POTATO BLACKLEG: ITS NATURE AND PROSPECTS FOR CONTROL

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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 or to attack and kill young sprouts before they emerge from the soil thus resulting 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 can be traced to 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 many 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 seed pieces 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 is generally 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 extremely 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 has often been unsatisfactory, enough success has been 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, however, overwhelming evidence has emerged from several independent laboratories in Scotland, Russia, England, Ireland, Romania and the U. S. A. (Colorado) which shows that the blackleg pathogen does not survive well in the soil, 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.

Further research has shown that the blackleg bacteria are seed borne rather than soil borne. Perombelon has reported that literally all potato stocks in Scotland are contaminated with blackleg bacteria. Our work in Colorado has shown similar results. Of 11 lots of seed collected in Colorado in 1969, 10 were found to be contaminated at levels ranging from 1.0 to 21.4%. When samples from these seed lots were planted in the field, they produced blackleg infected plants in numbers roughly proportional to the level of contamination detected by the laboratory assay. The actual percentages of blackleg infection in the field were, however, higher than predicted from the laboratory results. These results are illustrated in Table 2.

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

	% Infection	
Lot#	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	2.0
11	1.0	2.5

Similar results were obtained in 1971 when 19 seed lots representing 8 varieties from 4 states were sampled. All but one lot was found to carry blackleg bacteria in amounts ranging from 1.0-14.0 percent. This suggests that the problem of potato seed contamination with blackleg bacteria is probably widespread in the U.S.

One difficulty in achieving acceptance of the seed borne nature of potato blackleg is the fact that often a single seed lot planted in different locations will produce widely differing numbers of blackleg infected plants. This can be explained by the fact that many factors other than the presence of the blackleg organism govern the amount of blackleg that will develop and to a large extent will determine the stage of plant growth (i.e. seedpiece decay, early season or late season development) when blackleg will be expressed.

Some of these factors include numbers of bacteria in the seedpiece, soil temperature, other microorganisms which may attack seedpieces, plant nutrition, and storage and handling conditions. 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 seed lot at 4 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.

Similar results were obtained when the soil temperature was kept constant and the numbers of bacterial cells inoculated into potato seedpieces. The other factors mentioned above affect blackleg expression in a similar manner.

For most seed borne diseases Seed Certification Programs have offered the most promising approach to control. Such programs can be quite efficient when clean stocks are available and methods are available to detect and measure infection as it occurs. Since research has shown that most potato seed carries blackleg bacteria, often in very high amounts, and expression is often erratic, the traditional certification approach has shown little promise. With the blackleg bacteria present in the seed the chemical control approach becomes largely ineffective since it is difficult for toxicants to reach the inoculum without damage to the seed. Recent discoveries in Scotland have shown that blackleg bacteria do not move from contaminated seed pieces into the developing stems immediately and that cuttings taken from young potato plants are usually free from blackleg contamination. This has provided the means to develop clean stocks with which to begin effective certification programs. This coupled with the discovery of better methods for detecting and identifying reinfections and an increased understanding of factors which influence blackleg expression have made such programs much more feasible than in the immediate past.

With clean stocks available, the first requirement for an effective control program has been met. Intelligent use of "flow thru" or "flush out" programs with continual introduction of clean stocks should go far toward reducing the blackleg problem.

Such a program was begun in Colorado in 1972. Over 2000 plants were grown from bacteriologically tested stem cuttings at an isolated location. None were found to be infected with blackleg when visually inspected or when tissue from the base of each plant was tested in the laboratory. The progeny from these plants was increased in 1973 and 1974 without the detection of any infected plants. Currently 700-800 cwt of blackleg free material representing 4 varieties is available. This will be released to foundation seed growers in 1975.

Carefully controlled studies have been made at Colorado State University in which cuttings taken from mother plants grown from tubers collected from seed lots badly infected with blackleg bacteria have been compared in field plots with plants produced by tubers from the same seed lots. The results summarized in Table 4 show that no infection was found in the stocks grown from stem cuttings while as much as 31 percent blackleg infection was present in plants produced from the mother stock.

Table 4.

Blackleg infection in stem cuttings and plants produced by mother tubers in 1972

	Percent blackleg	
Variety	Mother stock	Stem cuttings
Red McClure	1.3	0
White Rose	10.7	0
Sebago	30.0	0
Rural New Yorker	31.0	0
Manona	9.3	0

These results leave little doubt that badly contaminated stocks can be effectively "cleaned up" by the stem cutting procedure.

The clean stocks and their mother lines were grown for 2 years in nonisolated or semi-isolated locations with elaborate precautions to prevent spread by machinery or other means or without any precautions against these sources of infection. The stocks thus exposed were then evaluated for performance at two locations in Colorado in 1974. The results are shown in Tables 5 and 6.

The data show that the stem cutting stocks showed superior performance as measured by plant emergence if they had been kept isolated from contaminated potato crops. Stand increases over the contaminated mother stock were as high as 59.4%.

Although some recontamination had occurred during 3 years exposure the stem cutting materials still performed much better than the mother stock. These results agree with Scottish experience which suggests that recontamination may be quite common but that levels of recontamination may be relatively low. Over a period of 2-3 years 75-80% of the Scottish stocks derived from stem cuttings which were rejected for blackleg infection carried levels only in the range of .001 to 0.1 percent. Common sources of recontamination include tractor tires and other field machinery, grading equipment and storage facilities. Seed cutting operations in the U.S. are almost certainly major sources of contamination and spread of infection. Recent data from Colorado suggest that insects may contribute to the recontamination of clean stocks also.

Maintaining and increasing clean stocks and avoiding recontamination will be a real challenge which must be met to insure a successful blackleg control program.

Overall, the stem cutting approach to blackleg control appears to be a highly promising method of reducing the blackleg problem. Additional benefits such as the reduction of stand losses and perhaps some other disease problems which may not be obvious at present may also accrue from such programs in the future.

Table 5.

Performance of stem cutting stocks after 3 years of field exposure 1974

Treatment[1/]	Stem cutting stocks	"Mother" stocks	% Stand increase or decrease compared with mother stocks
	Center, Colorado Stand (Plants/600 ft)		
NI + NP	471	515	-8.5
NI + P	514	502	+2.4
I + NP	497	421	+18.1
I + P	534	496	+7.7
	Greeley, Colorado Stand (Plants/560 ft)		
NI + NP	294	312	-5.7
NI + P	346	387	-10.6
I + NP	391	253	+54.5
I + P	405	254	+59.4

1/ NI = Nonisolated I = Semi-isolated.
NP = Not protected from contaminated machinery et.
P = Protected from contaminated machinery etc.

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