COMMON SCAB

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COMMON SCAB

Common scab is a classic soil-borne disease caused by species of the *Streptomyces* genus. *Streptomyces* is an Actinomycete, classified as bacteria with characteristics typical of a fungus. Both the disease complex and the pathogen complex are complicated in nature, and the pathogens are able to survive in the soil for many years.

The disease is common in potato producing countries around the world. In South Africa it occurs in all production regions. On the fresh produce market tubers bearing symptoms of damage, can be downgraded. This excludes the damage suffered by seed potato growers due to downgrading.

Management requires an integrated approach, and in South Africa this depends mainly on the planting of tolerant cultivars, the use of long rotation periods with non-host crops, and the effective treatment of seed potatoes.

It is becoming ever more evident to researchers that the type of common scab symptom that occurs can be influenced by the interaction of the following factors:

- Pathogen or pathogenic complex in the soil.
- Potato cultivar.
- Prevailing soil temperature and soil moisture.
- Microbial population and activity in the soil.
- Physiology of the potato plant.

Specific types of lesions are associated with particular *Streptomyces* species. It is not always that simple, however, because different species can be present in a single lesion, and pathogens can be influenced by the particular composition of the microbial population in the rhizosphere.

A link has been found between surface scab and a weak pathogenic *S. scabiei* isolate, and also between deep lesions and *S. caviscabies*.

Fissure scab is most likely caused by a *Streptomyces* species not yet described in South Africa.

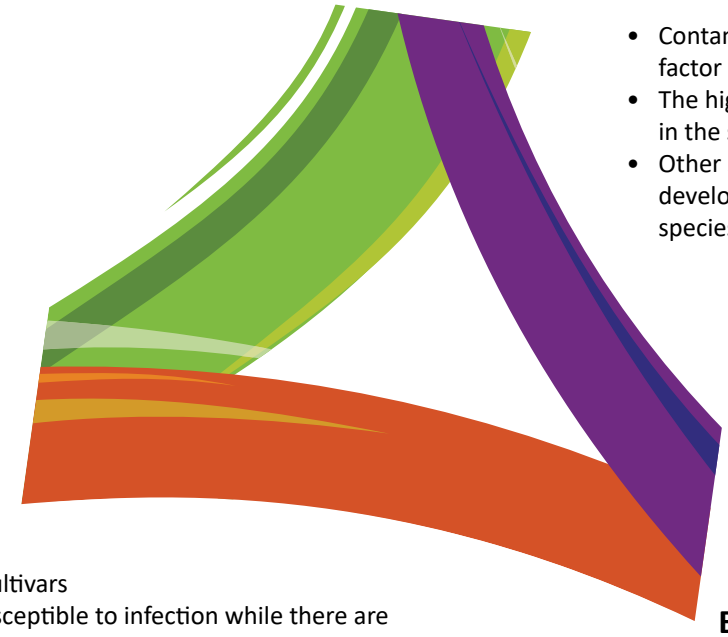
MANAGE THE RISK OF COMMON SCAB

	RISK	MANAGEMENT
PLANTING TIME	Hot, dry time of the year	Soil that is hot and dry creates ideal conditions for the proliferation of common scab. - Do not under-irrigate, particularly during tuber initiation, and for four weeks thereafter. It is important to regularly monitor the occurrence of tuber initiation. - If common scab occurs repeatedly, consider planting at a cooler time of the year, if possible.
CHOICE OF LAND	Contaminated soil	- Maintain a rotation programme of at least four years. - Ensure that rotation crops are not host to common scab pathogens. Wheat, soybean, lucerne, rye and oats are suitable options. - If the preceding crop was affected by common scab, postpone the planting of potatoes by four years. - Volunteer plants must be controlled to maintain the effectiveness of the rotation programme and to limit soil inoculum. - Treat the soil with a registered remedy such as quintozene, especially in the case of seed potatoes. - Green manure with rye, oats, beans and grasses (e.g. millet and babala) to reduce the incidence of common scab. - Consider biofumigation with a *Brassica* crop (e.g. Caliente mustard, cabbage and canola) to suppress disease within the soil.
	Natural contamination of soil	- Animals that have fed on contaminated tubers should, as far as possible, not be allowed access to new fields and the natural veld, as the pathogen can be spread through their manure.
	Soil pH> 5.5	- In consultation with experts, design fertilisation programmes aimed at preventing a rise in soil pH level, particularly where animal manure is used.
	Soil with a porous structure	Sandy and sandy loam soils create a favourable environment for *Streptomyces* pathogens. - Make sure that the soil is not too dry.
CHOICE OF CULTIVAR	Susceptible cultivars	- Plant cultivars with a high tolerance to common scab. Mondial, for instance, is known to be a highly tolerant cultivar, while BP1 is highly susceptible. - Test new cultivars on your farm. Plant new and standard cultivars together in strip trials in fields where problems have occurred. - Where susceptible cultivars are planted for niche markets or for processing, it is of cardinal importance that the other components of an integrated common scab management programme are in place.
SEED POTATOES	Contaminated seed potatoes	- Where possible, plant low generation seed potatoes (G3 or G4). Keep in mind that Elite class seed potatoes have a lower incidence of soil-borne diseases than Class 1 or Standard Grade. - Where virgin soil is used, it is essential that only seed potatoes of the highest quality are planted in order to reduce the risk of soil contamination. Discuss the situation with your seed potato supplier,W request an inspection report and study it carefully before deciding whether the seed potatoes in question are of suitable quality for planting in new soil. Uncontaminated soil is becoming ever more scarce and taking good care of such soil is well worth any extra expense. - Treating all seed potatoes with a registered remedy will reduce the risk of symptom free contamination.

