The development of novel risk reduction strategies for Sclerotinia head and stem rot of sunflower and soya beans

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Sclerotinia sclerotiorum has an extensive host range of more than 500 plant species, including sunflower, soya beans and canola. These crops play an important role in the South African economy as protein and oilseed crops.

Vegetables that may serve as alternative hosts include (but are not limited to) cabbage, potatoes, squash, carrots and tomatoes. Many common South African weeds are also susceptible to infection and can harbour the pathogen within these crop production systems.

Disease symptoms and signs

Seedling wilt may occur, although *Sclerotinia* head and stem rot frequently develops at flowering and pod or seed fill stages. The initial symptoms are brown water-soaked lesions that become covered with white cotton-like mycelium on sunflower heads and soya bean pods, as well as in and on the stems of both sunflowers and soya beans.

Mycelium (A), sclerotia (B) and stipes (C), the apothecia initials of Sclerotinia sclerotiorum.

The white mycelium on the face of sunflowers eventually develops into a net of black sclerotia. As the disease matures, a shredded appearance, with sclerotia between plant fibres, can be observed, particularly in sunflowers. This fungus can also infect the subterranean crown and forms sclerotia within the lower stem of sunflowers and soya beans.

> Although extensive literature is available regarding Sclerotinia, this disease remains problematic in economically important crops and the pathogen's local behaviour needs to be clarified.

The symptoms associated with a disease are a host response to the pathogen, whereas the signs are a physical reaction of the pathogen. These signs may also be seen morphologically in the laboratory. In the case of *Sclerotinia* diseases, mycelium and sclerotia are the primary signs of the pathogen's presence. Sclerotia, melanised masses of hyphae, are key to the life cycle of this fungus, as they are its primary survival structure.

Infection and spread

Infection by *Sclerotinia sclerotiorum* can occur through two means of germination to produce primary inoculum, namely myceliogenic and carpogenic germination. Carpogenic germination results in the formation of an initial stipe, followed by the apothecia, which are mushroom-like structures.

The bird's nest fungus is commonly misidentified as apothecia. Apothecia release ascospores into the air under conditions of high relative humidity and changes in air pressure, favouring long distance dispersal and infection. *S. sclerotiorum* has the ability to remain dormant in the form of mycelium in infected plant residues when environmental conditions are unfavourable for germination and infection.

Environment and microclimate

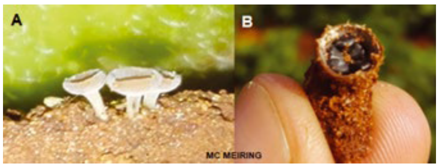
Sclerotinia sclerotiorum is highly dependent on its environment, both weather and agronomic conditions, for disease initiation, development and survival. Cool, wet conditions favour disease development.

The disease is more prevalent in fields where there is a dense crop canopy and limited air circulation, which creates a favourable microclimate for disease development. This is directly related to plant population density and row spacing selected at planting, and to the selection of cultivars prior to planting. Cultivars vary in their physiological structure, i.e. they are determinate or indeterminate, with the latter tending to have a denser canopy.

The pathogen has a complex life cycle and interaction with its hosts and its environment, which makes the management of this disease complex.

Disease resistance and response

Currently, in an international context, there are no commercially available sunflower or soya bean cultivars with resistance to this disease.

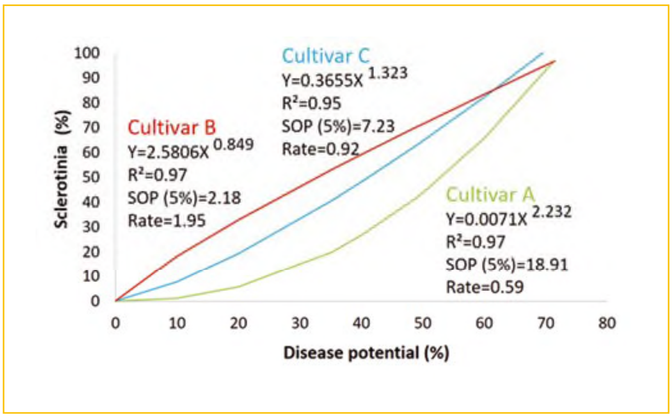


Apothecia (A) and the common bird's nest fungus (B).

