Sclerotinia Diseases of Sunflower

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The Sclerotinia diseases are some of the most important diseases of sunflower. Three diseases, Sclerotinia wilt, middle stalk rot and head rot, are recognized in the field. Sclerotinia wilt is caused by soilborne fungal bodies called sclerotia, which infect the sunflower roots. Wilt is distinct from the other two diseases because it begins in the roots. Sclerotinia head rot and middle stalk rot are caused by airborne spores. They are above-ground diseases with similar disease development. All three diseases are caused by the same pathogen, *Sclerotinia sclerotiorum,* a very destructive fungus which is often called the "white mold" fungus. This is the same fungus that causes white mold of soybean, dry bean, canola and other susceptible crops.

Sclerotinia wilt. [Click Here for larger (25KB color photo) **]**

Sclerotinia wilt is the most important of the three diseases in North Dakota. It occurs whenever sunflowers are planted on *Sclerotinia* infested soil and can cause severe yield loss. Entire fields have been destroyed by this pathogen. Yield loss depends on the number of infected plants and when they were infected; the greater the number of infected plants and the earlier the infection, the greater the yield loss. On the average, an infected plant yields less than 50 percent of a healthy plant. In addition, the seed oil content is reduced on infected plants. Equally important, however, infection leads to increased levels of *Sclerotinia* in the soil. This can result in the removal of fields from sunflower production for many years. This has occurred in numerous infested fields in the Red River Valley. *Sclerotinia*, therefore, not only reduces yield, but it affects future production and economic gain from sunflowers.

Head rot and middle stem rot occur sporadically and only following periods of wet weather. These diseases are rarely observed in dry years. In 1999 and 1986 there were epidemics of head rot; the 1986 epidemic resulted in a 4 percent yield loss in eastern North Dakota. Head rot reduces seed weight and seed number and lowers oil content. The presence of sclerotia in seed can reduce the grade and market value of the crop. Infected heads often disintegrate in the field, resulting in all the seed falling to the ground. Furthermore, when the combine hits plants with infected heads, the heads shatter and seed is lost before it enters the combine. Head rot is a special problem in seed production fields because seeds produced in infected heads may have reduced germination and sclerotia produced in infected heads contaminate seed lots, affecting cleaning operations and certification. No toxins are produced by *Sclerotinia* in sunflower seed, but heavy contamination with sclerotia is considered unacceptable for human or animal consumption. Head rot usually has a greater impact on confectionary seed because of the low tolerance for sclerotia in such seed. There is also a low tolerance for infected seed for human food since about half of the infected seeds result in "brown roast" after toasting of the seed. Sunflower seed for export may be rejected at foreign ports if it contains sclerotia. Another important result of these two diseases is that they are the principal ways the fungus is introduced into clean sunflower fields. This occurs when sclerotia from diseased stalks and heads are incorporated into the soil. These sclerotia can cause wilt in following years.

Head rot showing skeleton head filled with sclerotia.
[Click Here for larger (29KB color photo) **]**

Symptoms

Sclerotinia Wilt

The most characteristic symptoms are sudden wilting of leaves, a root rot and a basal stem canker. Generally, wilting is first observed in fields just prior to flowering, but infected plants can be observed in the seedling stage. At first, wilted plants are scattered in the field, but later they are commonly found in series within rows. This disease usually appears in patches within the field. Because plants can wilt within several weeks from the time of infection, the onset of symptoms in the field appears rapid.

The bases of wilted plants showing various stages of canker development and decay. Note black sclerotia and white mycelium. Healthy stem on the left. [Click Here for larger (22KB) color photo **]**

White mycelium (mold) at base of wilting plant. [Click Here for larger (29KB) color photo **]**

Sclerotia inside pith at base of wilted plant. [Click Here for larger (23KB) color photo **]**

A water-soaked lesion develops at the base of the plant. The lesion becomes a grayish green to brown canker that often girdles the stem. As decay progresses the stalk becomes bleached and has a shredded appearance. The decayed portion may extend a foot or more up the stem. The pith is decayed in the base of the stem and there are hard, black resting bodies called sclerotia (about 1/8 to 1/4 inch in diameter). The sclerotia are produced by the pathogen and provide a positive identification of the disease. Infected plants lodge easily. During wet weather, white mycelium (mold) often develops at the base of the stem, hence the name "white mold."

