

Managing Sclerotinia in Oilseed and Pulse Crops

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Summary

Sclerotinia sclerotiorum (Lib.) de Bary is a fungal pathogen that infects more than 400 plant species in more than 60 families, causing significant economic losses in many crops in Canada and worldwide. Sclerotinia diseases are among the most important constraints to successful production of oilseed and pulse crops in the prairie region of western Canada. Although significant sclerotinia levels can develop in many broadleaf crops, levels can vary widely among fields and years. Successful management of sclerotinia diseases can be difficult to achieve given the lack of resistant crop cultivars, and limited impact of cultural practices on disease risk. However, it is still possible to minimize the risk of sclerotinia through the adoption of key management strategies for canola, sunflower and bean.

Introduction

In western Canada, plant diseases can be one of the major constraints to maintaining high yields and quality in oilseed and pulse crops such as canola, sunflower and dry edible bean. Unfortunately, there is no single “magic bullet” that can be used by producers to eliminate the risk posed by plant diseases as crops typically face multiple pest and crop management issues. Producers need to look at a combination of tools from their management toolbox to provide long-term, consistent management of plant diseases, while maintaining crop yield and quality.

Overall, strategies for disease management relate to the components of the “disease triangle”, a diagrammatic representation of what is required for an infectious plant disease to occur (Figure 1). The presence of a virulent pathogen in sufficient quantity, the occurrence of favourable weather conditions, and the presence of a susceptible host all are needed for a disease to occur. *Sclerotinia sclerotiorum* (Lib.) de Bary is a fungal pathogen that infects more than 400 plant species in more than 60 families, causing significant economic losses in many crops in Canada and worldwide. It is one of the major diseases of canola and sunflower as well as beans. This review will highlight the key strategies to help limit the negative impact of sclerotinia in these crops.

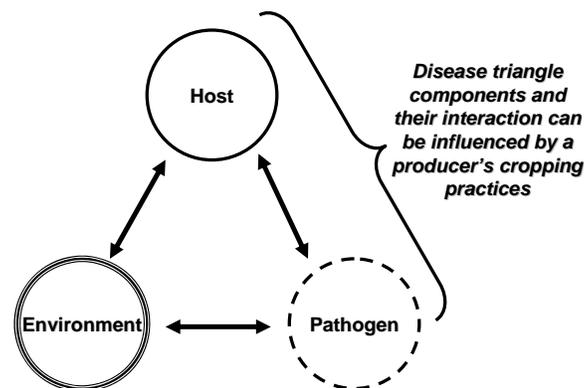


Figure 1. The “disease triangle”, a symbolic representation of the interactions among the three factors required for infectious plant diseases to occur.

Sclerotinia stem rot of canola

Sclerotinia stem rot, caused by the fungus *Sclerotinia sclerotiorum*, is a disease (Figure 2) that has not been effectively controlled using typical management tools such as crop rotation, variety resistance or tillage^{1,2,3,4,5,6}. There are several reasons for the limited success of these measures for stem rot control: 1) resting structures (sclerotia) produced by the stem rot pathogen are very long-lived in the soil, and rotations of 2-3 years away from canola may not be enough time to render a significant number of sclerotia incapable of contributing to disease epidemics; 2) *S. sclerotiorum* is a pathogen that is widely distributed geographically and has an extensive host range, including most of the common broadleaf weeds and crops. Thus, there is the potential for production of sclerotia and survival of the stem rot pathogen in the absence of canola, even with extended intervals between canola crops; and 3) the disease has the potential to be dispersed from one field to another, since spores produced by this fungus are wind-borne and sclerotia may be moved in soil and crop residues. The potential for disease resistance is currently limited, and while there may be subtle differences among varieties in the incidence of sclerotinia stem rot, this is of limited practical value. However, the most recent new varieties of canola may be less susceptible to sclerotinia and may provide an option to reduce the impact of this disease via variety choice.

Effective stem rot control has been achieved using foliar fungicides. A number of chemical products and one biofungicide are registered for stem rot management in canola in Canada; more information on these can be obtained by consulting the provincial farm chemical guides: [http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex32](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex32), http://www.agriculture.gov.sk.ca/Guide_to_Crop_Protection, <http://www.gov.mb.ca/agriculture/crops/cropproduction/gaa01d01.html>), the Pest Management Regulatory Agency's electronic label search engine (<http://pr-rp.hc-sc.gc.ca/lr-re/index-eng.php>), or fungicide manufacturers' websites. Options such as split applications, modifying spray patterns through nozzle selection, increased spray pressure, and increased water volumes may help to improve the level of control achieved with fungicides^{7,8,9,10,11}. Additionally, producers need to ensure that fungicides penetrate the crop canopy to reach leaf bases and stems to protect these from infection.

