

POWDERY SCAB



potatoes
aartappels **SA**

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POWDERY SCAB

Powdery scab is a **classic soil-borne disease** caused by *Spongospora subterranea* f.sp. *subterranea* (Sss). Powdery scab is known for occurring under cool and wet conditions. This is the likely reason why until relatively recently the disease was thought to hold no major risk for potato production in South Africa. However, as in many other parts of the world, e.g. Great Britain, Europe, North America, Australia, New Zealand and even Israel, powdery scab has spread to South Africa over decades, causing mounting problems and degradation of potatoes on fresh produce markets and of seed potatoes. Although most regions in South Africa do not have a cool and wet climate, potatoes are often planted and irrigated in early spring. In regions where potatoes are planted during winter, the risk of powdery scab exists throughout the season.

The damage caused by powdery scab is visible in the form of unsightly blemishes on the surface of tubers. However, the pathogen also infects the roots, causing galls that can lead to

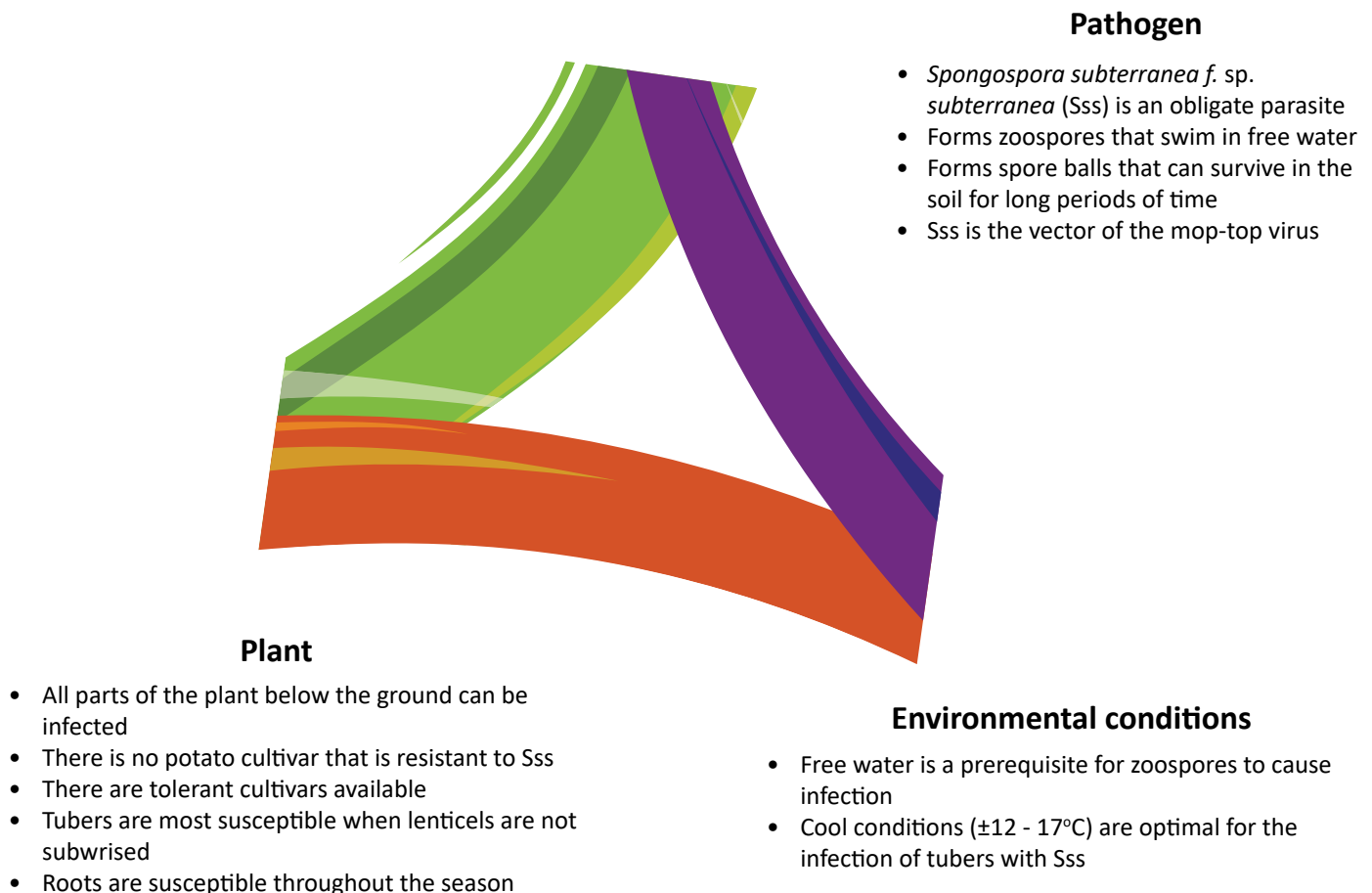
reduced water and nutrient uptake, and subsequent reduction in yield.

