Conservation agriculture – Achilles' heel of charcoal rot

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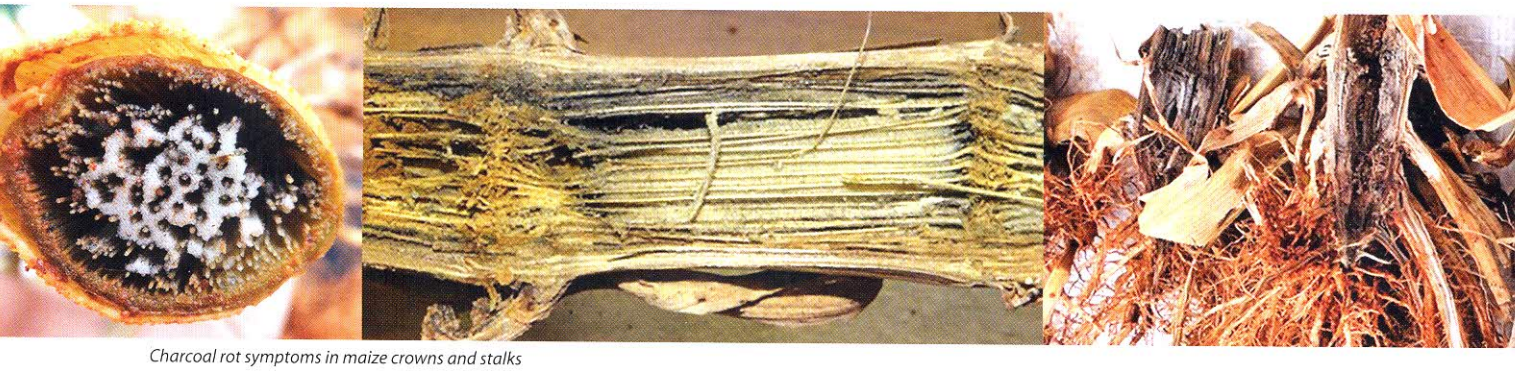

Charcoal rot symptoms in maize crowns and stalks

Conservation agriculture generally consists of a combination of practices that include minimal soil disturbance (no-till), permanent soil cover (mulch) and crop rotation. Aside from the potential financial gains associated with conservation agriculture, practices that preserve soil moisture and topsoil are vitally important to preserving soil as a resource for future generations.

Disease development is an ever-present risk in conservation agriculture. A range of pathogens that survive on plant residues causes soil-borne diseases. Reduced-tillage practices create the risk of increased disease incidence and resultant yield loss, especially where maize monoculture is practised.

Research findings of a trial conducted on sandy loam soil in the Ventersdorp area in North West indicated that all is not doom and gloom when it comes to conservation agriculture and disease. The trial basically consisted of different treatments within the following systems:

- Maize monoculture under both conventional and conservation agricultural practices
- Cowpea and sunflower conservation agriculture in two- and three-year rotation systems with maize (maize/cowpea and maize/sunflower). For each of the cowpea and sunflower systems, pearl millet was included as a third crop.

The trial commenced during 2008. Three seasons were monitored – 2011/12, 2012/13 and 2013/14 – with regard to root and crown rot development, which is expressed as a disease index value. Soil-borne pathogens that occurred in the roots and crowns were identified and quantified to establish the frequencies at which they occurred within the various treatments.

The three seasons differed vastly regarding the climate conditions experienced. The 2012/13-season had the lowest levels of rainfall and the highest maximum temperatures from approximately 70 days after planting, resulting in a late season drought. Although the preceding season did not receive optimum rainfall, the precipitation frequency was more evenly spread, whilst moderate temperatures dominated. The 2013/14-season experienced favourable conditions (moderate maximum temperatures and sufficient and timely rainfall). Of all the seasons monitored, 2012/13 yielded the most significant results with yield reductions varying between 52 to 62% in the maize monoculture treatment when compared to the conservation agriculture treatments that all had the benefit of soil cover. Increased crown rot was observed at 100 days after planting in the conventional tillage treatment, which was significantly higher compared to all of the conservation agriculture treatments (*Figures 1* and *2*).

