Current research on canola diseases

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The South African canola industry has grown steadily over the last 25 years. After a record average yield of over 2t/ha was achieved in 2020, the year 2023 marked the period of both the highest area planted to canola (131 200ha) and the highest total canola production (237 500t).

With this growth comes the need to address some of the challenges that canola production faces. Blackleg and *Sclerotinia* stem rot are the most damaging canola diseases globally and in the Western Cape, and local producers have become increasingly aware of their impact over the past few years.

Hurdles to disease control

Blackleg is caused by the fungi *Leptosphaeria maculans* and *Leptosphaeria biglobosa* and occurs only in the *Cruciferae* family (*Brassica* species). Blackleg is managed by integrating host resistance with chemical control. Agronomical practices such as ploughing or burning stubble, which decreases the inoculum load, effectively reduce disease levels but cannot be integrated with conservation agriculture.

Planting canola at least 500m away from the previous year's stubble, which enables the crop to evade the disease, is also effective, but limited space on farms often makes this impractical. The use of host resistance is the most durable, cost-effective and environmentally friendly approach to managing blackleg, but must be managed carefully due to the large number of genetically distinct races of the pathogen occurring globally. While chemical control can effectively reduce blackleg, it must also be carefully managed to avoid the build-up of resistance to fungicides.

To address these problems facing canola producers, the Western Cape Department of Agriculture and the Department of Plant Pathology at Stellenbosch University are conducting numerous research projects aimed at mitigating the detrimental effects of blackleg and *Sclerotinia* stem rot.

The cultivar trial at Uitkyk farm in the Hessequa-region near Riversdale was established to assess the resistance of canola cultivars to blackleg under field conditions.

In this article, the work being addressed in the respective research projects is briefly discussed.

Leading causes of blackleg

The first task at hand is determining the race structure and genetic diversity of *Leptosphaeria* species causing blackleg disease of canola in the Western Cape. Resistance to the pathogens causing blackleg in canola is provided by both major genes (qualitative resistance) and minor genes (quantitative resistance) in the canola plants, of which the former is better understood and more widely used to control blackleg.

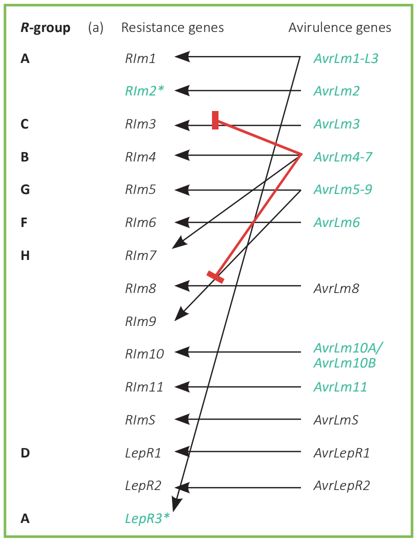
Major gene resistance occurs as a gene-for-gene interaction between canola and *L. maculans*. This means that a resistance response depends on the presence of a resistance gene (*R*-gene) in the canola plant and a corresponding avirulence (*avr*) gene in the pathogen. Conversely, the lack of an *R*-gene in the plant or an *avr* gene in the pathogen results in a susceptible reaction and subsequent disease development in the canola plant. To date, at least 15 *R*-genes have been identified in *Brassica* species conferring resistance to *L. maculans*, while 12 corresponding *avr* genes have been identified in *L. maculans* (*Figure 1*).

The total number of possible *R-avr* combinations could theoretically generate thousands of different races of the fungus. In Manitoba, Canada, for example, 170 races of the pathogen have been identified.

This is one of the primary reasons why blackleg is so difficult to manage. No single canola cultivar is resistant to all possible races of the pathogen. The occurrence and frequency of races of the pathogen within a country or region is also not static, but changes in response to the major resistance genes present in canola cultivars.

When cultivars with the same complement of major resistance genes

Figure 1: Interaction between *Leptosphaeria maculans* avirulence genes and *Brassica* resistance genes. (Source: Van de Wouw and Howlett, 2020)



are cultivated each year in the same region, it results in the rapid increase of races not suppressed by these resistance genes, up to the point where resistance is effectively overcome. This can happen within three years, as witnessed in Australia and France. The pathogens are heterothallic, meaning that the different mating types (similar to male and female) are carried on separate individuals.

Sexual reproduction occurs easily and in large numbers in canola stubble, and results in offspring carrying genetic material from both parents. This ability, coupled with the seed-borne nature of the pathogens, allows for the introduction of new races into production regions.

While the *R*-genes present in canola cultivars planted locally are known, no information on the *avr* gene profile of the pathogen occurring in the Western Cape has been available before this study, which aims to determine the prevalence, genetic diversity and distribution of races of *Leptosphaeria* species associated with canola across the Western Cape.

To achieve this, an isolate collection of more than 4 000 isolates was obtained from various locations throughout the Western Cape over three seasons. All isolates were identified, which showed that *L. maculans* is the dominant pathogen responsible for blackleg of canola in the Western Cape. Whole genome sequence data was then generated for a subset of these isolates, which reveals the *avr* allele profile of the isolates, thereby elucidating the race structure of the pathogen in the Western Cape.

