Current research on canola diseases: Impact of retained seed and fungicide deposition

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The June issue of *Oilseeds Focus* featured our first article on canola diseases, emphasising the fact that steady growth in canola production has brought with it the need to address some of the challenges producers face. Among these, the most economically damaging are diseases such as blackleg and *Sclerotinia* stem rot, the impact of which local producers are increasingly aware of.

Blackleg is caused by two closely related fungal species, *Leptosphaeria maculans* and *Leptosphaeria biglobosa*, which affect *Brassica* species. Managing blackleg involves integrating host resistance with chemical control. Agronomical practices such as ploughing or burning of stubble, which reduce the inoculum load, are effective in lowering 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 is often impractical to implement.

Using host resistance is the most durable, cost-effective and environmentally friendly approach to managing blackleg, but it should be carefully managed due to the potential of the fungus to overcome this resistance through sexual reproduction. Similarly, chemical control should be carefully managed to avoid the build-up of resistance to fungicides.

Sclerotinia sclerotiorum, the causal agent of *Sclerotinia* stem-end rot (SSR) in canola, can affect more than 400 host plants. Specific environmental conditions and senescent tissue are required for disease development, but once successful infection occurs, the disease can be extremely devastating. The sporadic nature of the causal pathogen and its tough survival structures that remain in soil and plant debris for years, challenge the management of the disease. Chemical control remains the most effective disease management strategy; however, producers often over- or under-apply fungicides, which has cost implications and detrimental effects to the environment.

To manage these diseases, the Western Cape Department of Agriculture (WCDA) 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. This article discusses the effects of planting

The canola retained seed trial at Langgewens research farm during 2023, showing the difference between treatments. (Photograph: Gert van Coller) retained seed on disease development, and the quality and quantity of fungicide deposition on canola canopies.

Planting retained canola seed

Australian canola cultivars are primarily planted in South Africa. This seed is propagated and imported from Australia, South America, and Canada as no local propagation occurs. Canola, a self-pollinating crop, produces commercial seed through careful cross-pollination between two parent plants. This seed is known as F1 seed (first generation). The producer is thus guaranteed that the new seed purchased commercially is genetically pure and uniform.

When F1 seed is planted, the crops will develop and pods containing seeds will eventually develop, following self-pollination. After ripening the crop is harvested. This harvested seed is called F2 seed (second generation). Due to recent seed availability challenges and other factors, producers are more frequently planting F2 seed in subsequent seasons, a practice known as planting retained seed.

However, significant differences occur between F1 and F2 seed of the same cultivar. While F1 seed is genetically pure and uniform, the same cannot be said of F2 seed. Since F1 seed is a hybrid seed (derived from cross-pollination between two parent lines), F2 seed, which developed following self-pollination, can revert to the genetic background of either of its original parental lines used in cross-pollination. This has important implications, not only for agronomical characteristics such as a reduction in vigour, yields and oil content, among others, but also for resistance against blackleg disease.

Resistant genes in F2 seed

Genetic resistance to blackleg is governed by major genes conferring well-understood qualitative resistance (Van de Wouw and Howlett, 2020), and by quantitative resistance, which is poorly understood but involves numerous minor genes, contributing to overall resistance (Delourme *et al*. 2006; Stuthmann *et al.* 2007). The major genes present in canola cultivars against blackleg are indicated by the letters A, B, C, D, F and H, different cultivars containing various combinations of one to four of these genes (*Table 1*). In harvested F2 seed, the combination of major genes is no longer uniform, unlike F1 seed.

During seed production, gene segregation causes the major resistance genes to segregate into separate seeds, meaning F2 seed will not retain the original set of resistance genes. For example, each F1 seed of the cultivar 44Y94 contains both major genes B and C; in the F2 retained seed, 50% will have only the B gene, while the other 50% will only have the C gene. The occurrence of *R*-genes (resistance genes) in F2 seed of cultivars such as Hyola Solstice, which has four *R*-genes, is much more unpredictable. In this case, some seeds will contain only one *R*-gene, others will contain two or maybe three, but none will contain the full complement of resistance genes present in the F1 seed.

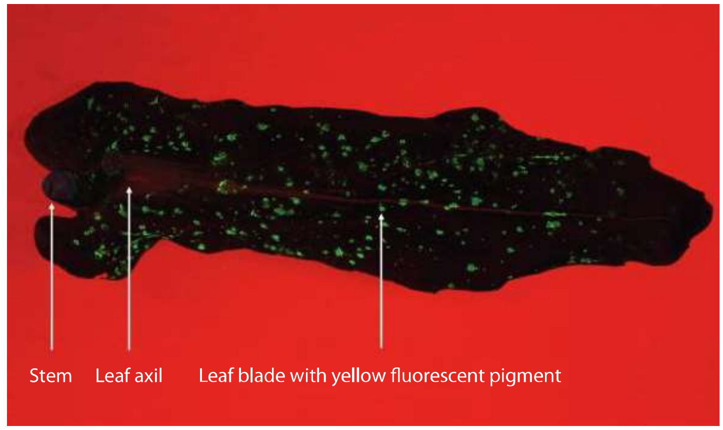
For a cultivar such as 45Y95, where only one *R*-gene occurs in the F1 generation,

Table 1: Major genes (*R*-group) present in F1 (commercial) and F2 (retained) seed of different canola cultivars.