Decay of the lateral roots and tap root is obvious, as often the plant can be easily pulled from the ground. The decayed cortex (outer layer of root) easily sloughs off, leaving the fibrous vascular tissues. Roots often have a wet rot consistency. Sclerotia may be found on larger lateral roots and the tap root.

Infected plants eventually die. The plant may or may not produce seed, depending on when infection occurs. Heads on wilted plants are generally smaller than those on healthy plants. Wilt can significantly reduce seed yield primarily through lower seed weights. Wilted plants in advanced stages of root decay are often blown over during high winds.

Sclerotinia Middle Stalk Rot

Middle stalk rot. [Click Here for larger (24KB color photo) **]**

Middle stalk rot is usually observed around or past flowering in the middle to mid-upper portion of the stalk. It begins as a brownish to grey water-soaked lesion, most commonly at or near the leaf node. A canker develops around the stalk, and the decayed tissue often has a wet, pulpy consistency. Usually the stalk falls over at the point of decay and the tissues above the canker die. Often a dense white mycelium and some sclerotia will be produced both inside and outside the stalk, especially during wet weather. Eventually the affected tissues become bleached and have a shredded appearance. Stalk decay may proceed downward to the stem base or upward to the head. Sometimes a leaf will be infected with *Sclerotinia*

and the fungus will decay the petiole and eventually reach the stem to cause middle stalk rot.

Sclerotinia Head Rot

Head rot. These symptoms occur prior to shredding of head.
[Click Here for larger (26KB color photo) **]**

The first symptoms of head rot usually are the appearance of a white fungus mycelium growing over the flower parts or the development of water-soaked spots on the receptacle (the fleshy part of the head). The fungus grows profusely within the receptacle, decays it, and produces white mycelium and many large black sclerotia. The receptacle is usually bleached and is easily distinguished from a healthy head. The entire receptacle can rot and the seed layer falls away, leaving only a bleached, shredded skeleton which consists of vascular bundles interspersed with large sclerotia. These bleached skeleton heads are very obvious in the field, often from a distance. When harvested, infected heads often just shatter and all remaining seed is lost. During wet weather the fungus will grow over the seeds and form large net-like sclerotia which can cover the front of the head. The seeds are usually not decayed but many are not filled. The large sclerotia in the heads are harvested along with the seed. These sclerotia may be ½ inch or greater in diameter. Sclerotia mixed in with seed confirms that a field had head rot. Head rot is a serious problem in seed production fields. In addition to reduced seed production, the outer portion of many seeds may be invaded by the Sclerotinia fungus, resulting in reduced germination.

The Pathogen

Sclerotinia sclerotiorum has been reported from almost all counties in North Dakota, but it is less frequently observed in the southwestern part of the state. The fungus is most common in eastern and central North Dakota where there is a history of production of susceptible crops such as sunflower, soybean and dry bean. As production of sunflower and other susceptible crops has moved westward, however, there have been increasing reports of Sclerotinia diseases in the western counties. The fungus is especially common on irrigated dry beans and soybeans.

Sclerotinia sclerotiorum has an extremely wide host range; it attacks approximately 370 species of plants in 142 genera, especially in the Cruciferae, Leguminosae and Solanaceae families. In North Dakota the row crops commonly damaged are sunflower, dry bean, soybean and canola; however, many other crops are susceptible, such as buckwheat, borage, flax, lentils, peas, potato, mustard, crambe, Jerusalem artichoke and safflower. Not all of these crops are as susceptible to *Sclerotinia* as sunflower and some are rarely damaged. Flax, for example, is rarely infected in the field and is recommended as a rotation crop in Canada. There are also many broad leaf weed hosts such as marsh elder, lambsquarter, pigweed, Canada thistle and wild mustard. *Sclerotinia* is also a pathogen on many common home garden vegetables and flowers.

