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Common Scab of Potato Caused by *Streptomyces* Species

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Introduction

COMMON SCAB OF POTATO is caused by several plant pathogenic bacteria in the genus *Streptomyces*, including *Streptomyces scabiei* (also known as *Streptomyces scabies*). These bacteria induce scabby lesions on potato tuber surfaces that range from relatively superficial to deeply pitted. In the United States, the strains that are pathogenic to potato and other root crops (such as radish, parsnip, beet, and carrot) have in common the production of thaxtomin, a phytotoxin that induces the scab symptom. Common scab occurs worldwide wherever potatoes are grown. Though common scab does not typically lower total yield, the disease causes unsightly blemishes that reduce the marketability of both fresh-pack and processing varieties, especially if the deep-pitting symptoms of the disease are present.

The Pathogens

At least fourteen species of *Streptomyces* can cause common scab, including the well-known *S. scabiei* and others such as *S. acidiscabies*, *S. reticuliscabiei*, and *S. turgidiscabies*. Bacteria that cause common scab are part of a larger group known as actinomycetes. Members of this group are gram-positive, filamentous bacteria. This group is primarily comprised of nonpathogens and even beneficial bacteria, including those that produce the antibiotic streptomycin, and they are found around the world. This group is unique among bacteria in that its members form branched strands that resemble fungal hyphae. The spore-producing hyphae of these bacteria develop into corkscrew-like spiral chains with cross walls that eventually constrict and break off into individual spores. As these spores mature, they develop gray or melanized pigmentation. The pathogens that cause

common scab are also efficient saprophytes, meaning they can actively live, grow, and reproduce on dead organic matter.

Generally, pathogens can be distinguished from nonpathogens within this group of bacteria by the presence of a gene that produces thaxtomin. Thaxtomin is a phytotoxin that is also a pathogenicity factor; with few exceptions, the bacteria cannot cause common scab without it.

Symptoms

Symptoms of common scab occur on the surface (skin) of the potato tuber. The cork-like lesions can vary from superficial (Figures 1a, 1b, 1d, and 1e) to deeply pitted (Figures 1c and 1f) and more than one lesion type can occur on the same tuber. Lesions like those shown in Figure 1d are often referred to as russeting since they resemble the skin of a Russet potato variety. Pitted lesions on average extend ⅛ inch into the tuber flesh, but the depth can vary. Lesion type is thought to be a result of the combination of potato cultivar, pathogen strain, time of infection, and environmental conditions, but research on North American pathogen isolates and potato cultivars has shown variability from year to year and location to location in terms of these interactions. Sometimes these specific symptoms are termed russet scab, corky scab, netted scab, or pitted scab.

Tubers can get infected as soon as they begin to form, but symptoms are usually first noticed late in the growing season or at harvest. The initially small, brownish lesions enlarge into water-soaked circular lesions within a few weeks of infection. Enlarging lesions may grow together (coalesce), forming large scabby areas that appear dry and corky by the time tubers are harvested. Common scab can form severe lesions (Figure 1f) under warm, dry soil conditions with a soil pH above 5.2. Though common scab-causing species are suppressed in acidic soils with a pH of 5.2 or lower, acid scab (caused by *S. acidiscabies*) can develop in acidic soils with a pH as low as 4.0 and is associated with raised lesions resembling common scab.