Fungicide application during flowering constitutes a significant monetary investment for canola producers, and because of the variability of stem rot from year-to-year, region-to-region, and field-to-field, routine application of fungicide is unlikely to be economical. In order to increase the probability of an economic benefit from fungicide application for control of sclerotinia stem rot in canola, growers must be able to predict with reasonable certainty the crop and environmental conditions under which spraying is warranted¹². Although producers and crop consultants have access to existing risk assessment tools, such as weather-based forecasting maps (<http://commandcenter.weatherbug.com/Pages/RiskMaps.aspx?tab=9&acct=5>; ¹²), checklists ([http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex148](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex148); ¹²), and petal testing protocols^{12,13,14,15,16}; (<http://www.agriculture.gov.sk.ca/Default.aspx?DN=a8664793-a3e6-4c6d-b36a-0dda36e735c7>), there has been only limited acceptance of these tools. This may be because weather maps provide regional rather than field specific forecasts, and only consider one component of the "disease triangle", while decision-making checklists are qualitative and make it difficult to calculate the cost/benefit ratio of fungicide application. Petal testing provides a direct assessment of the inoculum (ascospores) level, which can be used to forecast severity of plant infection and potential yield loss, however, the test requires a significant time span from sample collection to availability of results, which can be an issue for timely application of fungicides.

Numerous factors can influence the risk of sclerotinia stem rot infection of a canola crop, but given the monocyclic nature of the stem rot disease, the amount of disease in the mature crop is proportional to the amount of airborne inoculum in late June and early July. Moreover, the environment and host can greatly impact stem rot risk. Thus, when assessing disease risk the influence of all components (host, pathogen, and environment) of the disease risk triangle need to be taken into account.

Overall, there is an increased risk of economic levels of stem rot when following factors occur:

- History of significant levels of sclerotinia in the specific field or in adjacent fields
- Adequate June rain to maintain the soil at near field capacity and moderate temperatures which favour germination of sclerotia once crop canopies start to cover the soil surface
- The soil surface underneath the canola canopy remains wet for most or all of the day
- Apothecia are easily found in the specific field or adjacent fields
- Average percentage petal infestation is typically >30% throughout the bloom period
- Unsettled conditions in late June and throughout July with frequent showers interspersed with windy days without rain
- Increased yield potential (>30-45 bu/ac) as a result of a combination of variety, high fertility levels, and good agronomic practices
- Moderate average temperatures of 15-25°C and moderate rainfall that favour host infection while extending the bloom period and reducing sloughing off of leaves, thus maintaining potential infection sites
- A crop canopy that remains wet throughout the day or at least until late in the afternoon, and droplets of moisture that are readily found in leaf axils and bases even in the late afternoon
- Extensive sticking/clumping of petals in the crop canopy especially in the leaf axils and bases

In contrast there is likely limited risk of sclerotinia stem rot when the factors above do not occur, and in addition with:

- Continuous rain events that may lead to washing off of petals from plants and remove spores from the air, while trapping spores in water droplets that form on the tops of the apothecia (note these conditions will not completely eliminate the risk of stem rot, but may lead to a lower level of disease than expected)
- Well below- or above-average temperatures (<10°C or >25-30°C) and limited rainfall will reduce the risk of stem rot even if there is a history of disease in the field or region
- A large rainfall event over 1-2 days that is followed by several days or 1-2 weeks of dry, warm conditions that typically do not favour apothecia production and host infection and thus the risk of stem rot
- High temperatures (daily maximums of >30°C) and sunny dry conditions that significantly limit the risk of infection as well as greatly shorten the flowering period, while promoting rapid leaf senescence and sloughing off of leaves, and thus removal of potential infection sites.

With a better understanding of the factors that influence stem rot risk and options such as split applications and reduced rates of fungicide, growers can achieve economical control by tailoring management practices to the disease risk present.

