UNIVERSITY OF ILLINOIS EXTENSION
College of Agricultural, Consumer and Environmental Sciences

report on
PLANT
DISEASE

RPD No. 1008
March 2000

DEPARTMENT OF CROP SCIENCES
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

SCLEROTINIA DISEASE, WHITE MOLD OR WATERY SOFT ROT

Sclerotinia disease (also known as white mold, watery soft rot and cottony rot) is caused by three fungi in the genus *Sclerotinia: S. sclerotiorum, S. minor*, and *S. trifoliorum*. These fungi attack over 370 species of plants in 64 plant families (Table 1).

Figure 1. Sclerotinia drop rot on lettuce.

These widespread fungi infect plants grown outdoors and in greenhouses throughout the United States. Sclerotinia disease is most serious in the cool, wet regions of the world.

Depending on the crop or weed host, the *Sclerotinia* fungi can cause a blighting or rotting of any above-or below-ground part of the plant (Figures 1-20). Initially, disease outbreaks are usually patchy and spasmodic. But if favorable temperature and moisture conditions prevail during the growing season, the incidence of the discase can be high and its development can be extensive.

In addition to direct losses in the field, detection of a very small percentage of diseased beans, carrots, peas, pumpkins, or other vegetables in a truckload at the processing plant may result in rejection of the whole load. Even a low incidence of this disease may lower the grade or raise the cost of processing.

Sclerotinia disease generally becomes most prevalent in areas where the plant population is high, vegetative growth is dense, air movement is restricted, and the soil is quite wet for an extended period.

Figure 2. Alfalfa, Sclerotinia. K.T. Leath

Signs and Symptoms

The first symptom of the disease is a brown lesion shortly followed by a characteristic fluffy, white growth (mycelium) of the *Sclerotinia* fungus on infected host plants. Resting bodies (globular, flattened, elongated, or irregular in shape) called sclerotia are produced in the white mycelial growth.

For further information concerning diseases of ornamentals contact Nancy R. Pataky, Extension Specialist and Director of the Plant Clinic, Department of Crop Sciences, University of Illinois at Urbana-Champaign.

The sclerotia are white at first, but later become hard and black and are usually about 1/16 to ½ of an inch (2 to 10 millimeters) in diameter (Figures 2, 6, 10, 11, and 12). Droplets of water are often present on young sclerotia. In the later stages of the disease the fluffy mycelial growth may disappear but the black sclerotia are still visible either inside the stems of affected plants or on the surface of the lesions.

Figure 4. Lettuce head infected with Sclerotinia, showing symptoms of watery soft rot.

Symptoms vary according to the type of plant tissue involved. Leaves, stems, fruits, and storage organs may all be attacked.

Figure 5. Sclerotinia wilt and stem rot of larkspur. Sclerotia of the causal fungus have formed in the stem pith of the two plants on the left, and on the outside of the crown of the plant at the right (IL Natural History Survey photo).

Stem and crown (collar) rot, wilt (e.g., aster, begonia, cabbage, columbine, dahlia, delphinium, larkspur, lettuce, peony, potato, snapdragon, strawberry, tomato). Pale or dark brown and water-soaked areas or cankers (lesions) usually develop on the stem at or near the soil line. Under cool and moist conditions, the lesions on the stem become quickly covered by cottony webs of mycelium (Figure 3). The lesions continue to enlarge and may completely girdle the stem. Infected plants may not show symptoms other than the lesions during the early stages of infection. Symptoms at later stages of infection may include a slow or rapid wilting, withering, and death of the foliage beyond the lesion (Figures 1, 4, and 5) which may result in wilting and the collapse of the plant. Infection may also occur through the blossom, leaf, or petiole, then progressing into the stem. Sclerotia are formed internally in the stem pith or on the outside of the stem.

Leaf and petiole rot, flower or blossom blight (e.g., bean, beet, cabbage, cauliflower, celery, chrysanthemum, endive, lettuce, stephanotis). The leaves and petioles of such plants as beet, cabbage, cauliflower, celery, Chinese cabbage, endive, and lettuce suddenly collapse (drop) following infection of the oldest leaves and stem base (Figure 3). A slimy, wet, bacterial rot usually follows (caused by species of *Pseudomonas, Erwinia carotovora*, or both). The dense, cottony mycelium and sclerotia of the fungus are often visible on the lower surface of the outer infected leaves.

Figure 6. Wilting of leaves, canker formation, and dieback associated with Sclerotinia wilt and stem rot of larkspur (IL Natural History Survey photo).

In celery and celeriac, a characteristic area that is pink to reddish brown and water-soaked develops at the base of the affected petioles. This is often followed by the production of an abundant cottony mycelium. When infection is severe, the entire plant may collapse.

In some plants (such as garden beans, soybeans, and stephanotis), symptoms often become visible about a week after flowering. This happens because the blossoms are generally the first part of the host to become colonized by the fungus (Figure 7). The leaves, petioles, stems, and pods that are in contact with the invaded blossoms can

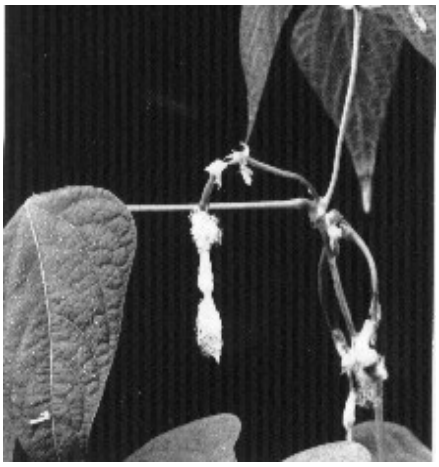


Figure 7. Blossom blight of snap bean caused by Sclerotinia sclerotiorum.

then become infected when moisture is present (Figure 8).