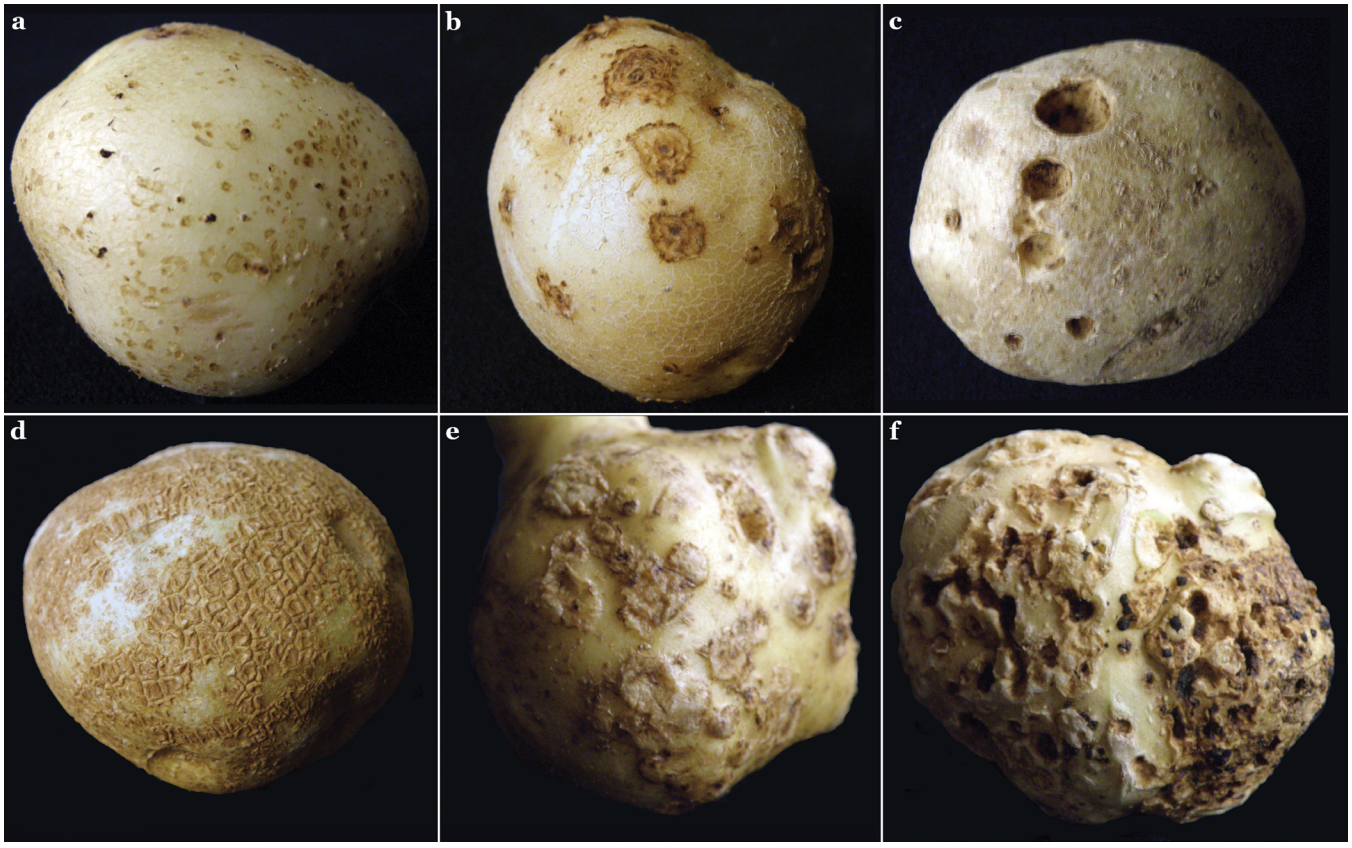

Figure 1. Various symptoms associated with common scab: **A**, superficial discrete; **B**, raised discrete; **C**, pitted discrete; **D**, coalescing superficial; **E**, raised superficial; and **F**, pitted coalescing lesions.

Common scab symptoms sometimes resemble those associated with the disease powdery scab (caused by the soilborne fungal-like cercozoan *Spongospora subterranea*) and the elephant hide symptom sometimes associated with Rhizoctonia diseases on potato tubers. Damage associated with certain chemicals can also cause similar symptoms in some cases.

Disease Cycle

The common scab pathogens overwinter either in the soil or on the surface of tubers and crop residues. They move from one location to another via splashing water (irrigation or rain), wind currents, seed tubers, and soil-contaminated farm equipment. Most soils where potatoes are grown in Idaho have resident populations of both pathogenic and nonpathogenic species of *Streptomyces*.

When a spore comes into contact with a suitable host, it germinates and the infection process begins.

The optimal temperature for infection of potato tubers by *S. scabiei* is 68°F–72°F, but the pathogens can attack tubers in soil within a wide range of temperatures, from 50°F to 88°F. Infection usually begins at the onset of tuberization (Figure 2). The pathogen primarily invades lenticels, but it can take advantage of any open wound on the surface of a potato tuber. After penetration, the pathogen grows through up to three peridermal cell layers, causing the cells to die. The bacterium then feeds on these cells saprophytically.

The pathogen also secretes a compound that promotes rapid cell division in the living cells surrounding the lesion. This causes the tuber to