MANAGE THE RISK OF COMMON SCAB

	RISK	MANAGEMENT
CROP MAINTENANCE	Cross-contamination of potato fields	Prevent the spread of the pathogen. - Clean tractor tyres and implements with a high pressure hose, allow them to dry thoroughly and then apply a sanitiser. - Cultivate new and uncontaminated fields before cultivating any fields that are already contaminated.
CROP MAINTENANCE	Soil is dry	- Ensure optimal irrigation, particularly during tuber initiation and for four weeks thereafter.
HAR-VESTING	Contaminated tubers increase the disease pressure	- Gather any remaining contaminated tubers and bury them deep underground. Unmarketable tubers left in the field raise the inoculum level even further.
WASH-ING	Common scab lesions are contaminated with soft rot	Sanitation within the pack house is of cardinal importance. - Change wash water regularly and clean and disinfect equipment at the end of every day. - Ensure that tubers are completely dry before packing and keep bags out of the sun.

DEVELOPMENT OF DISEASE



Pathogen complex

- Contaminated soil is the most significant factor in the occurrence of common scab
- The higher the inoculum level of *Streptomyces* in the soil, the more serious the disease
- Other soil microbes can suppress the development of the pathogenic *Streptomyces* species

Plant

- Susceptible cultivars
- Tubers are susceptible to infection while there are still lenticels that have not yet formed a cork-like layer
- The physiological state of the plant

Environment

- Dry and hot soils
- Sandy soil that has a tendency to dry out and become hot
- Soil with a pH of >5.5
- Soil with a porous structure, for example sand and sandy loam

Germinating *Streptomyces* spores invade the tuber through non-corked lenticels, as well as microscopic tears and cracks on the surface of the tuber. Common scab spores are not capable of invading the stomata and lenticels on their own, but as the tuber expands microscopic lesions and fissures form, allowing the newly germinated common scab hyphae to penetrate and systematically infect the parenchyma cells.

Corking of the lenticels is the potato plant's protection mechanism against further intrusion by the pathogen, resulting in the formation of cork-like tissue at the points of infection. New lenticels and new internodes are formed as the tuber grows, thus allowing contamination by common scab throughout the tuber initiation period. Newly lenticels are formed as the tuber grows and consequently leave the tuber vulnerable to pathogenic infection for a period of up to ten weeks.

The infective spores function optimally in an environment where the spaces between the soil particles are moist, but not wet, and where the temperature is relatively high (especially soils with a porous structure).

Following contamination, *Streptomyces* hyphae grow amongst the host cells and secrete a toxins known as thaxtomin [A, B, AB], which stimulates the cells surrounding the lesion to form a cork-like layer, thus isolating the underlying unaffected tissue. As the tuber grows, the infection spreads and cracks form in the cork tissue, allowing spores to intrude deeper into the cracks. This in turn stimulates the plant to form a cork-like layer deeper within the tuber. The repeated formation of cork tissue is often evident in lesions. Initially, lesions appear reddish-brown in colour and saturated with water, but later become dry and darker.

Because the *Streptomyces* genus is aerobic in nature, spores are less effective in moist soil where oxygen is less readily available. Under such conditions other soil microbes with the ability to flourish under deoxygenated conditions, can compete with *Streptomyces*.

In wet soil, common scab lesions can allow access by other soil-borne pathogens, including soft rot pathogens.

From the above it is evident that disease control measures should be focused on the tuber initiation phase and the early tuber development phase, when the lenticels have not yet formed a cork-like layer and are thus susceptible to infection by *Streptomyces* pathogens.

Due to the effect of different soil characteristics, time of initial contamination, etc., common scab does not necessarily occur uniformly in a particular potato field.

The higher the inoculum level of *Streptomyces* in the soil, the more serious the disease.