Managing powdery scab is incredibly difficult, as spore balls can survive in the soil for decades. There are currently no plant protection products registered in South Africa for the treatment of seed potatoes or soil against Sss. The only means of managing the disease once the soil has been infected, is through an integrated strategy. Such a strategy is based on:

- the use of tolerant cultivars;
- the management of soil moisture;
- planting at times when conditions are unfavourable for the development of the disease; and
- crop rotation with non-hosts of Sss.

It is important to ensure that soil not infected with Sss is kept free from contamination.

DEVELOPMENT OF DISEASE



MANAGING THE RISK OF POWDERY SCAB

	RISK	MANAGEMENT
PLANTING TIME	Early planting	<ul style="list-style-type: none"> - Where the soil is infected with Sss, consider planting when conditions are warmer, since infection is optimal at temperatures of $\pm 12 - 17^{\circ}\text{C}$. - If it is not possible to plant under warmer conditions, the risk of powdery scab may be reduced by planting a cultivar that is tolerant to Sss. - Do not over-irrigate during the first eight weeks after planting.
CHOICE OF LAND	Infection of non-infected or fallow soil	<ul style="list-style-type: none"> - The most effective method of controlling powdery scab is to prevent the infection of soil. The planting of uninfected tubers is thus of cardinal importance where the soil is not infected with Sss. - Ensure that the source of the seed potatoes does not experience problems with powdery scab, as seed potatoes can be infected latently and with no visible symptoms. - Visit seed potato growers towards the end of their growing season to discuss the situation and to inspect the plants in the fields, as well as the tubers destined for the fresh produce market.
	Infected soil	<ul style="list-style-type: none"> - If potatoes showing symptoms of powdery scab have been harvested in the past, the land must be managed as if it were infected, even if the past harvest had occurred many years ago. - Do not plant on infected lands during cool and/or cool-wet times of the year, and do not over-irrigate. - Seed potatoes planted on lands with a history of powdery scab, must be certified seed potatoes with a low percentage of symptoms. Other aspects of the integrated management program are of cardinal importance. - Select cultivars that are tolerant to Sss, and implement an integrated management strategy.
	Waterlogged soil	<ul style="list-style-type: none"> - Avoid fields and sections of fields that are inclined to become waterlogged. - Do not plant during cool and wet times of the year. - Do not plant susceptible cultivars there.
	Spreading of Sss through implements	<ul style="list-style-type: none"> - Do not make use of contractors where powdery scab is endemic to the region, as spore balls can be spread through implements. - Reduce the risk of the disease being spread through implements by hosing down the soil from implements, washing the implements with a solution of soap and water and leave it to dry in the sun for a day or two.
CHOICE OF CULTIVAR	Susceptible cultivars	<ul style="list-style-type: none"> - The use of cultivars that are tolerant to powdery scab is one of the few effective means to manage the powdery scab. - If it is impossible to make use of a different cultivar, other aspects of the integrated management program must be diligently implemented.
SEED POTATOE	Infected seed potatoes infect fallow/uninfected soil	<ul style="list-style-type: none"> - When fallow soil is used, all possible measures must be taken to plant seed potatoes that are free from powdery scab spores.
FERTILISATION	Unbalanced fertilisation	<ul style="list-style-type: none"> - Do not over-fertilise, especially with nitrogen.
HARVESTING	Pathogen spread through infected soil and plant residue	<ul style="list-style-type: none"> - Bury the soil and plant residue far from water sources.
WASHING	Infected tubers are susceptible to post-harvest pathogens	<ul style="list-style-type: none"> - Where tubers with lesions are washed and brushed and the spore balls are removed, the tubers are more susceptible to infection with soft rot pathogens. - Maintain strict hygiene standards in the packing store, and make use of a registered sanitiser in the wash water.

THE PATHOGEN

Spongospora subterranea f.sp. *subterranea* (Sss) is known worldwide as the pathogen that causes powdery scab. Sss is an obligate pathogen, making it extremely difficult to study the disease under controlled conditions in the laboratory.