Sclerotinia produces hard, black resting bodies called sclerotia which are highly variable in size and shape. The sclerotia survive in the soil for a number of years. Sclerotia germinate to form either a white mycelium (a mold which can attack the plant) or small mushrooms called apothecia. Apothecia are tan to light brown, average about 1/8 to 1/4 inch in diameter, and may be difficult to see. They produce spores termed ascospores (only visible with a microscope) which can infect susceptible plants. Ascospores are wind borne, which is the principal way the fungus is spread to other fields. Ascospores can survive on plants for two to three weeks during dry weather, but there is no evidence that they survive for extended periods, such as over winter.

Apothecia (side view). About 2½ times normal size. [Click Here for larger (20KB color photo) **]**

Apothecia in field next to soybean plant. [Click Here for larger (21KB color photo) **]**

Sunflower seed contaminated with sclerotia (arrows). [Click Here for larger (26KB color photo) **]**

There is another species of *Sclerotinia, S. minor,* which also causes wilt of sunflower. The symptoms are similar. This species has not been reported in the upper Great Plains, but occurs in California and in the east coast vegetable production areas.

Disease Cycle – Sclerotinia Wilt

Sclerotinia overwinters as sclerotia in the soil or plant debris. In summer when the growing sunflower roots come in contact with sclerotia, the sclerotia germinate and infect the roots. The fungus grows up the infected root into the tap root, then into the stem, and the plant dies. It also grows down the other lateral roots, eventually decaying the entire root system. Because there is contact between roots of adjacent plants within rows, the fungus can grow from one root system to another within the row, resulting in a series of wilted plants. The fungus does not generally move between 30 inch rows but may move between plants in adjacent narrow rows. Plants can wilt within two to four weeks following infection. The time from the first wilting symptoms to complete wilt may be only four to seven days. The rapid development of wilt is one reason why an apparently healthy field appears to come down with the disease in just several weeks.

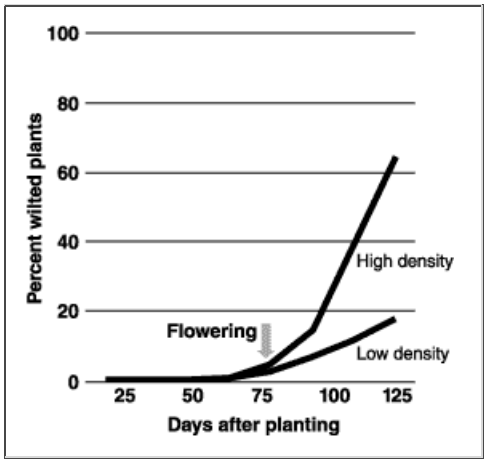
Sunflower is the only field crop that *Sclerotina* consistently infects through the roots. The other susceptible crops are infected mainly by ascospores on above-ground parts of the plant. This is a major difference between sunflowers and other crops.

As the fungus grows in and on tissues, sclerotia are formed; most are produced in the decayed stem pith and on the roots as the plant dies. From 25 to 100 sclerotia may be produced in or on an infected plant. These sclerotia are then returned to the soil during tillage operations and serve as sources of infection for the next susceptible crop. Sclerotia are long lived in the soil and fields remain infested for many years. A question most growers ask is, how long will sclerotia survive in a field? Unfortunately that is difficult to answer because each field has a different set of factors affecting survival, such as soil type, soil moisture and cropping history. These factors affect the numerous microorganisms in the soil that destroy sclerotia. High soil moisture and high temperature are conditions that favor microbial degradation of sclerotia. Survival also depends on inoculum density (the number of sclerotia in the soil). The higher the inoculum density the longer *Sclerotinia* will survive. Research in North Dakota has shown that on the average, populations of sclerotia decline about 20 percent per year when infested fields are planted to nonsusceptible crops. A highly infested field, therefore, would require many years in non-susceptible crops to reduce the inoculum density to a low level.