Name	Type of cultivar	*R*-genes present	
		F1 seed[a]	F2 seed[b]
Defender CT	Clearfield, Triazine tolerant	ADF	A / D / F / AD / AF / DF
PY327C CL	Clearfield	Unknown	
PY421C CL	Clearfield	A	A / nothing
PY520 TC	Clearfield, Triazine tolerant	BC	B / C
45Y95	Clearfield	C	C / nothing
Diamond	Conventional	ABF	A / B / F / AB / AF / BF
Alpha TT	Triazine tolerant	BF	B / F
Blazer TT	Triazine tolerant	ADF	A / D / F / AD / DF / AF
44Y94	Clearfield	BC	B / C
Quartz	Conventional	ABD	A / B / D / AB / AD / BD
Hyola Solstice CL	Clearfield	ADFH	A / D / F / H / AD / AF / AH / DF / DH / FH / ADH / DFH
Hyola Equinox CL	Clearfield	ADF	A / D / F / AD / DF / AF
CC90014	Conventional	ADFH	A / D / F / H / AD / AF / AH / DF / DH / FH / ADH / DFH
Hyola Continuum CL	Clearfield	ADF	A / D / F / AD / DF / AF
HyTTec Trophy	Conventional	ADF	A / D / F / AD / DF / AF
HyTTec Trifecta	Conventional	ABD	A / B / D / AB / AD / BD
PY429TT	Triazine tolerant	Unknown	
Ceres CL	Clearfield	AD	A / D

[a]F1 seed is genetically uniform, meaning each seed will contain all R-genes indicated. [b]F2 seed is no longer uniform, meaning individual seeds will contain the possible combinations indicated, and no longer the full complement of R-genes present in the F1 seed.

Fluorescent particle coverage of canola leaf (three- to five-leaf stage) showing fungicide deposition achieved at this growth stage. (Photograph: Gideon van Zyl)



Fluorescent particle coverage of canola leaf with stem and leaf axil attached (30% flowering stage) showing fungicide deposition achieved at this growth stage. (Photograph: Gideon van Zyl)

50% of the F2 generation may contain the *R*-gene, while the remaining 50% will not contain any resistance gene. Further examples are provided in *Table 1*.

Treatment impact investigated

F2 (retained) seed is, therefore, potentially more susceptible to blackleg compared to commercially produced seed. The result is that a larger variety of races of the pathogen will be able to infect the plants, leading producers to rely more heavily on fungicides for crop protection. This dependency can lead to the development of fungicide resistance. Seed treatments form an integral part of protecting seedlings against blackleg until the three- to five-leaf stage when the first foliar fungicide is applied. Commercially sold F1 seed is already treated with a fungicide seed treatment, but not all producers treat retained seed.

To investigate the impact of retained seed on blackleg, two field trials are being conducted (2023 and 2024) at Langgewens research farm (Swartland) and Uitkyk farm near Riversdale in the Southern Cape (see photograph). Five cultivars are included, which constitute F1 seed of each, as well as the fungicide-treated and untreated F2 seed of each.

Each of these cultivar treatments will receive a fungicide application at the three- to five-leaf stage against blackleg, and the same treatment at the 30% flowering stage against SSR. Alongside these are trial plots that receive no fungicide treatments post-planting. The incidence of both these diseases will be determined pre-harvest. Piet Lombard from the WCDA is also investigating the effect of these treatments on yield and oil content.

Fungicide deposition on canola

Chemical control is essential for managing SSR and very important in the integrated management of blackleg, given the ability of the pathogen to respond to selection pressure and overcome resistance (Sprague *et al*., 2006). Depending on the choice of active ingredients, the costs of a single application can range from approximately R350 to R1 000/ℓ.

Labour, fuel, and maintenance add additional costs for each application. Producers unfortunately often make decisions with cost-effectiveness in mind, and not so much disease control. Ironically, this often results in sub-optimal fungicide deposition and concomitant low levels of disease control.

For the application of foliar fungicides to be effective, it needs to reach its target area, deposition quantity, quality and uniformity must be sufficient to achieve control, and timing of application must be optimal, among several variables. The growth period of cultivars can also significantly affect fungicide efficacy, given the large variation in flowering periods between cultivars. Reaching the target area and achieving adequate

Table 2: Spray volume (ℓ/ha), sprayer speed (km/h), nozzle selection, sprayer pressure, and droplet size (VMD in µm) used per treatment in trial one (four- to six-leaf growth stage) and trial two (30% flowering stage) spray applications.

