POTATO BLACKLEG

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Potato blackleg was first recognized and described in Germany sometime between 1878 and 1900. Since then, it has been recognized as a worldwide problem and causes significant losses wherever potatoes are grown.

The disease, caused by bacteria in the genus Erwinia, is widely recognized as a slimy black soft rot of the base of potato stems which can occur any time from emergence to plant maturity. This attack results in wilting and/or stunting of the plant and a stiff, upright, yellow or "fired" appearance in the foliage, especially in young infected plants. Older plants tend to wilt rapidly and die prematurely.

Less commonly recognized is the ability of the same bacterium to rot seedpieces rapidly in the soil and to attack and kill young sprouts before they emerge. This results in stand losses which may not be attributed to the blackleg organism at all. Experience in Colorado has shown that considerable stand loss which is often attributed to other causes is often caused by blackleg bacteria. Serious losses due to tuber decay by the blackleg organism(s) also occur in storage.

Obviously, blackleg is an important disease since it causes serious losses from the time potatoes are planted until they are through the storage period and consumed. Chapman and Frutchy have even reported that tubers from blackleg infected plants have higher sugar contents than those produced by healthy plants and hence make dark potato chips when fried.

The blackleg disease cycle has been a controversial subject for years. Appel reported in 1903 that the blackleg bacteria live in the soil in Germany but Morse in Maine and Pethybridge in Ireland found that the organism did not overwinter in the soil. In 1930, J. G. Leach in Minnesota reported that the blackleg bacterium did in fact live in the soil and that it invaded through the unhealed cut surface of potato seedpieces to produce blackleg infection. The work of Leach was widely accepted and has served as the basis for most recommendations for blackleg control for many years. It has generally been recommended that growers plant well healed and/or chemically treated cut seedpieces in order to reduce the invasion by soil inhabiting bacteria and subsequent blackleg development. These practices have generally given variable results, seemingly good control in some cases, little or none in other cases and apparent increases in blackleg incidence in still other reports. Although blackleg control by these methods was often unsatisfactory, enough success was achieved to lead us to believe that this approach to control was basically sound, but that new chemicals were needed to improve the level of control. This effectively delayed the development of new information on the basic nature of the blackleg disease and the bacterium which induces it.

Recently, evidence has come from several independent laboratories in Scotland, Russia, England, Ireland, Romania and the U. S. A. which indicates that the blackleg pathogen does not survive well in the soil, at least in temperate climates, but tends to disappear rapidly especially when soil temperatures are high. Data shown in Table 1 illustrate the rapid decline in bacterial populations in field soil over a range of temperatures. This has been true whether the studies have been made in the field or under controlled laboratory conditions. The bacteria will, however, survive from one season to the next in non-decomposed plant debris and tubers.

Further research has shown that the blackleg bacteria are commonly present in seed tubers. Perombelon has reported that literally all potato stocks in Scotland are contaminated with blackleg bacteria. Work in Wisconsin and Colorado has shown similar results. When

samples from contaminated seedlots are planted in the field, they often produce blackleg infected plants (Table 2), seedpiece decay and soft rot in storage in amounts roughly proportional to the level of contamination detected by the laboratory assay. Good linear correlations have been found between the levels of seed tuber contamination and subsequent disease measured in the potato crop.

Table 1.

The survival time of Erwinia species
in field soil at three soil temperatures

Temperature	Numbers of cells per gram of soil					
°F	0 days	14 days	28 days	42 days	56 days	70 days
35	377,000	170,000	22,000	3100	1950	19
45	151,000	89,000	37,000	5000	38	0
55	730,000	212,000	16,500	2700	0	0

Table 2.

