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Detection of *Spongospora subterranea* f. sp. *subterranea* in virgin fields

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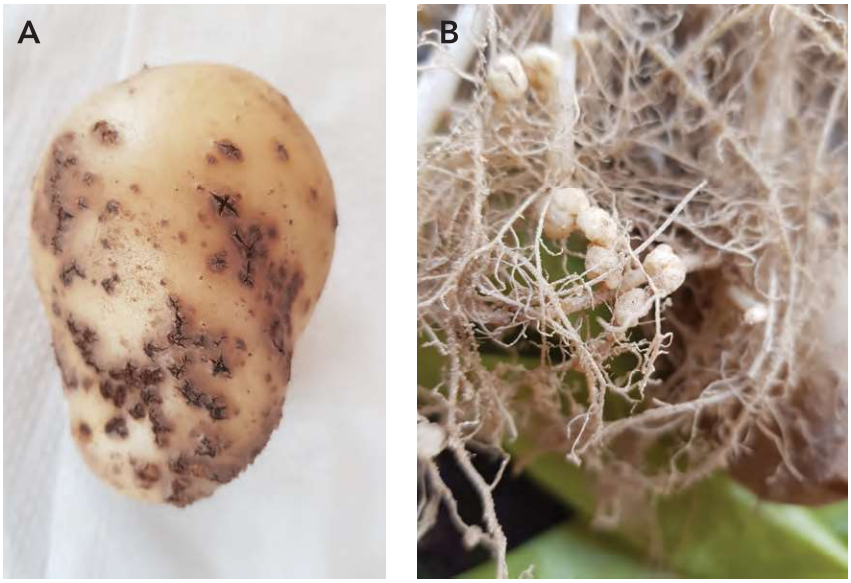
Powdery scab (*Figure 1.A*), root galling (*Figure 1.B*) and root infection are three potato diseases caused by *Spongospora subterranea* f. sp. *subterranea* (*Sss*). Powdery scab is a serious disease in potatoes and a major challenge in the industry worldwide. The powdery scab lesions reduce the quality and marketability of seed tubers or tubers intended for consumption. Root galls and root infection influence water and nutrient uptake, which impair shoot and tuber growth and subsequently reduce yield.

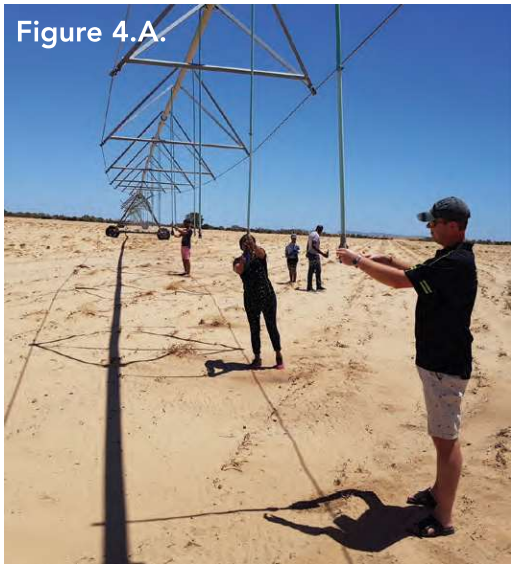
Disease management has proven difficult due to the prolonged survival of *Sss* sporosori (collections of resting spores) in the soil and on infected tubers. Resting spores are triple-walled structures found in tuber lesions and root galls. The recalcitrant cell walls of the resting spores allow them to tolerate extreme environmental conditions and survive in the soil for many years. *Sss* is a seed- and soil-borne plant pathogen.

Figure 1: (A) Powdery scab lesions on a potato tuber. (B) Galls on the potato roots. (Photographs: Carmen Rensburg).



Infected seed tubers have greatly contributed to the dissemination of *Sss* to areas previously known to be disease- and pathogen-free.

On the left (Figure 2) is the sampled field used for potato cultivation in the Sandveld potato growing region of the Western Cape. On the right (Figure 3) is the sampled virgin field in the Sandveld potato growing region of the Western Cape. (Photographs: J.E. van der Waals).



On the left (Figure 4.A) is the irrigation pivot on the farm from which water samples were taken, with the irrigation pit (Figure 4.B.) on the right. (Photographs: J.E. van der Waals).