This project is in its final year and will provide baseline information needed to utilise major gene resistance in canola cultivars locally. This project also provided us with the opportunity to collaborate in an international study on the genetic diversity of *L. maculans* globally, which was published this year in an international journal and provides us with an invaluable research tool for future research.

Cultivar resistance to blackleg

The canola cultivars planted in South Africa are primarily of Australian origin. Upon arrival in South Africa, producers are provided with a resistance rating against blackleg based on how they performed in blackleg resistance trails in Australia. It is important to note that this rating is based on how the cultivars performed against blackleg in Australia, not the Western Cape.

The resistance response of a cultivar is dependent on the races of the pathogen present at a location, as well as environmental conditions, and although South Africa has a similar climate to Australia, a cultivar which achieved a high resistance rating in Australia will not necessarily perform the same under South African conditions, due to possible differences in the race structure of the pathogen.

To assess the resistance of the commonly available canola cultivars under local conditions, cultivar trails have been conducted at Langgewens research farm (Malmesbury region), Waterboerskraal farm (Hopefield region) in the Swartland, Tygerhoek research farm (Riviersonderend, Overberg) and Uitkyk farm (Riversdale, Hessequa region) from 2021 onwards. The same cultivars evaluated in the annual canola cultivar evaluation programme are included in our trials each year. The cultivars to be assessed this year, along with the *R*-genes present in each cultivar, are included in *Table 1*.

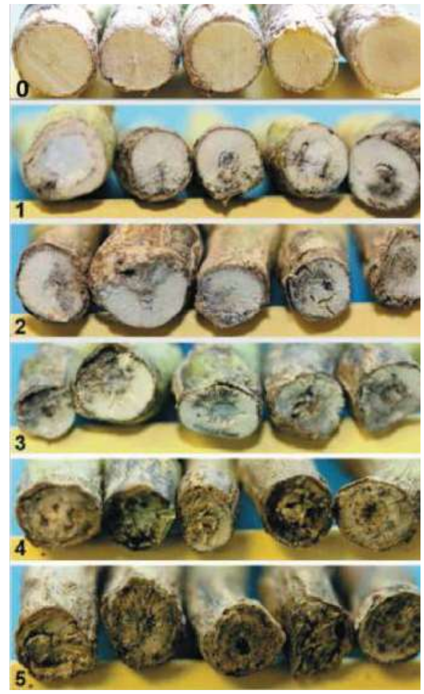
From 2021 to 2023, blackleg severity for each cultivar was rated close to harvest by determining the disease severity index (DSI) on a cross-section of the lower stem, since crown cankers were traditionally the most damaging aspect of the disease. This allowed us to determine the blackleg resistance rating of all the cultivars included each year at all locations.

In recent years, however, a shift has been detected in blackleg disease symptoms,

Table 1: Canola cultivars to be evaluated for resistance to blackleg in 2024 at four locations.

Name	Type of cultivar	*R*-group
Defender CT	Clearfield, Triazine tolerant	ADF
PY327C CL	Clearfield	Unknown
PY421C CL	Clearfield	A
PY520 TC	Clearfield, Triazine tolerant	BC
45Y95	Clearfield	C
Diamond	Conventional	ABF
Alpha TT	Triazine tolerant	BF
Blazer TT	Triazine tolerant	ADF
44Y94	Clearfield	BC
Quartz	Conventional	ABD
Hyola Solstice CL	Clearfield	ADFH
Hyola Equinox CL	Clearfield	ADF
CC90014	Conventional	ADFH
Hyola Continuum CL	Clearfield	ADF
HyTTec Trophy	Conventional	ADF
HyTTec Trifecta	Conventional	ABD
PY429TT	Triazine tolerant	Unknown
Ceres CL	Clearfield	AD

(A) Canola stem with limited stem canker visible on the outside. (B) The same canola stem exhibiting extensive disease on the interior.



The disease severity scale used to determine crown canker disease severity index. (Source: Peng et al., 2021)

which prompted us to launch a new project from this year onwards, which is discussed in the following section.

Disease management

Previously, crown cankers were the most devastating phase of the disease, which was also true for the Western Cape. Determining resistance against blackleg therefore relied on determining the DSI of the crown region.

Over the past decade, a shift in disease symptoms has occurred in Australia and is collectively known as upper-canopy infection. This includes infection and development of symptoms in main stems, side branches, flowers and seedpods (all above-ground parts 5cm above the soil surface), which are becoming increasingly common, while crown cankers are becoming less severe.

Similarly, in recent years in the Western Cape, the incidence of plants with stem cankers in the main stem (above the soil surface and up to the first branching of the plants) has increased drastically. At Tygerhoek research farm during 2023, for example, stem cankers in the main stem were detected in almost 75% of canola plants. An interesting aspect of these stem cankers on the main stem is that the stems appear relatively healthy on the outside, with only small canker lesions visible on the exterior, while the damage is much more severe internally.

