Disease Management and Control

Sam Markell,
Extension Plant Pathologist,
Luis del Rio Mendoza,
Research Plant Pathologist,
and
Michael Wunsch,
Extension Plant Pathologist

Two main diseases impact canola production in North Dakota: blackleg and sclerotinia stem rot. This section will focus heavily on those diseases and discuss others briefly. Photographs of various diseases can be found in the back of this field guide.

Blackleg

Cause

Blackleg is caused by two fungal pathogens, *Leptosphaeria maculans* and *L. biglobosa*. *L. maculans*, which is highly aggressive, is the predominant cause of blackleg in North Dakota and Minnesota. It consists of several pathogenicity groups (PGs) that differ in their virulence to specific canola varieties; to date, four pathogenicity groups have been identified: PG1, PG3, PG4, and PGT. *L. biglobosa* previously was considered a mild strain of *L. maculans*; in the 1990s, it was referred to as PG2 of *L. maculans*. Today it is recognized as a distinct species. *L. biglobosa* is less

damaging than *L. maculans*, and it is found in North Dakota and Minnesota infrequently.

Signs and Symptoms

Infection by the blackleg pathogen often is observed first on leaves. Round to irregular-shaped lesions with a tan or buffed color appear as early as the seedling stage but can occur anytime until crop maturity. Leaf spots enlarge, and small black fruiting bodies called "pycnidia" are formed in the center of the lesions. Pycnidia are small but visible to the unaided eye and resemble ground black pepper flakes in color and size.

Stems are most susceptible to infection before they reach the four- to six-leaf stage. Lesions can occur anywhere on the stem, but often they are found near the base of the stem where a leaf was attached. Stem lesions are gray to dark gray and are surrounded by a dark or black border. Pycnidia frequently are produced in the center of stem lesions. Lesions become sunken and may rupture and girdle the stem, producing the characteristic "blackleg" symptom. Infected stems also exhibit internal discoloration; when split open, the internal tissues of infected stems frequently are black, gray or stained with gray streaks. Early infection of the stem may result in premature senescence and lodging. Late stem infection can cause plants to be less vigorous but otherwise causes few above-ground symptoms.

Roots, pods and seeds also are susceptible to infection. Infected roots develop internal discoloration; when split open, internal tissues will be black, gray or stained

with gray streaks. Root infection causes premature senescence and yield loss but is not always associated with other above-ground symptoms. Infected pods may split open, resulting in seed loss, and seed produced in infected pods may be gray and shriveled.

Survival and Spread

The blackleg pathogen survives for several years on infected crop residue. In the spring, the blackleg pathogen forms fruiting structures on this residue. These fruiting structures produce sexual spores (ascospores), which can be dispersed to new canola plants and cause infection. Ascospores can be dispersed for several miles, but most are deposited much closer to the source. Maximum ascospore discharge occurs the year following a canola crop but can occur until residue is degraded completely.

Infection by ascospores results in the development of blackleg. On diseased tissues, the blackleg pathogen produces abundant pycnidia (asexual fruiting structures); during wet weather, pycnidia release a gelatinous ooze containing pink asexual spores (conidia) that are dispersed by rain. The conidia are responsible for localized spread of the blackleg fungus, resulting in "hot spots" of infection.

Temperatures in the 70s F and extended periods of canopy wetness favor infection. Disease development is inhibited by temperatures above 85 F or below 50 F. Plant injury (from insects, hail, herbicides, etc.) can increase the incidence and severity of blackleg.

The blackleg pathogen can survive for several years in infected seed. When infected seed is planted, seedlings emerge and develop cotyledon, leaf and stem infections. Infections from seed can result in early and widespread epidemics. Transport of infected seed to other regions has contributed to the spread of blackleg throughout the world.

