Evaluating soya bean cultivar tolerance to Sclerotinia stem rot under field conditions

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Sclerotinia sclerotiorum is a devastating, yield-limiting fungal plant pathogen with an extensive host range of more than 500 plant species, including soya beans. The severity of *Sclerotinia* diseases is highly dependent on environmental factors and host crop susceptibility. Several studies have reported strong genotype x environment interactions, emphasising the importance of screening for tolerance to *Sclerotinia* under various field conditions.

Managing *Sclerotinia* diseases through host tolerance or potential resistance may contribute to yield stability or increases. Currently, South African soya bean cultivars do not have complete resistance to *Sclerotinia* stem rot, but some do show tolerance to this disease.

It is internationally recognised that complete resistance does not exist in soya beans, although there are promising genotypes which indicate partial resistance (Kim & Diers, 2000; McCaghey *et al*., 2019). A tolerance to plant diseases is a response of the plant to infection and having the ability to endure disease without serious yield loss or death (Agrios, 2015). However, resistance is the plant's ability to completely or partially overcome the damaging effects caused by a pathogen (Politowski & Browning, 1978).

Cultivar field trials

Soya bean cultivars from the National Cultivar Trials were evaluated in field trials in Delmas, Mpumalanga, during 2018/19 and 2019/20. Plantings were conducted sequentially from November to December, creating a range of weather conditions during each season of evaluation. Soya beans were inoculated with *S. sclerotiorum* in the form of milled grain mycelium at flowering and were given a second inoculation after two weeks to ensure successful disease development.

To produce milled grain mycelium inoculum, sorghum grain is inoculated with a single isolate of *S. sclerotiorum*, incubated for a few weeks until the grain is fully colonised with the mycelium of *S. sclerotiorum*, air dried and milled into a powder. This inoculation technique does not require injuring plants before application, therefore ensuring no induced resistance mechanisms are triggered through wounding (Bester, 2018). The presence or absence of *Sclerotinia* on the stems was measured at R3 and the disease prevalence was calculated. Data analyses were conducted using R and R-studio.

The bar graphs illustrate the mean *Sclerotinia* prevalence (%) observed in the different soya bean cultivars at each planting date from the 2018/19 season (*Figure 1*) and one planting date from the 2019/20 season

Figure 1: Average Sclerotinia stem rot prevalence (%) in soya bean cultivars on three different planting dates in the 2018/19 season.

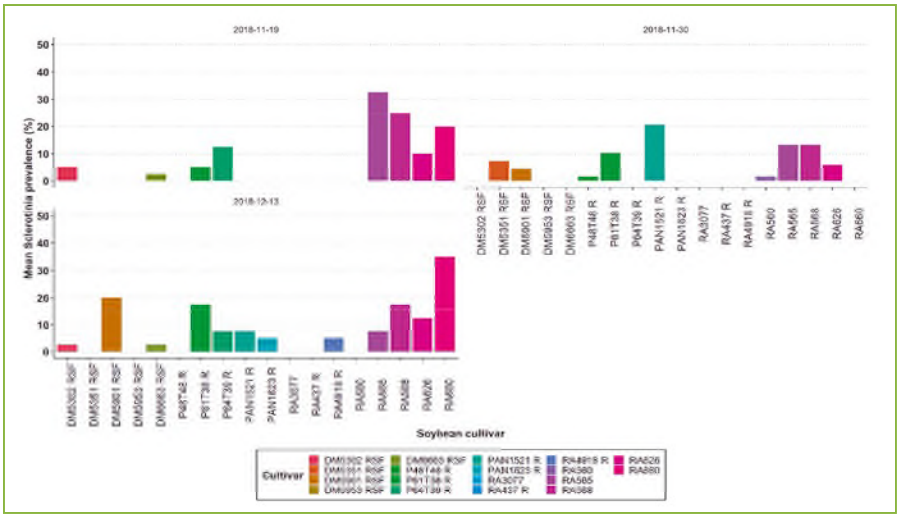
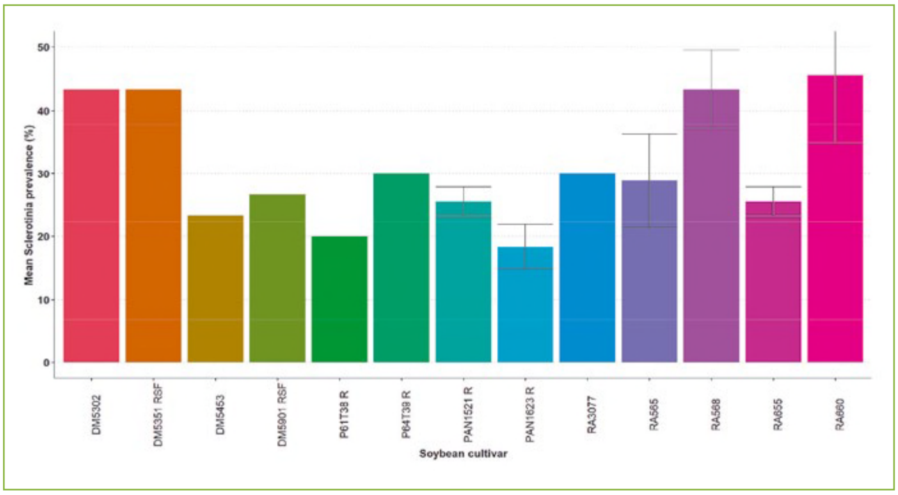


Figure 2: Average Sclerotinia stem rot prevalence (%) in soya bean cultivars on one planting date in the 2019/20 season.