In North Dakota, Sclerotinia wilt occurs every year sunflowers are planted in infested soils. This distinguishes wilt from head rot and middle stalk rot. Wilt develops in most soil types found in North Dakota and during most environmental conditions that occur in the growing season. Soil moisture and temperature do not appear to be critical factors in disease development. There is some evidence that late planting reduces disease incidence. Infected plants are less tolerant of drought stress compared to healthy plants because of damage to their root system.

The most important factor affecting incidence of wilt is inoculum density. Research in North Dakota has shown that an inoculum density of 0.1 sclerotium per 1,000 cubic centimeters (about 1 quart) of tillage layer soil can result in about 13 percent wilted plants in a susceptible cultivar. However, an inoculum density of 1.0 sclerotium per 1,000 cubic centimeters of soil would result in about 65 percent wilted plants. In practical terms this means the fungus does not have to build up to very high levels before sunflower losses occur. At high inoculum densities, root infection occurs earlier in the season. Generally, many plants wilting within four to five weeks of planting is a strong indication that the ground has a high inoculum density. Early infections usually result in death of plants prior to flowering, which can completely destroy a crop.

Figure 1. Examples of disease progress of Sclerotinia wilt in fields with different inoculum densities. Notice that most plants wilt following flowering.



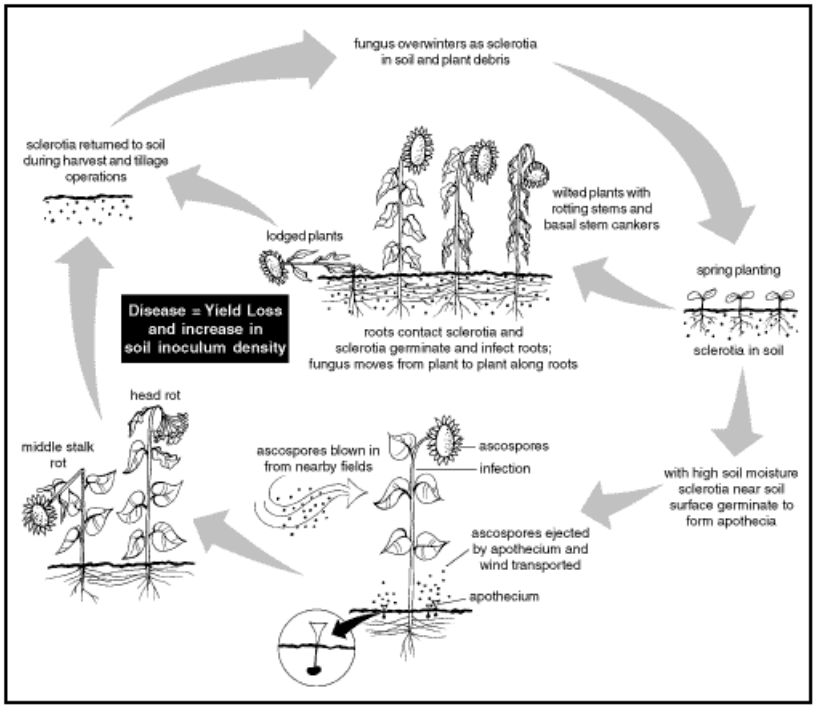
Plant-to-plant spread of the fungus is important in disease development in a field. It has been suggested in several publications that lowering plant populations to increase the distance between plants would reduce disease incidence. However, research in infested fields in North Dakota has shown no difference in the percentage of diseased plants between plant populations of 15 to 30 thousand plants per acre on 30- or 36-inch rows. There is, however, more lodging of wilted plants at high plant populations.