Management

Resistance – Host resistance is one of the most effective and least expensive management tools for this disease. We recommend that producers plant a resistant hybrid. However, hybrids marketed as resistant to blackleg carry resistance to only one strain of the blackleg pathogen, PG1; they are susceptible to the other strains of the blackleg pathogen: PG3, PG4, and PGT. In a greenhouse study conducted at NDSU in 2010, 73 commercial hybrids were screened for resistance to blackleg and none was resistant to PG groups PG3, PG4, and PGT. PG3, PG4, and PGT have been identified in North Dakota, and growers affected by these strains of the blackleg pathogen should recognize that resistant (PG1) hybrids will not confer protection against these new strains. Efforts to breed resistance are underway, and resistant hybrids to the other PGs may be available in the future.

Hybrid Rotation – Rotating hybrids may slow the development of new strains (pathogenicity groups) of the pathogen by reducing selection pressure on the pathogen. If severe blackleg is observed, a different hybrid should be used in the future.

Crop Rotation – Because the blackleg pathogen survives in crop residue for multiple years, we recommend a four-year crop rotation. In addition to reducing disease pressure, a longer crop rotation will reduce the likelihood that new pathogenicity groups are formed.

Disease-free Seed – Plant certified disease-free seed. This is especially important when planting canola into a new area.

Seed Treatment Fungicides – Numerous fungicide seed treatments are registered for blackleg in North Dakota. Make sure to use a seed treatment that is effective against blackleg. Metalaxyl alone will not control blackleg. Consult the most recent issue of the "North Dakota Field Crop Fungicide Guide" (Extension publication PP-622) when selecting a fungicide seed treatment.

Foliar Fungicides – Take economics and disease risk into consideration before applying a foliar fungicide. High-risk factors include a susceptible or moderately susceptible variety, the known occurrence of one of the new pathogenicity groups of the blackleg pathogen (PG3, PG4, or PGT), or a tight crop rotation. Fungicide trials conducted in 2004 and 2005 demonstrated that a single fungicide application was able to reduce disease and provide some yield protection in susceptible varieties but that foliar fungicides did not give adequate control as a single management strategy. If utilized, foliar fungicides should be applied at the two- to four-leaf stage.

Consult the "North Dakota Field Crop Fungicide Guide" (Extension publication PP-622) for available products and always follow label directions.

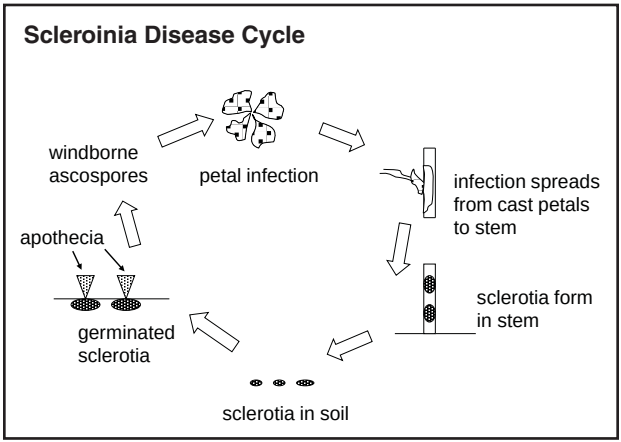
Control Weed Hosts – Volunteer canola and wild mustard are hosts to the disease and should be controlled in crops rotated with canola.

Resources and Citations

This information was adapted from publication PP-1367, "Blackleg of Canola," and additional information and photographs can be found in that publication. Fungicide information can be found in publication PP-622, "Field Crop Fungicide Guide."

Sclerotinia Stem Rot (SSR)

SSR is one of the most serious and common diseases of canola in North Dakota. Average statewide yield losses in North Dakota and Minnesota have reached 13 percent, with losses in some fields as high as 50 percent. SSR occurs almost every year and in most regions of the state. However, in recent years, new management tools, including a forecasting model to aid in fungicide decision making, have become available. Additionally, multiple fungicides are labeled, giving canola producers options that were not accessible a couple of years ago.



Cause

The fungal pathogen *Sclerotinia sclerotiorum* causes disease in more than 400 different plant species, including canola, dry beans, soybeans, sunflowers, flax and the pulse crops (peas, lentils, chickpeas).