Further information on sclerotinia stem rot of canola can be found at the following websites:

[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/faq7009](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/faq7009)

[http://www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/agdex148?opendocument](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex148?opendocument)

<http://www.agriculture.gov.sk.ca/Default.aspx?DN=a8664793-a3e6-4c6d-b36a-0dda36e735c7>

<http://www.canolacouncil.org/chapter10c.aspx>

Sclerotinia wilt, stem rot, and head rot in sunflower

As already mentioned, *S. sclerotiorum* has an extensive host range that also includes sunflowers (*Helianthus annuus* L.)^{17,18}. The pathogen infects sunflower in two ways: 1) infection of the roots and basal stem area by mycelia produced from the myceliogenic germination of the sclerotia (an overwintering dark hard and thick mycelial mass) in the root zone causing basal-stem rot and wilt of the plant (Figure 3); and 2) infection of the heads and the mid-stem by ascospores produced on apothecia resulting from carpogenic germination of the sclerotia following 1-2 weeks of soil moisture saturation, and leading to head rot or mid-stem rot and breakage¹⁹; Figure 4). Either infection type results in plant death and partial or total yield loss, depending on infection earliness and severity. No resistance to the pathogen exists in commercial sunflower hybrids. However, sources of genetic

resistance have been identified in wild sunflower species, and interspecific breeding may lead to resistant sunflower hybrids being available in the near future.

Presently, managing sclerotinia in sunflower is achieved by:

- i) crop rotation away from sunflower for 3-4 years, and avoidance of crops susceptible to sclerotinia, to reduce the levels of inoculum (sclerotia) in the soil, thus reducing the incidence of root infections and wilt;
- ii) avoidance of planting in fields adjacent to fields that had heavy Sclerotinia infections in previous years since ascospores produced in such fields can become airborne and readily move to adjacent sunflower crops;
- iii) use of a biocontrol microorganism that is commercialized to decompose the sclerotia in soil or/and protect plants from ascospore infections (<http://www.contans.ca/>);
- iv) application of fungicides that have proved effective in protecting sunflower heads from ascospore infections and reducing disease and yield losses by 50-60% (when they become registered for use on sunflower);
- v) cultural practices that include wide row spacing, normal plant populations, and weed control to reduce root-to-root mycelial infections and create a well-aerated canopy, thus reducing the risk that airborne ascospores will initiate infections.

Sclerotinia white mould of bean

Diseases caused by *S. sclerotiorum* are among the most destructive known and have the potential to severely reduce yield in many economically important crops²⁰ including pulses such as dry bean. White mould infection of bean is initiated by ascospores from carpogenic germination of sclerotia of *S. sclerotiorum*²¹. Infection of the crop is associated with senescent blossoms which provide a source of energy for germinating ascospores. Pod, stem and leaf tissues (Figure 5) in contact with infected blossoms develop water-soaked lesions under moist conditions and secondary spread can occur through direct hyphal growth from adjacent infected tissues. Infection of stems and branches causes affected plant parts to wilt (Figure 6) and eventually die, taking on a dried, bleached appearance (Figure 7). Following infection, abundant white mycelia of *S. sclerotiorum* can develop on diseased tissues when environmental conditions are favourable, and sclerotia are produced internally or externally on infected plant parts. In western Canada, mycelia of *S. sclerotiorum* can overwinter in infected stubble of dry bean, canola and sunflower²² but they rapidly lose viability during spring and early summer and are therefore not considered an important source of inoculum for the disease.

Disease development is highly influenced by prevailing weather conditions and cultural practices²³. High plant populations, vigorously vining varieties, narrow row widths, excess fertilizer and abundant irrigation/rainfall all favour the development of white mould. Initially, infection often is localized within the more cool and moist regions of a field. Specific agronomic practices in combination with the application of fungicides can be effectively combined to reduce disease severity and yield losses in bean crops. Crop rotation generally does not prevent infection because sclerotia can survive for many years in soil. However, it does help to reduce the number of sclerotia in individual fields and hence the potential for yield loss. Dense, thick growth of the crop causes high moisture and lower temperatures under the crop canopy creating conditions that favour the disease. Escape from *S. sclerotiorum* infection due to modifications of growth habit has been reported in bean²⁴. Cultivars that are more upright leading to more open plant canopies are recommended. High plant populations, and narrow-row spacing especially should be avoided as heavy foliage and dense plantings retain moisture and interfere with thorough coverage of plants by fungicides. To avoid excess canopy development, apply fertilizer to meet crop needs, but avoid excessive fertilization that can lead to dense, lush plant growth.

Complete resistance to white mould does not exist in dry bean. However, there is considerable optimism that a commercially acceptable, white mould resistant variety of dry bean will be developed in the future. Another control measure to consider is the use of fungicidal sprays. Fungicide application is warranted when weather is moist during flowering, target yields are high and vine growth is heavy. Application that protects as many blossoms as possible from infection is important. Morton and Hall²⁵ found that effective control of the disease was directly related to

blossom coverage by fungicide. Using fungicides only when needed requires an effective disease forecasting system. Under irrigated conditions, use of a spray advisory model based on environmental conditions, in conjunction with bean developmental stages, indicated that periods of high risk were forecasted with reasonable accuracy and that one well-timed fungicide spray could provide a good level of protection²⁶. Generally, weekly scouting of bean fields and fungicide application based on environmental conditions and crop stage are the standard practice. Because of the year-to-year and field-to-field variation in white mould occurrence and severity, routine fungicide use may be uneconomical. Currently, a spray advisory system for white mould of bean is being evaluated to assist in decision-making. Several fungicides are registered for management of white mould in bean. Information on these products is available in provincial farm chemical guides under the links listed previously for sclerotinia stem rot of canola.