The disease spreads through spore balls that can survive in the soil for many years (even decades). The spore ball has an outer layer that is highly resistant towards environmental factors and other organisms. Each spore ball contains a large number of resting spores and in each of these spores is a zoospore equipped with two flagella. The zoospores can move in free water by swimming with the flagella.

Resting spores are released from the spore balls when exudate is secreted from potato roots (or from other host plants), thus stimulating the process. However, not all spores are released simultaneously. This means that a single spore ball can release spores repeatedly in the same, or different seasons.

Zoospores are released by the resting spores and spread through water in the soil. Some scientists are of the opinion that zoospores can swim for up to two days in groundwater amongst the soil particles. Upon reaching the underground plant tissue (roots, stolons or tubers), zoospores form a protective cell wall and penetrate the plant's epidermal cells. Once inside the plant cells, the cell wall is broken down again and the zoospore divides

in the plant tissue to form a plasmodium, within which a number of secondary zoospores are formed. At this point, one of two things can happen with the secondary zoospores: they can be released to cause another cycle of infection, or they can remain inside the plant tissue to form spore balls. If conditions remain favourable for infection, plants can be infected repeatedly in a single season with spore balls forming repeatedly, leading to a significant increase in the inoculation level of the soil. As a result of this multi-cyclical growth, immense damage can be caused during a single season if conditions are favourable for the development of disease, even with very low numbers of spore balls present in the soil. This also explains why control is often not possible with normal rotation periods.

Research done in Great Britain found that spore balls survive better in the soil at low temperatures, whilst survival is reduced at soil temperatures of >20°C. However, this aspect requires further research, particularly in South Africa with its different climatic regions.

Spongospora subterranea f.sp. *subterranea* is the vector for the mop-top virus. This virus is a quarantine organism that does not occur in South Africa. However, there is a risk of it being brought into the country along with imported *in vitro* plants or seed potatoes.

SPREADING OF *SPONGOSPORA SUBTERANNEA* f.sp. *SUBTERANNEA*

Seed potatoes. Worldwide, infected seed potatoes are the most significant means whereby powdery scab is spread. Where infected seed potatoes are planted and cool and wet conditions prevail, there is a very high risk of daughter tubers being infected in the same season. In Great Britain it was found that seed potatoes can also be infected with Sss spore balls without showing any symptoms. There is currently no seed potato treatment against Sss registered in South Africa.

Wind. Research in Israel has found that spore balls brought to the surface of the soil during harvesting can be spread by wind.

Soil washed or brushed from infected tubers, and infected soil clinging to implements and tyres, can spread spore balls from

one field to another on a particular farm, and also from one farm to another.

Water in rivers and irrigation canals can also spread the pathogen. Spore balls can be spread through run-off water resulting from heavy rainstorms and over-irrigation and spores can be spread to deeper layers of the soil through groundwater.

Implements. Sss can be spread through infected soil clinging to implements.

Animals spread Sss through soil clinging to their hooves and through their manure, as the pathogen is able to survive conditions in the digestive tract.

MANAGEMENT OF POWDERY SCAB

The pathogen *Spongospora. subterrannea* f.sp. *subterranea* has developed such effective strategies that the disease can only be managed by means of an integrated approach. The critical risk factors for powdery scab are infected soil, susceptible cultivars as well as cool and wet conditions. Any management plan for powdery scab must give serious consideration to each of these three factors.

Prevent the infection of soil. In the case of powdery scab, preventing the infection of soil is the most effective means of managing the disease. However, if one field does become infected, all possible measures must be taken to prevent the disease from spreading to other areas.

Integrated management. The control of powdery scab is complicated by the fact that the pathogen has developed a number of strategies to ensure its ability to survive in the soil for decades, to infect a host repeatedly in a single season, and to significantly raise the inoculum level in the soil in one season. The only means of managing the disease once the soil has been infected is through an integrated strategy. Such a strategy is based on:

- the use of tolerant cultivars;

- the management of soil moisture;
- plant at times when conditions are unfavourable for the development of disease; and
- crop rotation with non-hosts of Sss.

