

Role of seedling diseases in poor sunflower establishment

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Sunflower is grown in many parts of the world and is considered one of the most important oilseed crops. It is also a key crop in South Africa – in 2019, 678 000 tons were produced on 515 350 hectares. The most important production areas are in the Free State, Limpopo and North West.

Poor establishment is a major yield-limiting factor of sunflower production in South Africa. Although the contribution of other factors such as seedling vigour, seedbed preparation and soil temperature have been investigated, there was, prior to the current study, no information on the role of seedling diseases as a production constraint in sunflower production in South Africa.

Factors such as seedling vigour, plant depth, seedbed preparation and soil temperature have previously been identified as possibly contributing to poor establishment. However, seedling diseases have not been considered as playing a role in poor seedling establishment. This is most probably because information on seedling diseases of sunflower prior to the current study, was almost non-existent in South Africa.

Research conducted on soilborne diseases of maize and soya bean in South Africa, and on sunflower in other countries, showed that these field crops are susceptible to many soilborne pathogens that can cause damping-off and root rot, thus contributing to poor establishment. A study was therefore initiated to determine the role of seedling diseases in poor establishment of sunflower seedlings in South Africa.

Areas surveyed and sampling

Field trials were established with untreated and treated (fludioxonil, mefenoxam and thiamethoxam) cultivar PAN 7120 CL seed during 2014/15 and 2015/16 at six localities in the Free State, Limpopo, Mpumalanga and North West provinces. Sampling was conducted six weeks after planting and seedlings were also sampled from farm fields in these provinces. Both the seedlings and soil were collected from each sampling site for isolations and glasshouse bioassays.

Disease symptoms

Lesions were often observed on hypocotyls and cotyledons of seedlings, and cotyledons were sometimes completely rotten (*Figures 1A and B*). Dead seedlings or seedlings dying, and pre-emergence damping-off were quite rare. However, stunted seedlings were recorded at all localities, and often displayed root rot symptoms and the tap roots were usually stunted.

Pathogens

Isolations were made from diseased seedlings collected from all the areas sampled. At least 31 fungal genera, which included more than 94 fungal species, were obtained from diseased cotyledons, hypocotyls and roots. A large number of isolates representing each species from the different genera, was tested to determine their importance in causing disease on sunflower seedlings under glasshouse conditions. The effect of the standard seed treatment (fludioxonil, mefenoxam and thiamethoxam) against the pathogens that were identified, was also evaluated.

The most important pathogens were species within *Alternaria, Diaporthe, Fusarium, Macrophomina, Pythium* and *Rhizoctonia* which caused pre- and post-emergence damping-off, hypocotyl/stem rot, a reduction in growth and root rot.

Figures 1A and B: Lesions on hypocotyls and roots, and rotten cotyledons.



Alternaria

Alternaria species were isolated from seedlings from all localities. *Alternaria alternata (A. alternata)* and *A. tenuissima* were obtained from seedlings. The predominant species isolated was *A. alternata* and very few *A. tenuissima* isolates were obtained. *Alternaria* spp. was more frequently isolated from seedlings from untreated seed than treated seed, and was significantly more frequently isolated from the cotyledons and hypocotyls than the roots.

Glasshouse tests showed that *A. alternata* was the more aggressive of the two species with certain isolates causing significant root rot, although at low severities. However, neither of the two species significantly reduced the survival of seedlings or caused a reduction in growth when planted in soil infested with the pathogen (*Figure 2A*). Many of the isolates also caused lesions on stems (*Figure 2B*).

Research conducted in other countries showed that seedborne *A. alternata* can reduce seed germination and cause seedling mortality. However, seed infected with *A. alternata* and tested by us under glasshouse conditions, did not reduce seedling survival. *A. alternata* was also reported by other researchers to cause leaf blight in sunflower in South Africa.

Diaporthe

Diaporthe species were isolated from seedlings collected in all the provinces, but was more prominent on seedlings in North West compared to the other three provinces. They were also significantly more frequently obtained from hypocotyls than cotyledons or roots of seedlings. Seed treatment did not affect the incidence of these fungi in seedlings. Four species were obtained and one of these is currently being described as a new species.

Diaporthe gulyae was the most frequently isolated species and the most virulent when tested for pathogenicity on seedlings under glasshouse conditions. The fungus did not affect seedling survival or growth and did not cause root rot. However, it caused quite severe dieback of stems of seedlings under glasshouse conditions.