Symptoms and Signs

Symptoms on canola plants do not appear until after flowering. Spores of *S. sclerotivorum* colonize dead flower petals, and the first visible symptom of SSR is a mushy, light brown target pattern on and around cast petals (colored parts of the flower). Cast flower petals accumulate in the junctions where leaf petioles join the stem. When one or more of these petals become infected with Sclerotinia, the infection spreads into the leaf petioles (slender stalk connecting the leaf to the plant), branches and stems. Infected

areas become bleached, taking on the appearance of dry bone, and they frequently become brittle and shredded. If infection occurs in the main stem, plants may die early and become prone to lodging. Standing dead plants may be visible in fields with severe SSR infection. After infection is well-established, hard, black structures (sclerotia), which resemble rat droppings, may be produced in infected tissues. The sclerotia are the survival structures of the pathogen and, although they are not produced in every infection, they are a definitive sign of SSR.

Survival and Spread

The pathogen produces sclerotia (resting structures) in infected stems. Sclerotia fall to the ground during harvest, and they can survive on or in the soil for many years. After the sclerotia have overwintered, 1 to 2 inches of rain in a one- to two-week period will moisten soil enough for sclerotia to germinate and produce small mushroom structures (0.1 to 0.25 inch diameter) called apothecia. If rain does not occur prior to flowering, the soil will be too dry for sclerotia to germinate, no apothecia and spores will be produced, and infection will not take place. Sclerotia must be in the top 1 to 2 inches of the soil profile to form apothecia; otherwise, they will remain dormant. Apothecia can produce millions of spores (ascospores) that are dispersed by wind; however, most ascospores remain trapped in the canopy near the apothecia. The great majority of spores do not travel more than 150 feet, but some spores will be disbursed

significantly farther when the right conditions persist. Spores can infect floral parts directly, but most infections occur when spores land on dead or dying tissue. Canola petals that die after flowering provide an excellent food source for the SSR spores, and most SSR disease lesions are initiated from infected dead flower petals. If spores are produced, the canopy must be wet for 40 to 48 hours for the spores to germinate and for infection to take place. However, even when ample moisture is available, if temperatures are too hot during this time (above 86 F), spores may die before they can begin to grow. If infection occurs, disease development will not occur above 86 F, but it will resume once cooler temperatures return. Similarly, if weather becomes dry, disease progression will slow and increase only when the canopy becomes wet.

Management

Crop Rotation – Crop rotation is important to limit the buildup of sclerotia. Try to avoid more than one highly susceptible crop (sunflower, canola, crambe, dry bean, pea or soybean) in a rotation. Semileafless peas support less buildup of sclerotinia than the vining types and may be acceptable in crop rotations. In irrigated trials at Carrington, N.D., no sclerotia were produced in flax; therefore, flax may be a relatively safe crop in rotation with canola. Additionally, corn and small grains are not susceptible to SSR.

A preferred rotation would have canola planted after two or more nonsusceptible crops. Despite appropriate crop rotation, some sclerotia can survive for long periods of time and can germinate and cause infection many years after they were produced. Additionally, infection can occur from spores blown in from other fields.

Tillage – Management of SSR with tillage is uncertain. Deep tillage may bury sclerotia deep enough that they do not produce apothecia. However, some data indicate that these sclerotia do not break down as fast as those near the surface and may result in infection if they are brought back near the surface later. Additionally, even if deep tillage is done, it probably is of limited value if used on one or a few fields and not areawide.

Resistance – All canola varieties are susceptible to some degree. However, some varieties may be less susceptible than others.

Biological Control – The fungus *Coniothyrium minitans* can attack and kill sclerotia in the soil. The fungus is sold commercially as Contans WG. Use of this fungus to battle sclerotinia is relatively new, and limited data exists on its efficacy. Contans may be of greatest use under high disease pressure rotations or cropping practices (such as irrigation). Other biocontrol products are entering the market; consult the most current "North Dakota Field Crop Fungicide Guide," PP-622, for more information.

Fungicides – Numerous fungicides are available, and new products likely will be available in the future. To find products available, consult the most current "North Dakota Field Crop Fungicide Guide," PP-622. Fungicide trials are done frequently at NDSU's Research Extension Centers in Carrington, Langdon and Minot (North Central REC). For the most current information, visit their websites at *www.ag.ndsu.edu/research/recenthp.htm*.