Concern over the health and environmental risks associated with agricultural pesticides has resulted in a renewed interest in the use of biological control. Biological control involves the reduction of the pathogen population or its plant infection capacity by an antagonistic microbial agent. In Alberta, the application of a bio-control agent to soil at seeding reduced the production of apothecia under canopies of bean, canola, wheat and barley, thus reducing the amount of inoculum of the pathogen in fields sown to host or non-host crops²⁷. Currently, Contans[®]WG is registered for soil application in beans, soybean and sunflower to reduce the numbers of sclerotia in soil, thereby reducing ascospore production and subsequent plant infection.

Further information on white mould of bean can be found at the following websites:

<http://www.gov.mb.ca/agriculture/crops/diseases/fac04s00.html>

<http://www.gov.mb.ca/agriculture/crops/pulsecrops/bhd03s01.html#diseasemgmt>

<http://saskpulse.com/media/pdfs/ppm-dry-bean.pdf>



Figure 2. Typical symptoms of sclerotinia stem rot of canola. Note the bleached whitish appearance of affected host tissue versus healthy green tissue. Photo credit: T.K. Turkington



Figure 3. Myceliogenic germination of sclerotia to produce mycelia that infects the sunflower root causing root rot and wilt. Photo credit: K.Y. Rashid.

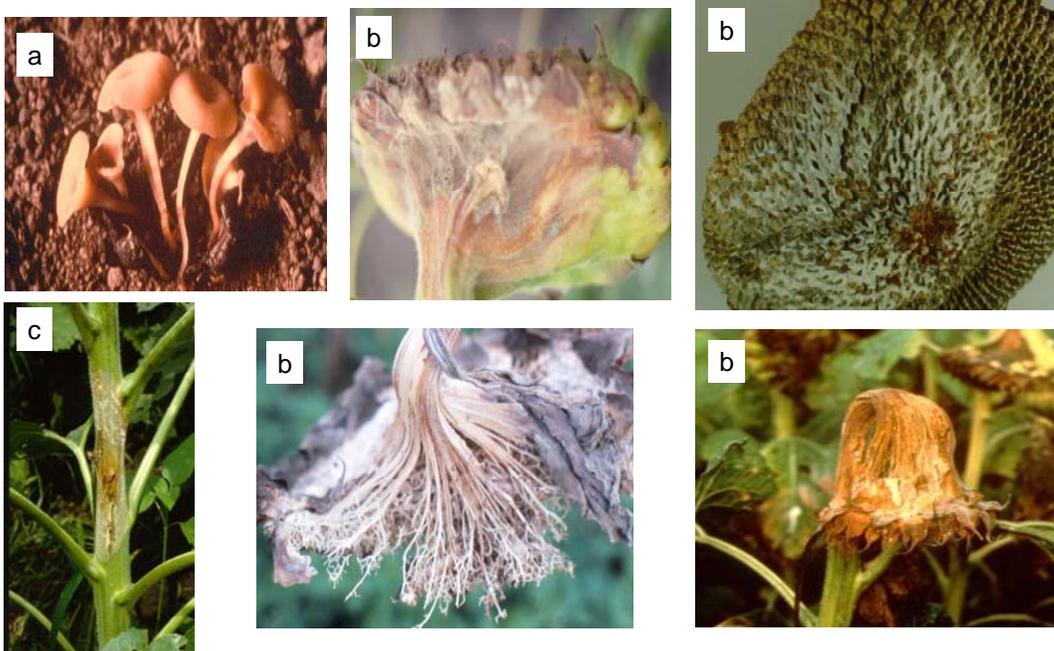


Figure 4. Carpogenic germination of sclerotia to produce apothecia (a), which release ascospores that infect sunflower heads (b) and mid-stems (c). Photo credit: K.Y. Rashid.



Figure 5. Water-soaked lesions on pod, stem and leaf tissue. Photo credit: D. McLaren.



Figure 6. Wilting due to white mould of bean in the field. Photo credit: D. McLaren.



Figure 7. Dried, bleached plant tissue due to infection by *S. sclerotiorum*.
Photo credit: D. McLaren.

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