(*Figure 2*). During the 2018/19 season, the least *Sclerotinia* stem rot, ~4%, was observed in the second planting date, 30 November 2018, while those of the first planting date (19 November 2018) and third planting date (13 December 2018) were ~6 and ~8%, respectively.

Impact of environmental conditions

During the 2018/19 season the majority of the soya bean cultivars varied in their response to *S. sclerotiorum* across the different planting dates. This indicates the significant impact of weather conditions during each planting date and the seasonal variation on disease development. During the three planting dates in the 2018/19 season, only three cultivars presented no *Sclerotinia* stem rot symptoms, namely DM5953 RSF, RA 3077 and RA 437 R.

In the 2019/20 season the *Sclerotinia* prevalence in RA 3077 was ~30%. The average *Sclerotinia* prevalence in the soya beans planted on 26 November 2019 was ~32%. A higher prevalence in the 2019/20 season may indicate a more conducive environment for disease development. Cultivars will respond differently to *S. sclerotiorum* under different environmental conditions.

These results – together with results from the 2020/21 season – will be incorporated into a study by the University of the Free State, where the response type of each cultivar at changing disease potentials will be determined. Disease potential is defined as the mean disease incidence in a planting across all cultivars.

Three cultivar response types can be observed: Cultivar tolerant to increasing disease potential; cultivar intolerant to increasing disease potential; and cultivar having a linear relationship with increasing disease potential. This regression methodology can be an effective and accurate tool to quantify the response of cultivars to different disease potentials and subsequently promote the selection process of cultivars for environments which may have a higher risk for *Sclerotinia* disease development.

Importance of adapted cultivars

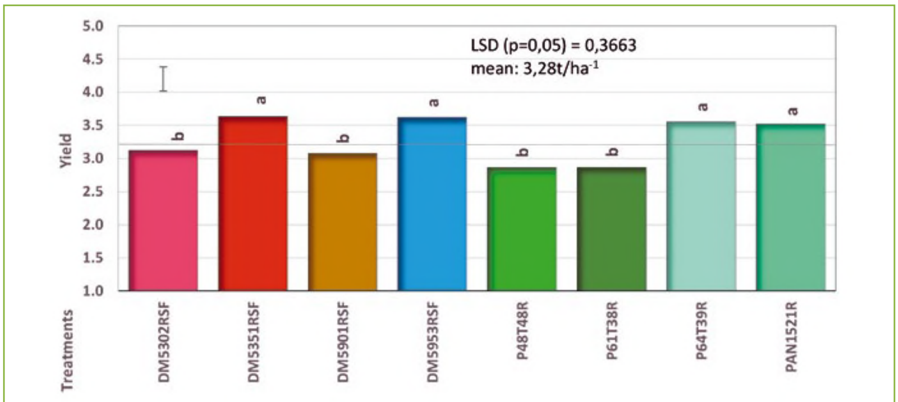
Sclerotinia is a yield-limiting disease, meaning higher disease severity is usually associated with lower soya bean yield (Grau & Radke, 1984). The ability of a soya bean cultivar to tolerate *Sclerotinia* and the cultivar's yield potential at different localities are important aspects to consider when choosing a cultivar.

The purpose of the National Cultivar Trials for soya beans is to support local soya bean producers in the identification of adapted cultivars for the different climate regions. The trials facilitate cultivar comparisons for agronomic/economic performance that should be well adapted for the particular soil and climate conditions.

Combined Analysis of Variance (ANOVA) was done for the yield over localities and cultivars for the cool, dry areas. *Figure 3* shows the yield for the main effect cultivar for eight of the overlapping cultivars inoculated with *S. sclerotiorum* for the variable yield, where it also was tested for *Sclerotinia* stem rot prevalence (%).

The standardised residuals were acceptable and normally distributed (Shapiro-Wilk test) and therefore the means of the significant effects were separated using the unprotected Fisher's Least Significant Difference (LSD) test at the 5% confidence level (Snedecor & Cochran, 1980). All data analyses were performed using SAS 9.4 statistical software (SAS, 2014).

Figure 3: Average yield and t-groupings for soya bean cultivars during the 2018/19 and 2019/20 seasons in the cold, dry areas over the different localities.



Field trial results

The cultivars DM5351 RSF, DM5953 RSF, P64T39 R and PAN1521 R performed significantly better than DM5302 RSF, DM5901 RSF, P64T64 R and P61T38 R over the 2018/19 and 2019/20 production seasons.

Relatively large differences in annual yields existed among cultivars. The difference between the highest- and lowest-yielding cultivars varied from 2,58 tons/ha^{-1} (P61T31 R) to 3,5 tons/ha^{-1} (P64T39 R) during the 2018/19 season, and 2,88 tons/ha^{-1} (P48T48 R) and 4,1 tons/ha^{-1} (DM5953 RSF) for the 2019/20 season.

Consequently, the 2018/19 production season's results indicated that the mean yield of the best-performing cultivar was 0,92 tons/ha^{-1} higher than the yield of the poorest-performing cultivar, while the difference is 1,22 tons/ha^{-1} for the 2019/20 season. This relates to R5 520/ha^{-1} and R7 320/ha^{-1}, respectively, at a product price of R6 000 t^{-1}.

The selection of a high-performance cultivar suitable for a specific climate region has a significant financial impact for the producer. When selecting a high-yielding soya bean cultivar for the coming seasons, producers must keep in mind that these cultivars are still at risk of being infected with *S. sclerotiorum*. Being equipped with the yield and *Sclerotinia* disease potential for cultivars will enable producers to select those that may perform best under their production conditions.

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