Fungicide Decision Making

Making the decision to apply (or not to apply) fungicides and spraying at the most appropriate growth stage are the two keys to managing SSR. Several resources can be used when determining whether a fungicide application is warranted, including the ***Sclerotinia Risk Map*** and the ***Sclerotinia Stem Rot Checklist***. In general, spraying is most beneficial when:

- One to 2 inches (or more) of rain occurred in the two weeks prior to flowering.
- Rain or high humidity is expected.
- Sclerotinia has been a problem in recent years.

Sclerotinia Risk Map – Environmental information generated from the North Dakota Agricultural Weather Network (NDAWN) weather stations are used to determine if conditions are favorable for the germination of sclerotia, development of apothecia and spore release. This information is used to generate a map with color-coded indications of risk throughout North Dakota and the canola-growing areas in Minnesota.

The map is an effective tool to help growers assess their risk of SSR infection. However, producers should keep several things in mind:

- The risk map only applies to you when your canola is flowering. Because the pathogen uses petals as a food source, no infection occurs prior to flowering.
- The map is meant as a *regional* guide to risk. The Risk Map is only as good as the information source, and even though NDAWN has approximately 67 weather stations, the environmental conditions in your field may be different. If you know you have had more/less rain than the NDAWN stations nearest you, your risk may be higher or lower.
- The Sclerotinia Risk Map calculates the likelihood of sclerotia germinating and, thus, spores being available to cause infection. Your fields may have greater or less risk, depending on other management techniques (crop rotation, less susceptible variety), field history and weather forecasts (for example, rain, high humidity, temperatures).

The map is available at *www.northerncanola.com* and *www.ag.ndsu.edu/sclerotinia/*.

Resources and Citations

This information was adapted from publication PP-1410, "Sclerotinia of Canola," and additional information and photographs can be found in that publication. Fungicide information can be found in publication PP-622, "Field Crop Fungicide Guide."

Sclerotinia Stem Rot Checklist

Reproduced from the Canola Council of Canada website by permission

When to complete the checklist:

Fill out the checklist and assess the crop shortly after first flower. First flower occurs when 75 percent of the canola plants have three open flowers on the main stem. Usually this occurs during the last week of June or the first week of July.

How to complete the checklist:

Read each question and circle the point value assigned to the answer you choose. Count up the points for each question and enter the total for each section. Answer all the questions in this section.

Section one:

1.	Have you had good looking crops at flowering and poor yields at harvest, even though growing conditions were favorable?	Yes.....20 No.....0
2.	Have you seen sclerotinia stem rot in your crops in previous years?	Yes.....20 No.....10
3.	Have you heard of sclerotinia problems in your area in the past two to three years?	Yes.....10 No.....5
4.	Have you seen black sclerotes (sclerotia) in your harvested seed in the past two to three years?	Yes.....20 No.....10

5.	In previous years, have your canola crops lodged?	Heavily .....20 Moderately.....10 Lightly 0
6.	Do you see large swaths at harvest but get low yield?	Yes.....10 No.....0
7.	If you sprayed a sclerotinia fungicide in previous years, what were the results?	Better crop.....20 No difference 0

Total points for section one = _____

If you scored 60 or more in this section, you probably had sclerotinia stem rot in your canola crops. Proceed to section two with a 60 or more score.

Section two:

8.	When you walk through the crop during the morning at the beginning of flowering, are your boots and pant legs wet when you come out?	Yes.....20 No.....10
9.	Have you had wet weather in the immediate area within 2 to 3 weeks prior to flowering that allowed the soil to remain moist for extended periods?	Yes.....20 No.....10
10.	Were apothecia found in the field, around the field or in any neighboring cereal or canola fields where canola was grown in the previous 1 to 3 years?	Yes.....20 No.....10
11.	Do you feel it will be dry throughout the flowering stage of the crop?	Highly likely .....0 Moderately likely .....10 Not likely.....20

Total points for section two = _____

If you had a high score in section one and more than 50 for section two, you should consider applying a fungicide to protect your crop against sclerotinia stem rot.

