the risk of soft rot development during storage.

General farm hygiene. To reduce sources of inoculum:

- remove rotten potatoes from the field;
- disinfect stores, boxes, and machinery;
- control weeds;
- eliminate volunteer potato plants;
- use deep well water for irrigation if the surface water is infested.

7 RESISTANCE

Resistance of

- the tubers to soft rot, and
- the stems to blackleg

is probably controlled by different mechanisms that are not always correlated. Standardized procedures exist to test for both diseases.

Resistance to tuber soft rot. Resistance can be evaluated in the following way:

- inject 0.01 ml (0.01 cm^3*) bacterial suspension with a micro-syringe into the tuber to a depth of 5 mm,
- seal the inoculation site with vaseline and incubate the tuber for 4 to 6 days in an anaerobic atmosphere as described in Section 6,
- measure the diameter of the lesion or the weight of rotting tissue.

By varying the inoculum concentration, an ED_{50} may be calculated (bacterial concentration required to cause rotting in 50 % of a sample of tubers).

When assessing degrees of resistance, the soft rot potential of different genotypes may also be compared:

- dip tuber samples in standard bacterial suspensions (usually 10^6 cells per cm^3) and determine their soft rot potentials as described in Section 6;
- count the number of rotting tubers and measure the weight of rotting tissue per tuber.

Note that this method also takes into account resistance mechanisms associated with the periderm, whereas the former only shows resistance of the parenchymatic tissue. Therefore, there may be no correlation between results from the two methods.

* In the International System of Units, 1 ml = 1 cm^3

Also, note that soft rot resistance increases and soft rot potential decreases with time in storage. Therefore, compare your genotypes by using tubers of the same physiological age, preferably immediately after harvest.

Blackleg resistance. Blackleg resistance can be estimated by two methods:

a Inject bacteria directly into the stem at the first leaf node, either in suspensions of varying concentration by micro-syringe or as bacterial colonies on sterilized wooden toothpicks, which should remain inserted in the stem throughout the test.

  This method does not take into account the resistant mechanisms associated with the seed tuber or the stem base. Furthermore, the sensitivity of the test is low.

b Dip or vacuum infiltrate seed tubers in bacteria suspensions, or wound them with infested toothpicks. Plant the tubers in field experiments.

  Field experiments demand much space and results vary with the fluctuation of climate. Useful results can be expected when soil moisture is maintained high by irrigation.

CIP scientists have identified varying degrees of resistance to soft rot and blackleg in CIP's germplasm, including some commonly grown native varieties of Peru. Four clones have been classified as immune to soft rot caused by *Echr*, and three as resistant to soft rot caused by all three erwinias. Similarly, resistance to soft rot caused by *Ecc* and *Eca* has been demonstrated in some native Chilean potato clones.

Bacteriologists found that even the reduced genetic base of modern cultivars presents some degree of resistance to erwinias. European and North American cultivars vary in their susceptibility to both soft rot and blackleg.

No sources of immunity to blackleg have yet been determined.

8 ADDITIONAL STUDY

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