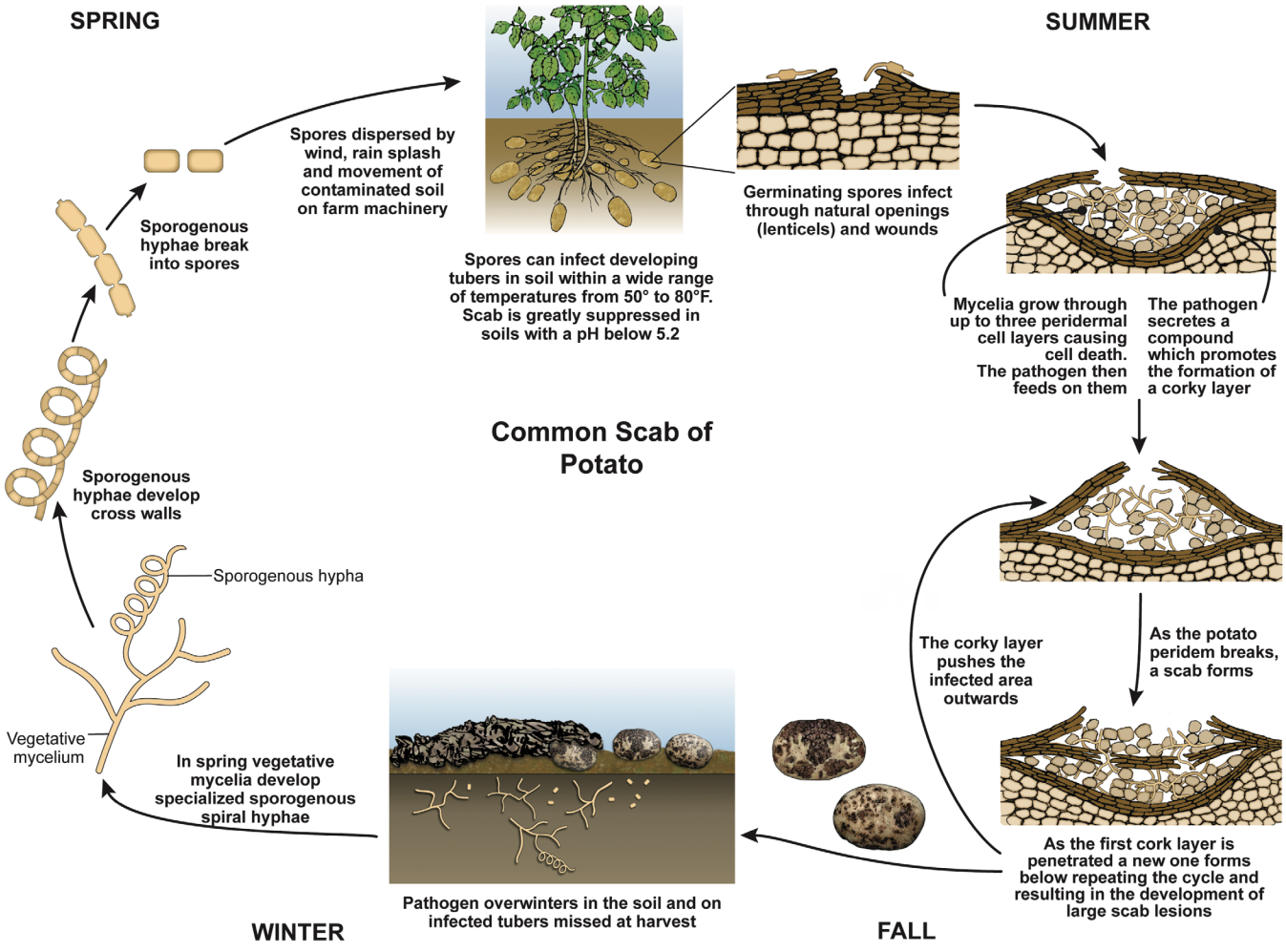

Figure 2. Disease cycle for common scab of potato.

produce several layers of cork (suberized) cells that isolate the bacterium and surrounding tuber cells. As the tuber cells above this suberized layer die, the pathogen feeds on them. As the suberized layers are pushed out and sloughed off, the pathogen grows and multiplies in the additional dead cells. This results in the development of the scab lesion. The growth cycle may occur several times throughout the growing season, enlarging the lesion. Lesion size also varies depending on when the infection occurs. Generally, the earlier a tuber becomes infected, the larger the lesion. New infections do not occur on mature tubers that have completed the process of skin set.

Management

No single measure effectively manages common scab. Thus, integrated approaches that combine the use of less susceptible potato varieties, cultural practices, and appropriate chemical approaches are encouraged.

Resistant Varieties

No potato variety is immune to common scab, but less susceptible varieties are available. The mechanism of resistance to common scab is not well understood and the pathogens display tremendous genetic variability. Varieties such as Russet Burbank and Dark Red Norland tend to show fewer symptoms in field screening programs, while Yukon Gold, Shepody, and Norkotah are generally considered more susceptible. However, the response to common scab can vary from location to location and from year to year, possibly due to differences in pathogen strain, inoculum density, environmental conditions, and disease pressure. Thus, host resistance alone is not sufficient to manage common scab.