Section three:

12. What is the condition of your stand of canola in terms of height, vigor and uniformity?	Excellent.....20 Good.....10 Fair .....5 Poor.....0
13. When you walk through your crop, how dense is the canopy?	Light.....0 Moderate .....10 Very dense 20
14. What is the yield potential of the stand?	10-20 bu/a .....0 20-30 bu/a .....10 Greater than 30 bu/a 20
15. In previous years, when your yield potential was 30+ bu/a, what were the actual yields?	Greater than 30 bu/a .....0 20-30 bu/a 20

Total points for section three = _____

If you scored 50 or higher in section three, along with high scores from the first and second sections (60 and 50 plus respectively), it may be worthwhile to protect your crop against sclerotinia stem rot. If you scored less than 50 in the last section, it is not likely worth applying a foliar fungicide.

Permission by the Canola Council of Canada
to reproduce this checklist is gratefully acknowledged.

Alternaria Black Spot

Cause

Alternaria brassicae and Alternaria japonica

Signs and Symptoms

Spots may develop at flowering on the leaves. These spots may be gray, gray with a dark border or black. Leaf spots often are surrounded by a yellowish halo. Black spots may develop on stems and pods. Severely spotted pods may contain shrunken seeds infested with the fungus. Green seeds often are found next to deeply penetrating pod spots, resulting in green seed formation and low test weight seed. Black spot usually is less severe in Argentine canola *(B. napus)* than in Polish canola *(B. rapa)*. Severely infected pods may split prematurely, resulting in shattering of seed.

Survival and Spread

Plants are infected directly from infested seeds or from spores produced on infected canola residue. The fungi also infect several weeds in the mustard family and survive on them. Frequent rains, fog or heavy dew and temperatures around 70 F during podding and ripening favor severe outbreaks of black spot.

Disease Management

Buy certified, disease-free, germination-tested seed that has been cleaned properly. Most seed treatment fungicides effective against blackleg also will help control seed-borne black spot. Use well-balanced fertilizer applications because stressed plants are

more susceptible to black spot. When swathing, avoid a heavy swath; instead, choose a light swath that will dry more rapidly. Combine as soon as possible.

White Rust (Staghead)

Cause

Albugo candida

Signs and Symptoms

This disease commonly occurs on Polish canola *(B. rapa)*, as well as on brown and oriental mustard *(B. juncea)*. The most obvious symptoms of white rust are the swollen flowering stems and pods. These swollen tissues may be spiny, resulting in the name staghead. The stagheads initially are green but later turn brown. In wet weather, powdery white spore masses develop on the stagheads, stems and lower surfaces of leaves. Severely diseased leaves may turn yellow and drop. Yellowing leaves may develop "green islands" of tissue over each pustule.

Survival and Spread

The fungus, *Albugo candida*, survives as thick-walled spores in the stagheads, many of which fall to the ground during harvest. Many stagheads are broken during combining, resulting in the release of the spores. The following spring, these thick-walled spores germinate and infect the cotyledons and leaves of young plants. Secondary spread from cotyledons and leaves to the flower parts occurs from a second type of spore.

Disease Management

All Argentine *(B. napus)* varieties are resistant to white rust. Most Polish canola *(B. rapa)* varieties are susceptible, but a few newer varieties are moderately susceptible, moderately resistant or resistant. Seed of susceptible Polish varieties should be cleaned thoroughly to remove staghead fragments from the seed. Do not plant canola on canola if susceptible varieties are being grown. Control volunteer canola and wild mustard early in the season because the fungus can reproduce on the cotyledons and young leaves.

Downy Mildew

Cause

Peronospora parasitica

Signs and Symptoms

A white, mealy growth develops on the lower surfaces of leaves as well as on the green stagheads caused by the white rust fungus. The upper leaf surface opposite the infected area turns yellow.

Survival and Spread

The downy mildew fungus, *Peronospora parasitica*, is favored by cool, moist weather. It frequently occurs in association with white rust, and the disease complex usually is more serious than either disease alone.

Disease Management

Downy mildew rarely is observed and has not been of economic concern in North Dakota. When disease is observed, it often is found on young seedlings in densely planted fields when conditions are very wet. As seedlings grow or temperatures rise, the disease usually disappears.