The worrisome aspect of this shift is that while blackleg stem cankers have been known for a long time in the Western Cape, they were previously fairly scarce. Anecdotal evidence suggests that infection of side branches, flowers and seedpods is also increasing. Determining resistance of canola cultivars against blackleg based only on the DSI of the crown region is therefore no longer accurate, since it does not take into account the incidence or severity of upper canopy infection. Development of a new resistance rating method is therefore needed to provide producers with accurate results.

Furthermore, we do not have any information, to date, on potential differences in disease onset and progression of upper canopy infection in different cultivars, which must also be addressed since it can influence the timing of fungicide application, among others.

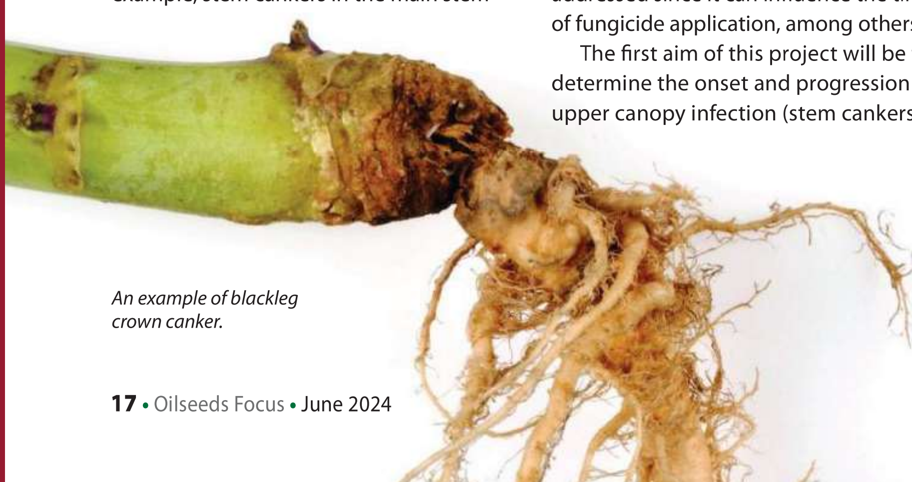
The first aim of this project will be to determine the onset and progression of upper canopy infection (stem cankers, infection of side branches, seedpods and flowers) in selected cultivars at different locations, using a rating system to be developed during the first year of this project.

The second aim will be to determine the resistance of local canola cultivars against blackleg in different production regions. To achieve the second aim, a two-phased approach is needed, namely:

- Determine the resistance of canola cultivars to upper canopy infection using the methodology developed for the first objective.
- Determine the DSI of crown cankers in different canola using existing methodology. This research will commence this year.

Management via fungicides

As mentioned earlier, blackleg is managed by integrating host resistance with chemical control. While chemical control of blackleg in the Western Cape was previously limited to seed treatments, given the cost of foliar fungicides and lower yields obtained in the early days of canola production, the use of foliar fungicides has increased drastically in the past years. Indeed, the use of DMI


An example of blackleg crown canker.

(A) Canola plant with a diseased side branch and (B) diseased canola seedpods. (Photograph B: Piet Lombard)

fungicides (triazoles, which include tebuconazole and prothioconazole, among others) has contributed to the 50-fold increase in canola production in Australia over the last 30 years.

The high genetic variability of the pathogens, however, allows for the build-up of tolerance toward fungicides over time, and represents a real threat to continuing canola production. This has been reported in Australia, Europe and Canada. Resistance against DMI fungicides now occurs in all canola-growing regions of Australia, with 15% of fungal populations there currently displaying a high level of resistance against DMI fungicides.

To determine the efficacy of foliar fungicides to manage blackleg, five fungicides registered against blackleg of canola as well as an unregistered fungicide were evaluated in field trials on two cultivars during 2022 and 2023. The trials were situated at the same locations as the trials to determine cultivar resistance.

Results from these trials have shown that foliar applications of all fungicides registered for blackleg management at the three- to five-leaf stage, decrease the crown canker DSI. The results also showed that the benefit derived from a fungicide application depends on the blackleg resistance of the cultivar and the disease pressure in the area.

The largest reductions in DSI were seen in susceptible cultivars in areas where disease pressure was high, while only marginal reductions in DSI were observed in resistant cultivars where disease pressure was low. A subset of isolates from each location are also currently being screened to determine the EC$_{50}$ value against different fungicides and to determine whether any differences in fungicide sensitivity exist in the pathogen population.

(A) Healthy canola stems and (B) canola stems with extensive disease on the interior.

In conclusion

The work we have done on blackleg over the past three years is the first major study on blackleg of canola in South Africa. The work presented in this article is only part of the research we are currently conducting.

In future articles we will discuss the work we are currently doing regarding:

- The effect of planting retained seed on blackleg, fungicide deposition and disease management achieved at the five-leaf and 30% flowering stage using different spray volumes, forward tractor speed, as well as aeroplane and UAV (drone) applications.
- The occurrence and distribution of different races of *L. maculans* on *Brassica* cover crops and weeds and the possible threat they pose to canola.
- The epidemiology and control of *Sclerotinia* stem rot of canola, which we are undertaking in collaboration with Lizette Nowers from the Western Cape Department of Agriculture.

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