The pathogen can also be spread by infested growing media as well as farm implements, and containers contaminated with sporosori. The infection process is initiated when the soil environment is cool (9 to 17˚C) and wet.

Resting spores germinate and release zoospores, which can swim short distances until they make contact with a susceptible host. Concerns of potato growers in the Sandveld of the Western Cape, suggested that *Sss* dissemination may not be restricted solely to seed and soil, but that the pathogen could also be disseminated by wind and/or water.

There have been a few reports stating that *Sss* may be dispersed by wind due to the morphology of the resting spores in the sporosori. A recent study by Tsror *et al.* (2020) in Israel using wind and ground spore traps, demonstrated how *Sss* can be dispersed by wind. Further studies of wind dispersal of *Sss* in South Africa were required.

Materials and methods

Soil sampling

Soil was sampled from two fields in the Sandveld potato growing region. One of those fields was previously used to cultivate potatoes and was known to be infested with *Sss* (*Figure 2*). The other was an adjacent virgin field (*Figure 3*).

Five soil samples were taken from each field and placed into brown paper bags to perform DNA extractions and quantitative polymerase chain reaction (qPCR) analysis.

Water sampling

Three water sources were sampled, namely the irrigation reservoir on the farm, the borehole and the irrigation pivot located on the previously mentioned sampled field. The water from the Kromantonies River (32°36'03"S 18°41'28"E) and the borehole is pumped into the irrigation reservoir and used to irrigate the fields on the farm (*Figures 4.A.* and *4.B.*).

Four 500 ml plastic water bottles were filled with water sampled from each of these sources. Before water was sampled from the reservoir, the pump was turned on to stir up the water. The irrigation pivot was switched on and the water was left to pump for two minutes before it was collected at the spray nozzles.

Borehole water was taken from the pump. Samples from the various water sources were centrifuged at 2 254 g for 5 minutes, after which the supernatant was carefully removed, and the pellet used to

Table 1: Mean quantity of *Sss* DNA (sporosori per gram of soil) in five soil samples from a potato field and five soil samples from an adjacent virgin field, determined by qPCR analysis.

Soil sample	Sporosori/gram of soil
Potato field 1	2.8×10^5 c
Potato field 2	8.4×10^6 b
Potato field 3	3.0×10^6 c
Potato field 4	1.6×10^7 a
Potato field 5	5.7×10^5 c
Virgin field 1	2.5×10^4 c
Virgin field 2	0 c
Virgin field 3	1.0×10^5 c
Virgin field 4	0 c
Virgin field 5	5.1×10^3 c

Different letters next to the values indicate significant differences at p = 0.05.

perform DNA extractions and qPCR analysis.

> It is therefore possible that virgin fields may be contaminated by *Sss* due to wind dispersal thereof.

Results

Detection and quantification of Sss from soil samples

Data indicated that the levels of *Sss* DNA detected in soil sampled from the field used for potato cultivation, were significantly different ($p = 0.05$) to those detected in soil sampled from the adjacent virgin field (*Table 1*). Despite low levels of pathogen inoculum in the virgin field, these results clearly showed the presence of the pathogen therein.

Detection and quantification of Sss from water samples

No *Sss* DNA was detected with qPCR in any of the water samples collected from the irrigation reservoir, irrigation pivot or the borehole on the farm.

Discussion and conclusion

In this study, *Sss* DNA was detected in soil samples collected from a virgin field on a farm in the Sandveld region. No *Sss* DNA was found in water sampled from three sources (irrigation reservoir, irrigation pivot and borehole). This indicates that wind could be involved in the dissemination of *Sss*, while water may not be a contributing factor to pathogen spread.

It is therefore possible that virgin fields may be contaminated by *Sss* due to wind dispersal thereof. Further research is needed in growing regions such as the Sandveld, where strong winds often blow soil from one area to another. Spore traps set up between *Sss*-infested fields and virgin fields could further confirm the dispersal of *Sss* by wind. Implications of the results from this research are of value to potato producers in the Sandveld region, where wind erosion is a problem.

To our knowledge, this is the first study conducted in South Africa documenting possible wind dissemination of *Sss* resting spores.

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