Choice of cultivar. There is currently no cultivar available that provides total resistance to infection by Sss. There are cultivars available with varying levels of tolerance. Research at the University of Pretoria has found that cultivars can be tolerant to the formation of tuber lesions, but that they can remain susceptible to root infection and the formation of root galls, and vice versa (Figure 1). Certain cultivars are, however, relatively tolerant to both tuber lesions and root galls. Where a cultivar does not have the tendency to form tuber lesions, yet is susceptible to the formation of root galls, this could lead to the build-up of soil infection. Where the risk of powdery scab exists, it is important to plant cultivars that show tolerance to both tuber lesions and galling. It has been found that cultivars with thin, smooth skins (as required by our domestic market) are more susceptible to powdery scab than the russet-type cultivars popular in the USA.

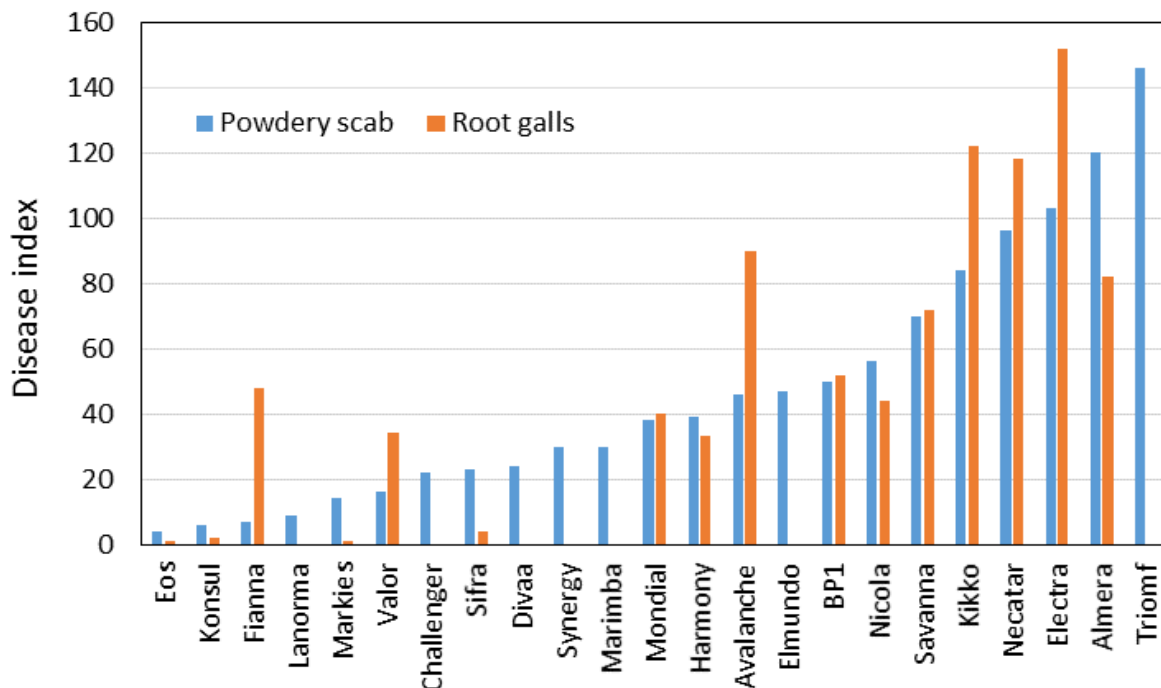


Figure 1. The average disease index of cultivars evaluated during local trials in different parts of the country (Adapted from: J van der Waals. 2015. Series: Powdery Scab 3. Choose your armour: Cultivar susceptibility. Chips Jul/Aug 2015)

Management of infected soil

Volunteer potatoes and alternative hosts (crops and weeds) growing in infected soil will contribute to increasing the inoculum level, even where potatoes are not planted there for a period of several years. Volunteers and other hosts must be controlled as quickly as possible, and for as long as necessary.

Alternative hosts include: tomato, celery, carrot, cabbage, beans and peas, cucumber, onion, kikuyu and maize, as well as weeds – especially those belonging to the Solanaceae family. Potatoes South Africa is currently funding a project at the University of Pretoria aimed at identifying crops that are not hosts of Sss.

Crop rotation periods of at least five years are recommended in view of the pathogen's ability to survive in the soil. However, the spore balls' ability to survive, together with volunteers, can make rotation periods of six years or longer ineffective. Control volunteers and plant rotation crops that are not hosts of Sss.

Choice of land. Avoid fields with cold soil (southern slopes, heavy clay soil, low-lying, etc.), or plant potatoes at warmer times of the year, if possible. Waterlogged soils should be avoided, as wet soil is conducive to the development of powdery scab.