Clubroot

Clubroot is a destructive disease of many crops in the cabbage family. In 2003, it was detected in Alberta, Canada, where it has become a serious threat to canola production. It subsequently has been detected in western Saskatchewan. It has not been reported in North Dakota.

Cause

Plasmodiophora brassicae

Signs and Symptoms

Galls and club-shaped growths appear on roots. The galls are firm and white, later becoming soft and gray-brown. Severely infected plants are stunted and may wilt.

Survival and Spread

Resting spores of the fungus survive many years in the soil. When soils are wet and susceptible roots are near, the resting spores germinate, producing swimming spores (zoospores) that infect the roots. The disease is spread by cultivating equipment moving soil from field to field.

Disease Management

No satisfactory management exists. Alkaline soils are less conducive to clubroot than acidic soils. In acidic soils, liming may reduce severity. Avoid introducing soil from infested areas. In Alberta, the primary mechanism of spread has been through infested soil carried on farming equipment. The clubroot pathogen is known to occur in British Columbia, Alberta, parts of Saskatchewan, Wisconsin, the Pacific Northwest, and eastern U.S. and Canada. Farm equipment obtained from those regions should be sanitized before use in North Dakota. The clubroot pathogen also causes disease on broccoli, cauliflower, cabbage and other Brassica species, so use caution when using transplants originating in these regions in gardens.

Aster Yellows

Signs and Symptoms

Distorted and sterile flowers are formed. Flowering portions of the plant may show excessive branching and stunting (shortened internodes), resulting in a "witches broom" appearance. Pods are replaced by inflated round or oval blue-green bladderlike structures. Infected plants produce little seed, but the percentage of infected plants usually is quite low. An exception was noted in 1999, when infection was noticeable in many fields in Minnesota and North Dakota, and economic losses occurred in a few fields.

Survival and Spread

The aster yellows phytoplasma does not survive the winter in Minnesota or North Dakota. It is transmitted by the aster leafhopper, *Macrosteles fascifrons*. The amount of aster yellows depends on the number of leafhoppers that migrate in from overwintering areas to the south, the percentage of leafhoppers carrying the aster yellows phytoplasma and the time of arrival of the leafhoppers.

Disease Management

The disease is rarely economic. Early planting may reduce the incidence of aster yellows.

Fusarium Wilt

Cause

Fusarium species

Signs and Symptoms

Affected plants first will exhibit stunting and foliar discoloration and eventually may wilt, leading to premature death. Pods of infected plants may be reduced in size and have few to no seeds. Fusarium wilt causes discoloration of the water-conducting vascular tissues in the upper roots and, when the disease is severe, in the lower stems; if a cross-section is cut through roots or lower stem tissues of infected plants, reddish-brown discoloration of the vascular tissues will be apparent. Yellow to brown streaking also may be observed along one side of the stem of infected plants.

Survival and Spread

In Canada, Fusarium wilt can be caused by either of the fungi *Fusarium avenaceum* or *F. oxysporum*. The pathogens survive in the soil. Little is known about the infection process, but symptoms may be more severe under hot and dry environmental conditions.

Disease Management

This disease has not yet been observed in the U.S. Crop rotation with cereal crops may reduce inoculum levels in the field. Data collected in Canada have shown that differences in cultivar susceptibility exist.

Root Rots

Several root and crown rots have been reported in North America. Seed decay and seedling diseases occur, but they usually are of minor importance. Foot rot (basal stem rot), caused by *Fusarium* spp. and *Rhizoctonia solani*, may develop late in the season, producing basal lesions with black borders and salmon-colored spore masses on the lesion surfaces. Basal cankers may cause plants to ripen prematurely. Brown girdling stem rot, caused primarily by *Rhizoctonia solani*, is a serious disease of Polish canola *(B. rapa)* in the Peace River region of northern Alberta, but it is not important elsewhere. A crown rot caused by *Rhizoctonia* sp. was reported in Indiana. No serious seedling disease or root rot problems have been reported in Minnesota or North Dakota.