Diaporthe species are important stem canker pathogens of sunflower in other countries. The isolation of these fungi from sunflower seedlings may have important implications not only for seedling health, but also for stem canker on older plants.

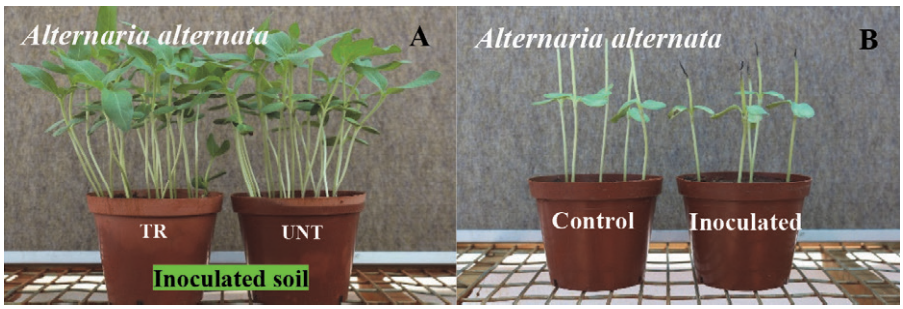
Fusarium

At least 38 *Fusarium* species or species complexes were isolated from sunflower seedlings. *Fusarium* species/species complexes were one of the predominant groups obtained from the seedlings and occurred on seedlings in all the provinces. The most frequently isolated species were species complexes of *Fusarium incarnatum-equiseti* (FIESC), *F. oxysporum* (FOSC) and *F. solani* (FSSC).

FIESC was isolated more frequently from cotyledons than hypocotyls and roots, whereas FOSC and FSSC were isolated much more frequently from the roots than cotyledons or hypocotyls of seedlings and incidences were higher on seedlings from untreated than treated seed.

Many of the species caused a slight reduction in survival and low root rot severities. However, a species within the

Figure 2: Effect of *A. alternata* on survival of seedlings planted in soil inoculated with the fungus and planted to treated (TR) and untreated (UNT) seed (A), as well as stem lesions caused by the fungus under glasshouse conditions (B).



F. solani species complex caused a significant reduction in survival and growth, as well as severe root rot that killed the seedlings. Seed treatment was not effective to manage this pathogen (*Figures 3A and B*).

Certain of the *Fusarium* species, such as *F. andiyazi* and *F. verticillioides*, also caused stunting of the taproots of seedlings (*Figure 3C*). Many *Fusarium* spp., including *F. equiseti, F. oxysporum, F. solani* and *F. verticillioides*, have been associated with diseases of sunflower seedlings in other countries, and the importance of *Fusarium* spp. as pathogens of sunflower seems to increase worldwide.

Figure 3: Effect of a species within *Fusarium solani* species complex on survival and growth of seedlings planted in soil inoculated with the fungus, and planted to untreated (UNT) and treated (T) seed (A), as well as root rot caused by the fungus under glasshouse conditions (B), and root rot and stunting of tap roots caused by *Fusarium andiyazi* (C).



Macrophomina

Macrophomina phaseolina was frequently isolated from seedlings, and significantly more frequently from roots than cotyledons and hypocotyls. There was no difference in the incidence of the fungus on seedlings from treated and untreated seed planted in field trials. The fungus was frequently obtained from localities in the Free State, Limpopo and North West provinces.

Glasshouse tests evaluating 50 isolates for their ability to cause disease on seedlings showed that the fungus, except for one isolate, did not cause a reduction in survival and caused more severe above-ground symptoms than root rot. The seed treatment significantly improved survival of seedlings in soil infested with the isolate, which caused a reduction in survival and root rot of seedlings (*Figures 4A and B*).

It is known that *M. phaseolina* can be both soil- and seedborne, is an important pathogen of sunflower, and can cause charcoal rot and root rot. If seedborne, the fungus can reduce germination and vigour of sunflower seed and cause damping-off and seedling blight. The seed used in our trials were tested and were not infested with the fungus.