Underground insects such as centipedes and wireworms can burrow into tubers through common scab lesions.

THE PATHOGEN COMPLEX

Streptomyces is a bacterial genus with numerous species that occurs naturally as a saprophyte in soil. *Streptomyces* is Actinomycete, classified as bacteria with characteristics typical of fungi, including the ability to sporulate.

Both the disease complex and the pathogenic complex are complicated in nature, and the pathogens are able to survive for many years in the soil due to the fact that they are natural soil dwellers.

Only a small number of *Streptomyces* species have developed the ability to cause plant diseases. Worldwide, *S. scabiei* is the most prevalent common scab pathogen. Several other pathogenic species have been identified in recent years. The incidence of other pathogenic species differs around the world.

In South Africa too, *S. scabiei* is the most prevalent common scab pathogen. *S. caviscabies*, *S. europascabiei* and *S. stelliscabies* also occur, but to a much lesser extent than *S. scabiei*. The species associated with fissure scab, namely RSA1, is in the process of being characterised.

Genes for pathogenicity were likely transmitted from *S. scabiei* to other species, leading to the existence of new pathogenic species.

Different isolates of a specific pathogenic species differ in respect of their virulence (pathogenicity), with some isolates not being pathogenic in nature. Isolates can become pathogenic through the exchange of genetic material between isolates within a population.

Different pathogenic *Streptomyces* species can occur in the same patch of soil. The pathogenic complex differs in different soils and different localities, and even in different plantings within a specific area.

Streptomyces pathogens secrete phytotoxins, namely thaxtomin A, B and AB, with A being the most common. The method that is used involves the inhibition of cellulose formation by TA, causing cell hypertrophia in dividing cells.

Streptomyces is aerobic in nature (i.e. requires oxygen to function), and filamentous spores are formed on airborne hyphae.

Streptomyces does not form survival spores as a means of surviving under unfavourable conditions, it instead survives saprophytically on organic matter in the soil.

SPREADING OF *STREPTOMYCES*

Seed potatoes are the most significant means by which common scab is spread. Where contaminated seed potatoes are planted, it is unlikely that the daughter tubers will be contaminated during the same season. When the seed potatoes collapse at the end of the season, the common scab spores are released into the soil, where they will infect the daughter tubers in the following season. Symptomless seed potatoes originating from a field with a history of common scab could infect any field in which they are subsequently planted, but an integrated control programme could serve to suppress the development of common scab.

Soil. Common scab pathogens can survive in soil for ten to 20 years. There have been reports of contamination in soil where potatoes have never been cultivated. There could be multiple reasons for this. Some researchers are of the opinion that pathogenic *Streptomyces* could occur naturally in the soil.

Volunteer potatoes growing in contaminated soil will raise the inoculum level of the entire field.

Floodwaters could spread the pathogen. Since *Streptomyces* is dependent on oxygen (aerobic), it is unlikely to survive for long in the stagnant water of dams and rivers.

Implements. *Streptomyces* can be spread through soil clinging to farm implements.

Animals can spread *Streptomyces* through soil clinging to their hooves, as well as through their manure due to its ability to survive through the digestive system.

Wind can spread contaminated soil particles.

Host plants in South Africa include: Potato, beetroot, carrot, radish, turnip, other crops with fleshy roots and groundnuts.

Common scab does not affect groundnuts as such, but as a host crop it should not be cultivated in a rotation programme with potatoes.

Within the plant. *Streptomyces* cannot pass through the vascular tissue to other parts of the plant. It is normally limited to the tubers and roots. *Streptomyces* can survive saprophytically on plant residue left behind after a harvest.

CONTROL MEASURES

Choice of cultivar. Research conducted during the 1990s found that cultivars can be classified into four categories of tolerance: Extremely susceptible (incl. BP1), susceptible (incl. Up-to-Date and Buffelspoort), reasonably tolerant (incl. Caren, Darius and Mnandi), and tolerant (incl. Mondial and Fianna). There are currently no cultivars available that are totally resistant to common scab infection.

The tolerance level of a particular cultivar must be tested under local conditions, since the *Streptomyces* species and its population composition vary in different soils. New cultivars should be planted in strip trials, together with the standard cultivar, in contaminated soil over a period of at least two seasons.

Crop rotation periods of four to six years are recommended, due to the pathogen's ability to survive in the soil. Crops that are not host to the *Streptomyces* pathogen include wheat, soybean, lucerne, rye and oats.

Carrot, beet, radish, turnip and other crops with fleshy roots, as well as groundnuts, should not be planted, as they are potential hosts of the pathogen.

Treatment of seed potatoes. Flusulfamide and mancozeb are currently registered for the treatment of seed potatoes.

