Tackling the problem of soil-borne diseases of maize using molecular technology

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Root and crown rots as well as seedling blight are some of the least understood diseases of maize. This is mostly due to such diseases resulting from a disease complex: many fungi are involved in the eventual rot observed, each of which differ in their ability to result in disease. Symptoms often go undetected as root and crown rots affect the part of the plant that is not visible above ground. In most cases, producers are likely to attribute a decline in yield observed from one season to the next to climatic conditions or poor performance by the cultivar planted, without realising that the problem lies below the soil.

Figure 1: Varying degrees of root rot observed on maize roots (photos: M Craven).

Root rot impacts negatively on plant stand and plant vigour, which eventually affects yield. Research conducted under South African conditions indicated that a 1,81 t ha^{-1} yield decline could be expected for every unit increase in disease severity, with a unit being 1 = > 0 - 25% rot, 2 = 25 - 50% rot, 3 = 50 - 75% rot and 4 = 75 - 100% rot. Financial losses associated with root and crown rots can be significant, and it would serve every producer well to take note of its possible impact on annual yield.

Factors affecting the disease complex

Root rot occurs on every plant in every field, every year, with only the degree and severity varying over seasons (*Figure 1*). The environment, growth stage of the host plant and preceding crops can impact on the fungi present in the soil and the eventual root rot severity observed. Isolate pathogenicity, virulence, and conservation agriculture practices, together with soil type and bioclimates, contribute to the dynamics and occurrence of soil-borne diseases. Variable cultivar susceptibility to various soil-borne diseases also contributes to the complexity of managing these diseases effectively.

Fungi also differ from one another with regard to the climatic conditions, host and soil cultivation practices survived to cause infection. Once the problem fungus is identified, management strategies can be implemented accordingly to lessen the impact that it has on root rot development. Root rot will never be fully absent from a maize field, but its severity can be managed.

Fungal complex

As a maize plant grows, the composition of the fungi in the soil changes due to some isolates being better competitors and/or colonisers of the maize roots. Seed rot, seedling blight and root rot can occur at the seed and seedling stage. Pythium species (mostly affecting seed and seedlings, *Figure 2A*) grow best in soils that are close to saturation point as the zoospores (a type of fungal spore) are able to move best in wet soils. Good drainage will assist in managing root and crown rots as a result of infection by this pathogen. Factors that enhance the occurrence of Pythium are soil kept wet for prolonged periods, temperatures that are unfavourable (too low) for the host plant, excess nitrogen in soil and monocropping.

Another fungus that might occur at the seed and seedling stage causing seed rot, seedling blight and root rot is *Exserohilum pedicellatum* (*Figure 2B*).

Fusarium solani and *F. roseum*, on the other hand, are regarded to grow very well in dry soils and are able to cause more severe disease in drier soils as the plants are more stressed by the lack of water. Flooding of such fields might consequently result in a reduction in the number of certain pathogens such as Fusarium in the soil by inducing starvation, lack of oxygen or desiccation.

As the plant matures, other fungi such as *Rhizoctonia solani* (*Figure 2C*), *F. oxysporum*, *F. graminearum* (*Figure 2D*), *F. verticillioides*, *F. chlamydosporum*, and *F. equiseti* (*Figure 2F*) tend to become the fungal pathogens that cause root and crown rots. Information regarding what type of pathogen dominates at a specific growth stage in the maize plant is necessary to know exactly how to manage the disease.

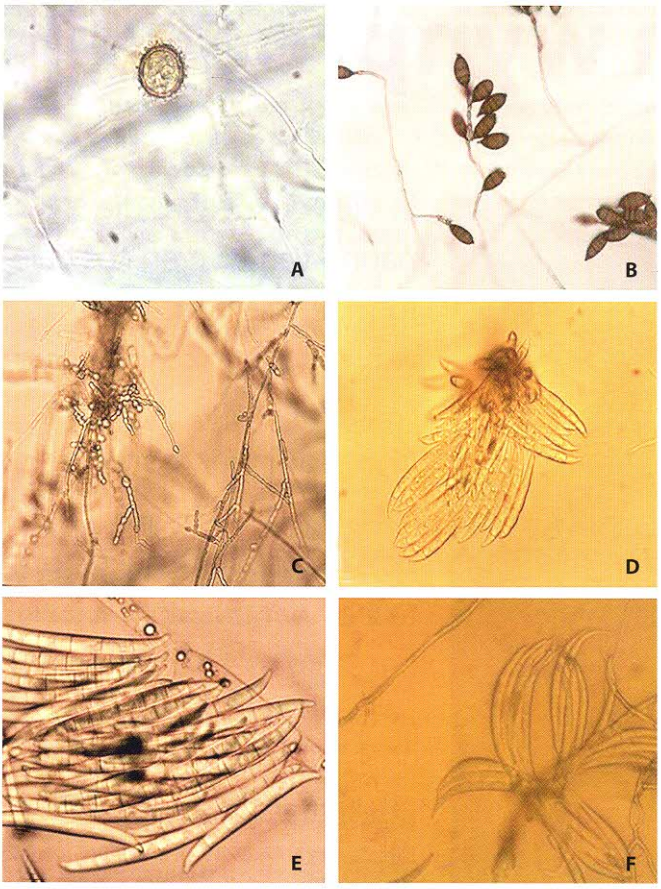

Figure 2: The fungal pathogens that are involved in the maize stem, root and crown rot disease complex are: A) Pythium species, B) Exserohilum pedicellatum, *C)* Rhizoctonia solani, *D)* Fusarium graminearum, *E)* F. semitectum *and F)* F. equiseti. *These morphological characteristics were observed when each isolate was grown on agar in a petri dish and examined using a light microscope (photos: M Craven).*

Future prospects

The ARC-GCI is in the final stages of the development of a rapid and accurate detection method of the different fungi associated with root and crown rots using molecular technology called quantitative PCR. It uses extracted DNA of the maize roots and crowns to detect the presence of a specific fungal pathogen. With this technique one will also be able to quantify the amount of specific fungi present within the sampled material, and it can be used on different host plants. The tools will hopefully aid in improving research capacity to better understand these diseases.

The technology will allow for the detection of 12 different soil-borne fungi with known association with root rot. Producers should take note of the age of the plant material brought in for analysis. Most often the maize has already been harvested and due to an unexplained yield loss experienced, some producers will bring in the roots. At this stage the plant material has already degraded due to natural breakdown of organic material, and what is left is normally colonised by saprophytes feeding on dead tissue. In such cases it is very difficult to pinpoint exactly which fungi caused the initial infection. Scout fields regularly and once root rot problems are suspected, submit samples for analysis whilst the roots are still viable.

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