However, the manner in which soya bean and sunflower cultivars differ in their response to the pathogen under conditions favourable to the disease, enables the selection of more 'tolerant' cultivars that can reduce the risk of infection and yield losses.

Marlese Meiring has conducted field trials to elucidate the response of soya bean and sunflower cultivars to disease potential, using regression analysis (*sensu* McLaren and Craven, 2008). This analysis determines the type of response and the relationship between *Sclerotinia* head and stem rot within a cultivar and changing disease potentials. Disease potential is defined as the expected mean disease incidence in a genetically diverse population under a specific set of environmental conditions.

Figure 1: Three potential disease scenarios associated with *Sclerotinia* head and stem rot of sunflower and soya beans.



Three response types can be observed between *Sclerotinia* incidence in a cultivar and *Sclerotinia* potential:

- Cultivar tolerant to increasing disease potential.
- Cultivar intolerance to increasing disease potential.
- Cultivar having linear relationship with increasing disease potential (*Figure 1*).

This regression methodology can be an effective and accurate tool to quantify the response of cultivars to different disease potentials, and to promote the selection process of cultivars for a specific disease potential. Further seasons will be added to this study to quantity the response of the cultivars across multiple localities.

Disease controls

There are a limited number of registered fungicides in South Africa. Currently, benomyl and procymidone are used on peas and sunflowers. The latter active ingredient is registered for use on soya beans. The exorbitant cost of the chemicals and their application and the potential requirement for multiple sprays is an economic risk for producers.

Disease forecast models serve as an early warning system that assists producers in optimising the timing of fungicide applications, ensuring optimal efficiency and healthy economic decisions. These risk assessments have been successful internationally for canola and soya beans. The systems range from simple checklists to more advanced mathematical modelling, which is ultimately visualised as a risk percentage or proportion, followed by a recommendation to apply and the application timing, or by a recommendation to withhold fungicide treatments.

In Europe, canola field experiments conducted between 1981 and 2004 indicated that fungicide sprays were only 27 to 33% cost-effective against *Sclerotinia* stem rot (Koch *et al*., 2007).

A risk analysis model

Professor Neal McLaren and Lisa Rothmann are currently in the initial stages of developing a risk analysis model to help producers identify the risk for *Sclerotinia* disease development at critical growth stages during the cropping season. Ten-year disease and weather data were bulked to identify critical infection windows and estimate the length of infection and colonisation periods.

Rothmann is conducting further exploration and optimisation of data collected for the model development in collaboration with Prof Emerson Del Ponte from the Federal University of Viçosa in Brazil. To ensure that all regions of sunflower and soya bean production are covered and correct estimations of risk are distributed, Rothmann has requested producer involvement with surveys, which are currently being conducted. These will be made available via the South African *Sclerotinia* Research Network.

Prevalence and prevention

The change in agronomic decisions, environmental weather conditions, management practices and the susceptibility of germplasm has led to an increase in the importance of *Sclerotinia* diseases worldwide. The greater the prevalence and severity of the disease, the lower the yield and the greater the inoculum build-up.

In the 2017/18 season, sunflower and soya bean epidemics causing yield losses of up to 80% were reported in the Eastern Free State. In South Africa, in 2014, the effects of *Sclerotinia* stem rot of canola gained more attention due to the greater prevalence of the disease during that season, compared to previous years. Although extensive literature is available regarding *Sclerotinia*, this disease remains problematic in economically important crops and the pathogen's local behaviour needs to be clarified.

This investigation is a priority of the South African National Sclerotinia Research Network. The spread of *Sclerotinia sclerotiorum* into critical South African crop production areas and its associated yield losses highlights the importance of identifying and deploying effective management measures to safeguard agricultural land against the initial incursion of the pathogen.

For more information, contact Lisa Rothmann at coetzeeLA@ufs.ac.za or follow the South African Sclerotinia Research Network on Facebook, Instagram and Twitter.