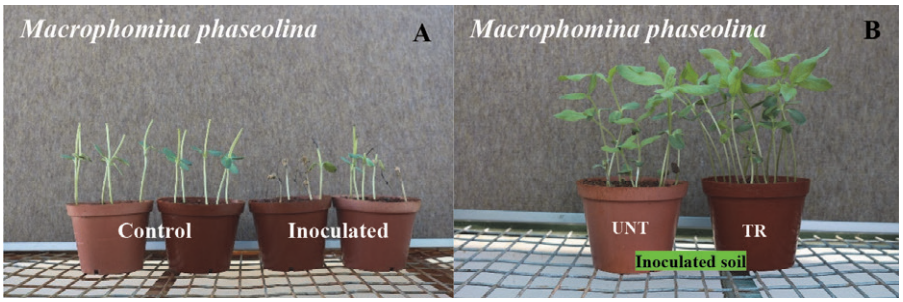
Pythium

Pythium species were obtained from seedlings from all provinces, and more frequently from seedling roots than cotyledons and hypocotyls. There was no significant difference in the incidences of *Pythium* spp. in seedlings from treated and untreated seed. Six *Pythium* species were obtained from the seedlings that were collected, the most virulent species being *P. irregulare* and *P. ultimum* var. *ultimum*.

P. irregulare significantly reduced survival and growth of seedlings, and caused cotyledon and root rot, while *P. ultimum* var. *ultimum* only caused root rot, but significantly less than *P. irregulare*. Although seed treatment significantly improved survival and growth, and reduced cotyledon and root rot of seedlings in soil inoculated with *P. irregulare*, seedlings from treated seed were still stunted.

Information on *Pythium* spp. as pathogens of sunflower seedlings in other countries is very limited. Our information thus far showed that it is possible that *Pythium* spp., especially *P. irregulare*, is one of the pathogens that may contribute to the stunted growth of sunflower seedlings, which is quite common in many sunflower fields.

Figure 4: Stem lesions caused by *Macrophomina phaseolina* under glasshouse conditions (A), and survival of seedlings in soil inoculated with the fungus and planted to untreated (UNT) and treated (TR) seed (B).



Rhizoctonia

Rhizoctonia anastomosis groups were obtained from all the localities sampled. There was no difference in the incidence of *Rhizoctonia* obtained from seedlings from treated and untreated seed and these fungi were isolated from cotyledons, hypocotyls and roots of seedlings.

Fourteen *Rhizoctonia* anastomosis groups were obtained from sunflower seedlings and four of these were pathogenic on sunflower seedlings, namely AG 2-2LP, AG 4 HGI, AG 4 HGIII and an unidentified anastomosis group temporarily labelled as SB3. These anastomosis groups caused a severe reduction in survival of seedlings, as well as hypocotyl and root rot, with AG 4 HGI and SB3 being the most virulent.

The seed treatment was quite effective in controlling AG 2-2LP, AG 4 HGIII and SB3. However, although the seed treatment improved survival and reduced hypocotyl and root rot of seedlings in soil inoculated with AG 4 HGI, it was still not satisfactory. This anastomosis group was obtained from seedlings collected from North West, whereas SB3 was obtained from seedlings from all provinces.

The information on *Rhizoctonia* anastomosis groups as pathogens of sunflower in other countries is very limited, but it appears that it may contribute significantly to poor establishment of sunflower seedlings in South Africa.

In conclusion

The results of the surveys and glasshouse studies showed that many fungal species, including important pathogens, are associated with sunflower seedlings and that certain fungi were more prevalent in some localities than others. This clearly shows that seedling diseases are caused by a complex of pathogens which can significantly reduce survival and growth of seedlings as well as cotyledon, hypocotyl and root rot, and can therefore contribute to poor establishment.

Pathogenicity studies identified the most important pathogens. Many of the pathogens identified have a broad host range and cannot be controlled with crop rotation. Since crop rotation is such an important part of conservation agriculture, crops that are susceptible to some of the same pathogens, such as maize, sunflower and soya bean, are often rotated in the same field.

Effective seed treatments can play a significant role as part of an integrated management strategy to protect sunflower against pathogens with a broad host range. The results obtained from seed treatment trials under glasshouse conditions showed that although the standard seed treatment, which targets a broad range of pathogens, is effective against many of the pathogens, it is unfortunately not effective against all the virulent pathogens identified.

Proper establishment of seedlings is very important to improve yield and is an essential component of sustainable production. Research is therefore currently being conducted to evaluate a range of seed treatments to identify the most effective treatment that will target most of the important pathogens responsible for poor establishment of sunflower seedlings in South Africa.

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