Blackleg infection in 11 lots of seed potatoes - 1969

Lot #	% Infection	
	Lab assay	Field
1	21.4	54.0
3	14.0	22.0
9	12.0	12.0
7	3.0	10.5
2	1.0	4.5
5	1.0	7.5
6	8.0	6.5
8	2.0	4.0
4	0.0	1.5
10	1.0	2.5
11	1.0	2.5

Numerous factors including numbers of bacteria in the seedpiece, soil temperature, other microorganisms which may attack seedpieces, plant nutrition, and storage and handling conditions affect the development of blackleg from infected seedpieces. Aleck has shown that soil temperature and bacterial numbers are very important in determining the type of blackleg expression that will develop when a contaminated seedpiece is planted. He planted samples from a single seedlot at different locations in 1971 and observed the amount and type of blackleg expression. The results are shown in Table 3.

Table 3.

The effect of soil temperature on blackleg expression in one potato lot planted at three locations

Location	Mean soil temperature C	Percent blackleg		
		Pre-emergence[1/]	Post emergence	Total
San Luis Valley	10.9	5.5	8.5	14.0
Weld County	17.8	15.9	14.7	30.6
Morgan County	21.1	20.5	5.8	26.3

[1/] Includes seedpiece decay and death of new shoots before emergence.

In the cool San Luis Valley much less blackleg was noted and most of it appeared in plants after they emerged. As the soil temperature increased, however, more blackleg was found and more of it appeared as pre-emergence expression (seedpiece decay) as the temperature increased. Generally higher losses occurred in the warmer areas. Therefore, a single seedlot may show different amounts of disease when planted in different locations or at different times depending upon the environment.

It is evident from the data presented in Table 2 that seedlots vary widely in the levels of contamination by blackleg bacteria and potato stem cutting programs in operation in Colorado and elsewhere have been shown to produce potato stocks free from contamination. Recent research has shown, however, that the bacteria which cause bacteria and soft rot can be readily spread to clean or relatively clean stocks in several ways. It has also been found that these organisms can survive in other ways than in stored potato seed.

Contaminated cutting and handling equipment appear to be a major means by which Erwinia cells can contaminate clean or relatively clean seed stocks. Scottish workers have shown that high levels of contamination can occur by passing clean stocks across grading equipment which had previously been used to sort a contaminated lot of seed. In Colorado, high levels of Erwinia contamination has been found on virtually all parts of all mechanical seed cutters examined. Table 4 shows that the cutting blades, splitter disks, rollers and conveyor belts were contaminated on 100% of the machines sampled in 1975 and Table 5 shows that from 50 to 100 percent of the seedpieces cut on those same machines had Erwinia cells present on the cut surfaces. Quantitive measurements made in Colorado in 1975 showed bacterial numbers as high as 264,000 per square inch present on the cutting blades on these cutting machines. It, therefore, becomes obvious that a good seedlot can easily become contaminated in this way. Contaminated planters, trucks and other handling equipment probably also

contribute to the contamination problem although sampling of these pieces of equipment has not been done to determine the extent of contamination.

Table 4.

Contamination of mechanical seed cutters *Erwinia carotovora*, 1975.

Machine part	% of machines contaminated
Cutting blades	100
Splitter disks	100
Rollers	100
Conveyor belts	100

Table 5.

Erwinia carotovora contamination of seedpieces cut on mechanical seed cutters, 1975.

Machine Number	% of seedpieces contaminated
1	100
2	65
3	50
4	50
5	100

It has been shown that potato cull piles and plant refuse dumps commonly serve as sources of blackleg and soft rotting bacteria in potato growing areas. Bacteria have been shown to be present in these sources throughout the winter and the following summer in Scotland, Colorado and Wisconsin. Insects associated with these sources are often heavily contaminated and are capable of transmitting the bacteria considerable distances to healthy potatoes, thus, reintroducing the pathogen which then may spread during the handling of the crops. At least 10 species of flies have been shown to be contaminated in Colorado.

Air borne bacteria (aerosols) can be generated by water drops originating from rain or overhead sprinklers. These may be able to survive long enough to be carried considerable distances by the wind especially if they are generated at night. This may also prove to be a source of contamination of crops by blackleg and soft rot bacteria.

Great care must be exercised by the grower especially in the cutting and handling operations to reduce the chances of converting a relatively clean seedlot to a heavily contaminated one. Principles of sanitation must be strictly exercised to prevent such problems from occurring.

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