Sunflowers have a very dense lateral root system that is concentrated in the tillage layer. This greatly facilitates contact with sclerotia. The root system is not fully developed until flowering, and then there is maximum root contact between plants facilitating plant to plant spread of the pathogen. Also, root senescence begins after flowering and the roots are more susceptible to the pathogen. These are the main reasons why most wilted plants are observed after the beginning of flowering.

In infested fields the first wilting plants will generally appear within 40 to 50 days after planting, but most plants will wilt after flowering. Some will even wilt just before dry down. Figure 1 shows the progress of disease over time in two fields with different inoculum densities. Notice the slower rate of disease development in the low inoculum density field and the greater rate in the high inoculum density field. Also notice that most of the plants in both fields wilted after flowering.

Many *Sclerotinia* infested fields in North Dakota are the result of field-to-field spread by ascospores with subsequent infection of susceptible crops. Others are infested by the spread of sclerotia from field to field in wind blown soil, in soil on farm implements, and in moving surface water. Sclerotia can also be introduced with contaminated seed. Fortunately, certified seed is relatively free of sclerotia. For example, the North Dakota State Seed Department has set a tolerance limit of 5 sclerotia per pound for certified sunflower seed. Growers who do not purchase certified seed have no way of knowing whether the seed is relatively free of sclerotia or not.

Disease Cycle – Head Rot and Middle Stalk Rot



Disease cycle of Sclerotinia wilt, middle stalk rot and head rot of sunflower.

After about seven to 14 days of high soil moisture, the sclerotia in the upper 1 to 2 inches of soil will germinate to form apothecia. Apothecia are only produced from sclerotia that have overwintered in the field. Apothecia produce ascospores for a week or more if soil moisture remains high. The ascospores are ejected into the air, carried by the wind, and may land on sunflowers or other susceptible plants. Apothecia are produced most abundantly under crops with dense canopies and with cultural practices that maintain high soil moisture such as irrigation. They can be found between June and September but usually are not observed until after the crop canopy has formed. They are formed under a variety of crops such as small grains, corn, potato, dry beans, soybean and sunflower. Research has shown that ascospores can be wind-carried to adjacent fields. Infested fields planted to non-host crops such as corn or wheat can, therefore, be sources of ascospores for adjacent sunflower fields.

Ascospores require a film of water and a food base such as dead or senescing plant tissue to germinate and grow before they infect the plant. They may also infect through wounds caused by hail, insects, etc. On the sunflower head, ascospores use the flower parts to begin growth and they penetrate the receptacle and decay the entire head. The pathogen can infect the seed and exist as mycelium (thread-like strands of the fungus) in the seed coat, but infected seed is considered of minor importance in the spread of the fungus. On the stem, the ascospores apparently come in contact with a food base and water that accumulates in the stem-leaf axil, and infection occurs. Also, there are sucrose producing glands on the leaves, petioles and stem that may provide nutrients for ascospore growth. Leaf infections can lead to middle stalk rot. Infection of sunflower by ascospores is similar to how *Sclerotinia sclerotiorum* infects canola, dry bean, soybean and other susceptible crops.

The major reason head rot and middle stalk rot are sporadic and not as common as wilt is because moisture is necessary for apothecia production and ascospore growth and infection of the plant. Prolonged wet weather during flowering is associated with head rot. Serious outbreaks of these diseases do occur in wet growing seasons or under irrigation. They are most frequently observed in the eastern half of North Dakota or in irrigated areas where ascospore sources are common.

Certain dinitroaniline and triazine herbicides have been shown to stimulate apothecia production while certain phenolic herbicides inhibit production, but their effects on disease in the field is not understood. Some herbicides are also reported to inhibit mycelial growth of the pathogen.