Cultural Practices

Seed Selection

Select certified seed with no common scab symptoms to avoid the introduction of additional and potentially more aggressive strains into a field. Regardless of symptom severity on seed tubers (5% compared to 50%), daughter tubers may experience similarly high incidence and severity. In addition, use of whole seed tubers tends to lead to more common scab on daughter tubers than using cut seed.

Crop Rotation

Continuous cropping of potatoes can increase disease severity. Carrot, beet, spinach, turnip, and radish are also host crops for the pathogens. If included in a potato rotation, these crops can increase soil inoculum. However, including green manure crops such as rye, millet, and oat in a rotation may help reduce the incidence of scab. Avoid planting highly susceptible varieties in fields with a history of high disease pressure.

Optimal Soil Moisture During Tuberization

Warm and dry soil (less than 65%–70% soil moisture) at tuber initiation and for several weeks afterward can increase the incidence of disease. Therefore, maintaining soil moisture levels at 80%–85% during tuber initiation until tubers are 1–1½ inches in size may help reduce the incidence and severity of common scab.

Soil pH

Acidic soils with a pH below 5.2 may significantly reduce the severity of common scab. In Idaho, soil pH often exceeds 5.2, so planting in fields with a low pH is not always an option. However, in some fields where pH is not excessively high, applying soil-acidifying products like elemental sulfur, gypsum, or acid-forming fertilizers (such as ammonium- or urea-based nitrogen) may help lower soil pH sufficiently to suppress common scab. Avoid excessive use of lime, fresh animal manure, and wood ash, all of which can raise pH. Some less common species of the pathogen (such as *S. acidiscabies*) can cause a form of common scab known as acid scab and these strains are known to survive at pH 4.0.

Soil Amendments

Streptomyces species are generally involved in the decomposition of organic matter and are thus thought to be stimulated by its presence. Therefore, if possible, avoid planting in light-textured soils and those with high levels of organic matter. Addition of organic matter in the form of animal manure, compost, and some cover crops (such as soil-incorporated red clover) may increase common scab. However, the use of green manure crops such as buckwheat, canola, oat, rye, and millet may inhibit common scab. Thus, although some soil

amendments that increase microbial activity in the soil are thought to suppress the pathogen, other research has shown that amendments can increase common scab symptoms. Such conflicting reports highlight the potential complexity of the mechanisms involved with disease suppression and the need for recommendations based on local conditions.

Planting and Harvest Dates

Both early planting and delayed harvest may increase yields but such practices may also increase levels of common scab and other soilborne disease such as black scurf. Optimize planting and harvest dates based on the potato variety used and for fields with high disease pressure. Avoid leaving tubers in the ground for longer than required after vine kill.

Chemical Options

Chemical and antimicrobial compounds have been used to manage or suppress common scab with varying degrees of success. No available chemical option has performed consistently in suppression of common scab from year to year.

In-Furrow Applied Fungicides

The chemical pentachloronitrobenzene, also known as Blocker (AMVAC LLC), has been shown to be effective when applied in-furrow at the time of planting at a rate of 4–5 lb a.i. per acre (a.i. = active ingredient). However, at these high rates, it may decrease tuber size or yield.

Fumigants

Chloropicrin (such as Pic Plus, Pic-Clor, or Strike) has shown efficacy in some regions and in some years, but it is costly relative to other chemical options.

Fungicide Seed Treatments

No fungicide seed treatments are labeled for use against common scab and reports on the treatment's efficacy in field trials are variable.

Biological Options

Soil application of Minuet (Bayer) is labeled for common scab. The effectiveness of biological control options likely vary widely, depending on the strain of the pathogen that is present, the potato variety selected, and environmental factors/conditions.

Diagnostics

Although it may be possible to diagnose common scab based on visual symptoms alone, sometimes even experienced diagnosticians will require a molecular-based laboratory test to confirm the causal agent due to potential similarity with powdery scab and elephant hide. Available molecular tests target DNA from the *Streptomyces* txtAB gene, which encodes for the thaxtomin phytotoxin. Targeting the thaxtomin gene in molecular assays enables detection of all pathogenic strains despite their genetic diversity in both tubers and soil.

For soil testing, the presence of the pathogens can be determined using molecular methods in combination with a robust DNA extraction method suitable for large volumes of soil (11 oz or more). The extracted DNA from one soil sample can also be used to detect the presence of *Spongospora*, *Colletotrichum*, and *Rhizoctonia* at the same time.

Summary

Common scab is caused by different species within the genus *Streptomyces*. Due to tremendous genetic variability within populations of the pathogens, managing common scab can be extremely challenging. It requires an integrated approach that starts with selecting certified seed free of common scab symptoms.

Further Reading

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