Time of planting. Wet and cool conditions ($\pm 12 - 17^{\circ}\text{C}$) are so important for disease development that the risk of powdery scab can be reduced by avoiding of such conditions, especially where the soil is already infected. In regions where planting takes place in different seasons, planting in the autumn and early summer would reduce the risk. Keep record of the soil temperature on the farm in order to gather information on soil conditions for use in a management plan.

Irrigation. Research done in Great Britain has found that judicious irrigation can be used to make conditions less favourable for infection, as part of an integrated management plan. This strategy should form part of the management strategy in regions with a dry climate. This measure would be most effective where cultivars with a specific tuber-initiation period are planted. In cases where tuber initiation takes place throughout the season, this measure would be less successful. This aspect of an integrated management strategy requires more research.

Certified seed potatoes. The maximum allowable percentage of seed potatoes with powdery scab lesions on certified seed potatoes is as follows:

Generation	Class		
	Elite	Class 1	Standard
G1- G3	0	0.2	4.00
G4 – G6	0.1	0.6	4.0
G7 – G8	0.5	3.0	4.0

Research conducted overseas found that spore balls can occur on the skin of symptomless seed potatoes and that seed potatoes can be infected with no visible symptoms. This means that all seed potatoes from an infected field could be infected and that it should not be planted in uninfected soil.

Treatment of seed potatoes and soil. There is currently no plant protection product registered in South Africa for the treatment of seed potatoes or for application in furrows. There are, however, products registered for use in seed potato production in countries such as Great Britain and New Zealand.

Green manure. According to research done locally and overseas the right green manure crop in a management programme can help to reduce the incidence of powdery scab. In a local trial, bladrammenas, mustard and sweetcorn were found to reduce the incidence of lesions. However, more research is needed in this regard before any recommendations can be made.

POWDERY SCAB CAN BE CONFUSED WITH COMMON SCAB

One characteristic of common scab lesions is the formation of cork tissue. Lesions can be superficial or deep and do not

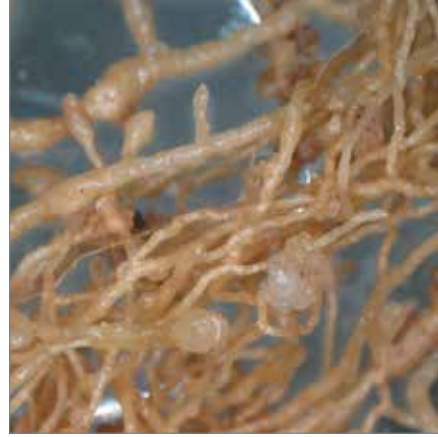
appear as pinkish-brown swollen tissue surrounding the lesions, as in the case of powdery scab.



POWDERY SCAB CAN BE CONFUSED WITH ROOT-KNOT NEMATODE

Lumps on tubers caused by the root-knot nematode are not covered with dark-coloured tissue. Root galls caused by the

root-knot nematode are mainly formed inside the roots, causing them to thicken.



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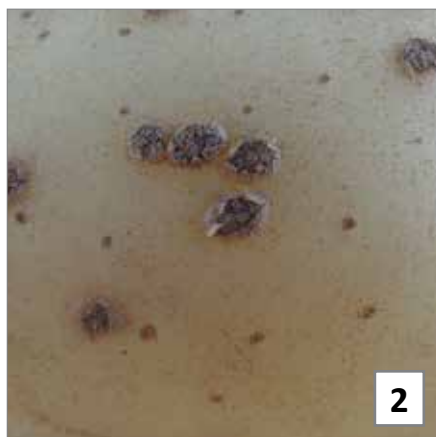
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SYMPTOMS OF POWDERY SCAB

Classic symptoms (photos 1 and 2) are not always observed in the potato field, because tubers are harvested before lesions have released any spore balls, or because the delicate structures are rubbed-off by the soil during harvesting. A characteristic property of powdery scab lesions is the slightly raised, brown-purple tissue surrounding the lesion (photo 4). If tubers with characteristic dark coloured lesions are harvested (photo 5) and left overnight, the skin covering the masses of spore balls often

tears, releasing the spore balls. In cases of serious infection, lesions can merge and cover large portions of the tuber (photo 6). Where lesions are washed and brushed prior to packing, rust-brown lesions are characteristic of powdery scab (photo 7). Root galls of varying sizes and shapes appear on the roots (photo 3). The size of the lesions can differ large (above left on photo 5) to small.



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