Biological control of Sclerotinia diseases **associated with oilseeds crops**

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Sclerotinia sclerotiorum is one of the most devastating soil-borne plant pathogens and it affects more than 500 plant species, including important oilseeds and protein crops. This pathogen has become a significant threat to the production of crops such as sunflower and soya bean in South Africa. The primary sign of *Sclerotinia* is white, cottony mycelium with the subsequent production of melanised hyphal masses, and survival structures called sclerotia.

One of the primary reasons why control of *Sclerotinia* diseases is so difficult, is related to the biology of the pathogen and its complex interactions with the host crop and environment. Sclerotia can persist on plant debris or in the soil for extended periods of time. Eliminating these sources of inoculum from fields remains a challenge.

Sclerotia can lead to the infection of plants by means of ascospores released from apothecia and by mycelial infection through the soil, both germinating from sclerotia under differential conditions. Recent research indicates that there is great potential in utilising micro-organisms, plant extracts and resistance inducers (RIs) to control plant diseases.

Cultural control

Current control of *Sclerotinia* diseases relies heavily on cultural practices and fungicides. Cultural control aims to reduce the number of sclerotia in the soil or to create conditions that are unfavourable for disease initiation.

Examples of cultural control include crop rotation and lowering plant density. Limited fungicides are registered for control of *Sclerotinia* diseases in South Africa. Benomyl and Procymidone are used on peas and sunflower, whereas the latter is registered for soya bean. The cost of buying and applying fungicides, and the potential requirement for multiple applications are economic risks for producers.

Fungicide efficiency is highly dependent on the ability to predict the infection establishment in the crop and correctly timing applications. Failure to correctly time applications can result in substantial losses to the producer. Furthermore, the irresponsible use of fungicides poses risks to the environment and human health.

Due to the risks and complexity surrounding chemical control, researchers investigated alternative methods for managing this pathogen. The use of biological control agents (BCAs) that directly parasitise the pathogen, have shown great potential. Researchers have also been focusing on utilising RIs to activate the inherent defence mechanisms of the host plant to reduce disease severity.

Possible control options

Trichoderma species are hyperparasitic against *S. sclerotiorum*. They are responsible for directly parasitising mycelial growth, inhibiting carpogenic and ascospore germination, as well as reducing apothecia density under laboratory conditions.

Moreover, by-products produced by the fungi not only reduce disease incidence but also promote seedling emergence and increase soya bean grain yield under field conditions. However, different strains within species of the *Trichoderma* genus result in varying degrees of disease control.

Intense field and glasshouse studies have been conducted with the parasitic fungus *Coniothyrium minitans*, which is part of commercial formulations. Damage caused by *S. sclerotiorum* is reduced by infecting and degrading sclerotia in the soil.

C. minitans is most effective when applied to the soil prior to planting and key to its success is its ability to persist and spread within the soil. However, some *S. sclerotiorum* strains produce varying amounts of oxalate (a determining factor of the pathogens virulence) and respond differentially to *C. minitans*. This

Sclerotinia is a significant threat to crops such as sunflower and soya bean in South Africa. (Photo: MC Bester) mycoparasite remains one of the most promising control options for destroying field-borne sclerotia.

A two-year field study indicated that *Pseudomonas chlororaphis* and *Bacillus amyloliquefaciens* can be used to control *Sclerotinia* stem rot of canola. Results were comparable to Iprodione, an active ingredient of fungicides. In 2015 the sclerotia-inhabiting strain *B. cereus* SC-1 demonstrated potential in reducing the incidence of canola stem rot under controlled and field conditions.

Bacillus species that indicated antagonistic activity against *S. sclerotiorum* also showed properties promoting plant growth. However, *Bacillus* strains only had significant impacts on disease reduction and growth promotion when they were applied in combination. The majority of characterised bacterial mycoparasites target ascospores and the growing hyphae of *S. sclerotiorum*. Typically, broth cultures and/or cell suspensions of the bacterial BCAs are applied to the crop's above-ground organs.

Owing to the risks and complexity surrounding chemical control, researchers have investigated alternative methods for managing Sclerotinia. (Photo: LA Rothman)

A word of caution

Although the levels of control achieved in some of the above-mentioned experiments are comparable to that of synthetic fungicides, contradicting evidence does exist. The research published on BCAs that does not include field trials and/or show inconsistent results under field conditions must be considered. Thus, conclusions made about the efficacy of BCAs cannot always be accepted as the expected result under field conditions.

Environmental factors influence the interaction of BCAs with the host and the pathogen, thus further field research and product development is needed to advance the effectiveness of BCAs within sustainable cropping systems. However, this does not take away from the inherent abilities of BCAs to inhibit and even parasitise this pathogen.

The use of resistance inducers

As a result of the agricultural industry seeking sustainable crop production methods and relying less on chemical control, a recent interest in the use of RIs has been observed. A wide range of RIs exists and their primary effect is to trigger the host crop's internal defence mechanisms.

The mode of action of RIs are diverse but work on the same premise, activating the systemic acquired resistance (SAR) in plants. SAR leads to the initiation of different defence mechanisms ranging from reinforcing cell walls to increasing defence enzymes. The activation of SAR in plants leads to resistance against a broad range of pathogens.

A well-known chemical inducer of plant defence is salicylic acid (SA) and its derivatives. Salicylic acid is effective at very low concentrations and induces plant growth promotion and yield, and increases microbial activity in the rhizosphere, the micro-environment surrounding the root system.

Trichoderma species are responsible for directly parasitising mycelial growth, inhibiting carpogenic and ascospore germination, as well as reducing apothecia density under laboratory conditions. (Photo: Alejandro Alarcon)

SAR to *S. sclerotiorum* has been induced in mature kiwi fruit vines with SA applications and a pre-treatment of SA + SA-derivative reducing subsequent lesion size. This serves as a promising tactic to manage damage incurred by *Sclerotinia* diseases on high-value crops.

Chitosan as control measure

Chitosan is an abundant natural polymer with nontoxic, biodegradable and biocompatible properties. It has dual effects, controlling the ability of micro-organisms to sporulate, germinate and infect. It also induces defence responses in the host plant.

Chitosan is known to enrich rhizosphere biodiversity. A richer rhizosphere diversity can lead to a disease- suppressive environment where micro-organisms can outcompete *S. sclerotiorum*. Low concentrations of chitosan and SA have been shown to inhibit mycelial growth of *S. sclerotiorum* in the laboratory. Inducing resistance leads to proactive protection and can lead to positive crop growth, yielding healthier plants.

Successful disease management

A plethora of evidence suggests BCAs and RIs have the potential to control *Sclerotinia* diseases. As with all disease management strategies, they too have limitations, requiring favourable environmental conditions to establish and be effective. They must also be applied prior to infection and sometimes as close to the event as possible, thus monitoring the environmental conditions is key to the success of disease management.

Ultimately, the use of biological control requires an integrated approach, with a commitment to long-term establishment within a cropping system.

References available from Alec Edwards at EdwardsA@ufs.ac.za. For more information on *Sclerotinia* diseases, send an email to info@sclerotinia.co.za or visit *www.sclerotinia.co.za.*