Trial[a]	Spray volume (ℓ/ha)	Spray speed (km/h)	Nozzle selection[b]	Sprayer pressure (Bar)	Droplet size VMD (µm)[c]
Three- to five-leaf application	100	**9**	TT11002	2,5	Medium
Three- to five-leaf application	150	9	TT11003	3	Medium
Three- to five-leaf application	200	9	TT11004	2,5	Course
30% flowering	100	9	TT11002	2,5	Medium
30% flowering	200	9	TT11003	6	Medium
30% flowering	300	9	TT11005	5	Course

[a]Three- to five-leaf application for control of blackleg disease; 30% flowering for control of Sclerotinia stem rot. [b]Nozzle referral code for turbo TeeJet nozzles (www.teejet.com). [c]Droplet volume median diameter (VMD) (µm) spectrum as classified by ASABE S572,1.

deposition quantity, quality and uniformity is especially difficult in a crop such as canola, given the three-dimensional architecture of the plant at 30% flowering when fungicide application against SSR is commonly done.

To date, no information is available on the fungicide deposition achieved at the three- to five-leaf stage, when fungicides are applied against blackleg, or at 30% flowering when fungicides are applied against SSR. Our research aims to quantify the deposition of fungicides applied to canola at different growth stages, using different spray volumes, tractor forward speeds, and application with a tractor, aeroplane and unmanned aerial vehicles (UAV or drone), to identify practices resulting in optimal fungicide coverage. Additionally, fungicide deposition achieved at the three- to five-leaf stage will be correlated against the blackleg disease severity index, to correlate deposition achieved to level of control.

Spray deposition trials

In 2023, two spray deposition trials were conducted in a uniform canola field at the Tygerhoek research farm near Riviersonderend in the Overberg region. The first trial was conducted when the predominant growth stage of the field reached the four- to six-leaf growth stage (3 July 2023).

The second trial occurred when the predominant growth stage of the field reached the 30% flowering stage (8 September 2023). For each trial, three spray volumes were applied (*Table 2*) at a constant forward speed of 9km/h. All spray treatments were administered using a stable boom sprayer operated at a constant height of 50cm above the target plants.

The spray liquid used included water, the fungicide Prosaro (tebuconazole + prothioconazole) (*www.bayer.com*) at a dose rate of 760mℓ/ha, and yellow fluorescent pigment (40% EC [South Australian Research and Development Institute, Loxton, South Australia]; 3mℓ/ℓ] at a dose rate of 900mℓ/ha for all treatments.

The spray deposition parameters suggest that canola plants in the four- to six-leaf growth stage are spray-friendly. All spray volumes realised acceptable spray deposition parameters when compared to results observed on other grain and vegetable crops treated with a horizontal boom sprayer.

It is important to note that no biological efficacy benchmarks for spray deposition are available on canola for any of the targeted plant diseases such as blackleg (*L. maculans*). However, this study indicates that there is a spray deposition advantage to using spray volumes lower than 200ℓ/ha, down to 100ℓ/ha. The 100ℓ/ha treatment realised the best spray deposition parameters across different parameters. Higher spray deposition quantities often correlate with better disease control, as illustrated by Van Zyl *et al*. (2013) and Rebel *et al*. (2020).

Spray complexity

Deposition quantity values realised in the 30% flowering application were lower compared to the four- to six-leaf stage. This was expected as the fluorescent pigment dose rate per hectare was the same for both trials. However, in this trial the canopies of the plants are now a three-dimensional, larger structure, which makes spraying it more complex. The complexity arises from physical barriers such as branches growing towards light, as well as leaves and flowers acting as filters that intercept incoming droplets.

Despite the lower deposition values observed in this trial, the trend of higher deposition with a lower spray volume was similar to a higher concentration of product per droplet intercepted. It is reasonable to hypothesise that there might be a benefit to going lower than 100ℓ/ha spray volume per hectare but that there will inevitably be a point of diminishing returns. Spray volumes lower than 100ℓ/ha should be included in follow-up studies to establish if lower volumes are viable.

Another trend that was observed in this study was the decrease in spray parameters on the middle and lower canopy positions. This was observed in all three deposition parameters. Spray volume per hectare increase has been ruled out as a solution for this problem with this study.

A possible option that could be considered is using an air-assisted spray machine with fine to very fine spray droplets. Reducing the size of droplets increases the area that could be covered by the volume on an exponential scale. However, smaller droplets lack momentum, making them prone to spray drift.

For this reason, the use of air assistance to deliver droplets into these canopies could increase the chances of leaves and leaf axils intercepting more droplets on the inside of canola canopies. This theory, however, was not supported by previous research done on potato plants, but potato canopies are denser than canola canopies at the 30% flowering stage.

The goal of these spray applications is to protect leaf and stem areas with fungicide, especially where flower petals will fall – serving as a nutrition source for spores of *S. sclerotiorum* and leading to the development of SSR. An accompanying study could explore the risk of lower deposition in lower canopy positions by quantifying petal distribution on top, middle and bottom canopy leaf axils.

Going forward

This study will be repeated this year and in 2025. The research will involve tractor-mounted boom sprayers and UAV applications for the three- to five-leaf application. Various spray volumes and tractor-mounted boom sprayers, UAV applications, as well as aeroplane-based applications will be explored during the 30% flowering stage. The tractor-mounted boom sprayer will apply fungicides at different volumes and forward speeds, while the drone will apply fungicides at different volumes.

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