The increased level of crown rot experienced within the conventional tillage soil is best explained by the *photosynthetic stress-translocation balance* concept. According to this concept, plants become more subject to root and stalk rot after flowering due to carbohydrate deficiencies that occur in the plant under stress conditions such as limited soil moisture, severe leaf diseases or hail damage. The stress brought about by the late drought experienced during 2012/13 predisposed the plants to infection in the monoculture maize conventional tilled plots that lacked the buffer effect of the cover layer.

Correlation analysis indicated that *Macrophomina phaseolina*, the causal organism of charcoal rot (*see photos*), was one of the major plant pathogens isolated from the infected crowns and occurred at the highest frequency in the maize monoculture conventional tillage treatments. This finding corresponds to international research findings that reported significantly higher incidence of stalk rot caused by *M. phaseolina* in con-ventionally tilled treatments compared to those in no-till treatments. *Macrophomina phaseolina* infection mostly occurs on maize plants after flowering and is always associated with drought stress conditions. International research findings verified the positive linear relationship between water stress incidence and frequencies of *M. phaseolina* isolated from maize roots. The better water infiltration and retention associated with the cover layer obtained within conservation agricultural practices could have an effect on the capability of this fungus to infect.

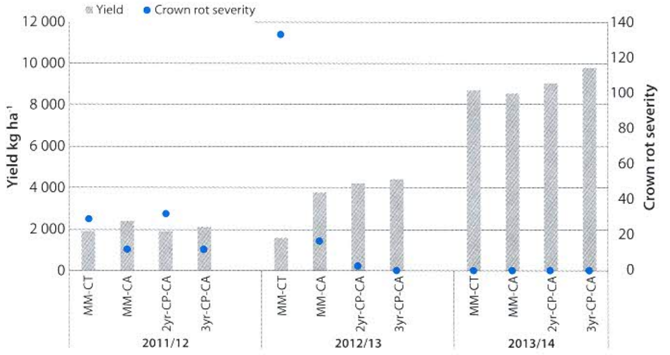

Figure 1: Yield versus crown rot severity observed over three seasons under various cultivation practices and crop rotation with cowpea. MM-CT – maize monoculture under conventional tillage, MM-CA – maize monoculture under conservation agriculture (CA), 2yr-CP-CA – two-year rotation system with maize-cowpea under CA, and 3yr-CP-CA – three-year rotation system with maize-cowpea-pearl millet under CA

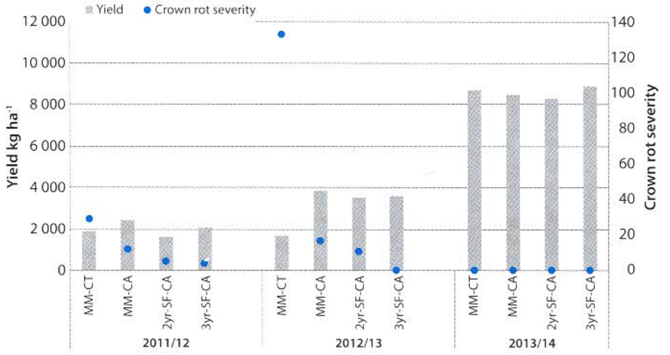

Figure 2: Yield versus crown rot severity observed over three seasons under various cultivation practices and crop rotation with sunflower. MM-CT – maize monoculture under conventional tillage, MM-CA – maize monoculture under conservation agriculture (CA), 2yr-SF-CA – two-year rotation system with maize-sunflower under CA, and 3yr-SF-CA – three-year rotation system with maize-sunflower-pearl millet under CA

Research conducted in 2009 demonstrated that South Africa has become approximately 2% hotter and at least 6% drier over a ten-year period (spanning 1997 - 2006) compared to the 1970s. The same research indicated that for the country as a whole, each 1% drop in rainfall would most likely lead to a 1,1% drop in the production of maize and 0,5% decline in winter wheat. Numerous other studies indicated the same likelihood with the consensus that South Africa is to become hotter and drier rather than cooler and wetter. High temperatures and low precipitation as a result of this phenomenon in the Highveld poses a threat to food security, not only as a result of less than optimum growth conditions created, but also as a result of increased risk of infection by *M. phaseolina*.

Crop rotation is commonly used to manage various diseases, but due to the wide host range of *M. phaseolina*, which include all common cultivated crops such as sunflower, soya bean and sorghum, crop rotation will contribute little to manage the inoculum levels of the pathogen. Conservation agriculture provides a plausible management strategy for charcoal rot on the South African Highveld.