Disease Control

The most important controls for the *Sclerotinia* diseases of sunflower are to not plant on infested soil and to prevent build-up of sclerotia in soils. Build-up prevention is done principally through 1) monitoring of fields for disease incidence and 2) crop rotation. Remember, a heavily infested field could be out of sunflower production for many years. Because occurrence of middle stalk rot and head rot is sporadic, disease control is usually aimed at control of wilt. At the present time plant resistance is not the principal control method. There are, however, differences in the susceptibility of hybrids to *Sclerotinia.* Also, there are no chemicals registered for control of wilt or ascospore infections of sunflower.

Summary of Control Recommendations

1. Do not plant sunflowers on land infested with sclerotia. Fields that have been planted to susceptible crops such as dry beans, soybeans or canola could be infested, especially in an area where *Sclerotinia* is common. If you rent land, find out the cropping and disease history before planting sunflowers. If you do not know if the land is infested, put out a test strip of sunflowers to check the amount of wilt that might develop.
2. Use clean sunflower seed. Planting certified seed minimizes the danger of introducing sclerotia into fields that are free of *Sclerotinia.*
3. Monitor fields of all susceptible crops for disease incidence. This is an important part of preventing *Sclerotinia* from building up in the soil. Accurate records of disease incidence and crop rotations are necessary for managing this pathogen. Sunflower fields should be monitored as late in the season as possible. If monitoring is performed too early, several weeks after flowering for example, disease incidence will be substantially underestimated. Remember that if other susceptible crops are planted in the rotation, you can maintain or build up the level of sclerotia in the soil even though there may appear to be little or no disease in those crops. Susceptible crops are often infected, but disease may not be apparent from above the canopy. It may be necessary to carefully search beneath the canopy to see sclerotia being formed. Dry bean, soybean, canola and crambe infected with *Sclerotinia* can produce large amounts of sclerotia and result in high inoculum densities in soil.
4. When disease appears, rotate to a nonsusceptible crop such as small grains, corn or sorghum. The rotation time will depend on the incidence of disease. A three- to five- year rotation may be necessary when there is low disease incidence, while six to eight years or longer might be needed at higher disease incidence. A non-irrigated field with 10 percent wilted sunflower plants might require a four to five-year rotation to non-susceptible crops to reduce the incidence of wilt to less than 5 percent. Do not permit the incidence of wilt to exceed 1-2 percent before starting a rotation. This is necessary because a low incidence of wilt increases substantially after several years of continuous sunflowers, and long rotations are needed when there is a high level of sclerotia. Crop rotation to non-hosts is the **most important method** to prevent build-up of sclerotia and to reduce the levels of sclerotia.
5. If a high incidence of wilt (20%) is observed within four- to five- weeks after planting, consider plowing or disking down the sunflower crop to kill the plants. This will prevent further development of disease and production of sclerotia in infected plants. If such a field is allowed to reach maturity, there would be an extremely large amount of sclerotia produced that would affect future susceptible crops. The field would also have little if any yield.
6. Maintain good broadleaf weed and volunteer sunflower control.
7. To minimize head rot and middle stem rot, avoid planting next to infested fields which could be sources of ascospores. Irrigated infested fields can be important sources of ascospores. Remember, ascospores can blow in from fields on adjacent farms.
8. The type of tillage operations may affect disease incidence. There is evidence that minimum or reduced tillage that maintains sclerotia on or near the soil surface may promote microbial degradation of sclerotia whereas deep burial of sclerotia promotes their survival. The number of apothecia, however, may be reduced by tillage practices that bury the sclerotia deep in the soil, such as with a moldboard plow. If sclerotia are buried by deep tillage, use shallow tillage in subsequent years to avoid bringing the sclerotia back near the soil surface. Tillage operations also redistribute sclerotia throughout the soil and can actually increase disease incidence by creating a more uniform distribution of sclerotia within a field.
9. Check current recommendations on susceptibility of sunflower hybrids to wilt and head rot.

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