Certified seed potatoes. Plant certified seed potatoes only. The maximum percentage of seed potatoes with common scab lesions allowable for each class of seed potatoes is as follows:

Generation	Class		
	Elite	Class 1	Standard
G1- G3	0.1	0.5	8.0
G4 – G6	0.5	1.0	8.0
G7 – G8	1.0	3.0	8.0

Soil treatment can be done with a registered fungicide such as quintozene, but it is costly. The soil type, application method and disease pressure can affect the success rate of any soil treatment programme.

Irrigation. Researchers in the Great Britain have found that irrigation can be used as a method to create unfavourable conditions for disease development. Indications are that the level of *Streptomyces* (and other Actinomycetes) is reduced under relatively moist soil conditions. Results have also shown that soil should be kept moist for a period of four to six weeks following tuber initiation. The climate and cultivars in

South Africa differ from those in Great Britain. As such, more research is needed to determine the potential benefits of irrigation scheduling in the management of common scab in South Africa.

Biofumigation. Research conducted both locally and overseas points to biofumigation as an effective means of controlling common scab. However, effective results are not always guaranteed due to the numerous unknown factors involved. Biofumigation is currently a topic of research worldwide.

Green manure. In South Africa, researchers have found that repeated treatment with green manure reduces the incidence of common scab. However, there is still much work to be done before any recommendations can be made.

Animal manure. Observations indicate that uncomposted manure can increase the incidence of common scab. Manure should thus be tilled into the soil one season prior to planting potatoes.

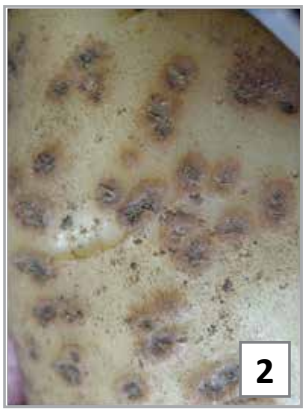
Integrated management. The control of common scab is hampered by the fact that several *Streptomyces* species are pathogenic, and their incidence varies in different soils. Adding to the problem is a lack of knowledge regarding environmental and soil conditions conducive to the development of disease, as well as the ability of *Streptomyces* to survive for long periods in the soil.

The control of common scab is currently reliant on tolerant cultivars, certified seed potatoes and new soil, but this is not a sustainable approach, and the search for alternative control measures remains ongoing. The availability of uncontaminated soil is becoming ever more scarce, and an integrated approach to the management of common scab is therefore essential.

COMMON SCAB CAN BE CONFUSED WITH POWDERY SCAB

Powdery scab lesions are mostly round and blackish just after harvest (1). They are not corky and skin tissue surrounding the lesion is slightly swollen and pinkish purple, which is not seen with common scab lesions (2). When powdery scab lesions mature and the skin covering the lesion ruptures, a brown mass of sporosori are seen (3). When tubers with powdery scab lesions are washed and brushed, the skin covering the lesion and the sporosori are removed and a shallow lesion remains (4).


1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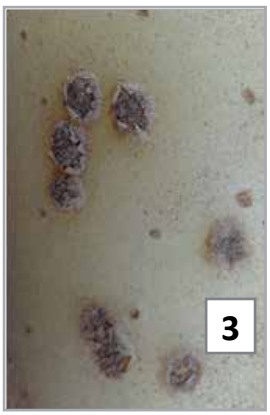
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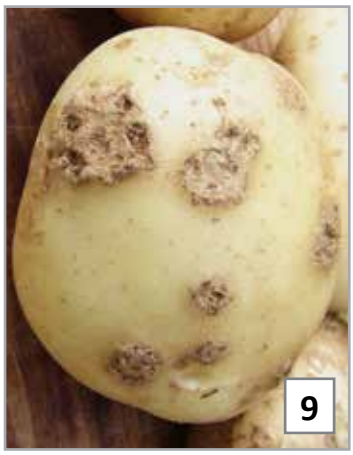
SYMPTOMS OF COMMON SCAB



Symptoms are visible on the tubers, and not on stems and leaves.

The most distinctive characteristic of common scab lesions is the cork-like tissue that forms on the surface of the potato tuber (1), which can be brown, dark brown or almost black in colour. More than one type of common scab can affect a single tuber.

Lesions can vary from a few small spots on the surface (5, 6, and 8) leading to minor cosmetic damage, to deep lesions (3, 4 and 7) that are unacceptable to consumers and processors.

Lesions are usually described as deep, 'russet/netted' (6 and 7) or raised (2 and 9) and are mostly round in shape. Corked, star-shaped fissures (11 and 12) were first referred to as fissure scab in 2012.

Common scab lesions often allow access to by other soil-borne pathogens and/or soil-dwelling insects, leading to secondary contamination.

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