Diseased tissue is pale and water-soaked at first. The enlarging lesions become covered with the white, cotony mycelium. Within a few days, the leaves of severely diseased plants gradually turn yellow, then brown, and drop early. As the disease progresses, infected plants wilt. If the disease continues to progress, all plant parts that are above the ground may be killed.

Flower or blossom blight begins as small, tan to light brown spots in the petals. In wet weather, the spots rapidly enlarge and merge, blighting the entire petal. Eventually, the whole flower may become a dark brown; and when moist, covered with abundant, white mycelium (Figure 7). The fungus may grow from the blossom into the adjoining fruit, shoot, or twig and kill them for some distance (fruit, shoot, or twig blight).

Figure 8. Rot on a snap bean leaf. Infection started when an infected blossom fell on the leaf.

Fruit rot (e.g., bean, cucumber, eggplant, muskmelon, pea, squash). The tips of pods and other fruits growing on or near the soil may become infected and start to rot, although infection commonly spreads from diseased flower parts. Eventually, a wet rot results in complete decay. The white mycelium and black sclerotia are usually evident externally as well as within diseased pods and fruits.

Rot of flesh storage organs (e.g., bean, bleedingheart, cabbage, carrot, celery, pumpkin, squash). The typical white, cottony growth develops on any part of the plant in the field, in transit, or in storage (Figure 9). The sclerotia form externally (Figure 10). In stored plant parts, a secondary spread occurs from a single infected root, bulb, rhizome, or tuber which can produce cottony pockets or "nests" of rotted storage organs. Diseased tissue tends to collapse and produces a dark, watery, soft rot that is colonized by secondary bacteria (usually species of *Pseudomonas* and *Erwinia*).

Damping-off or bed rot (e.g., celery, celeriac, endive, lettuce, stock, tobacco). Patches of seedlings wilt and collapse form a water-soaked rot at or near the soil line. The typical cottony mold growth is sometimes evident on the soil surface. Seedlings may also rot before emergence resulting in poor, patchy stands.

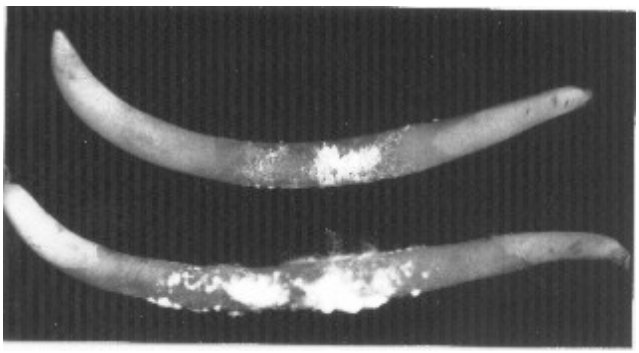
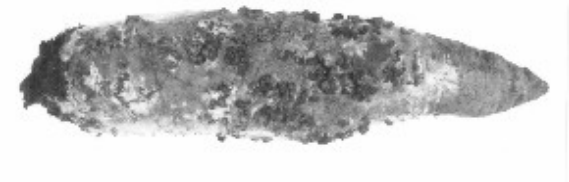


Figure 9. Snap bean pods infected by Sclerotinia sclerotiorum showing symptoms of watery soft rot.

Disease Cycle (Figure 12)

The *Sclerotinia* fungi survive between crop seasons as sclerotia in or on the soil. The sclerotia have a black rind and a dense gray center thus distinguishing them from seeds. After they mature, the sclerotia



become dry and fall to the soil surface or remain within diseased plant tissue. The sclerotia are distributed between fields on plant material, by machinery and vehicles, animals, flowing water, and with seeds. Sclerotia that overseason on the surface or in the top inch or two of the soil geminate, usually in the spring or early summer, at temperatures of 40° to 85F (4.4 to 29.4C).

The optimum range is 55° to 60°F (12.7° to 15.5°C). Germination results in one to many slender stalks that terminate in small (1/4 to ½ of an inch), disc or trumpet-shaped structures called apothecia.

Figure11.Sclerotia of Sclerotinia sclerotiorum taken from within a rotted peony stem. These hard, black bodies serve to carry the fungus through unfavorable conditions (IL Natural History Survey photo).

The pale, brownish yellow apothecia appear on or just above the soil surface following a damp period when the soil remains wet 9between saturation and field capacity) for about 10 days. When mature, the apothecia forcibly discharge large numbers of microscopic spores (ascospores) into the air as a cloud to a distance of 1 to 2 centimeters for a period of 2 or 3 weeks.

The ascospores are blown about by air currents up to a mile or more. Some of the sticky spores land on susceptible plant parts. If a film of water is maintained for 48 to 72 hours on host tissues, the spores germinate and invade the host tissue at temperatures of 40° to 85°F (4.4° to 29.4°C). The optimum range is 68°to 76°F (20° to 24.4°C). White, cottony fungal growth develops in and on the infected tissues within a few days. The production of sclerotia becomes evident in about 10 to 14 days, thus completing the disease cycle (Figure 12).

The sclerotia of the *Sclerotinia* fungi can also undergo a hyphal, or eruptive, mycelial germination. Hyphal germination is characterized by the production of a few short hyphal strands. These can colonize dying and dead plant materials that come in contact with them. Using the colonized material as an energy source, the fungus can then invade healthy host tissue. Eruptive mycelial germination is characterized by the production of a massive and dense mycelium that can directly infect healthy host tissue. In either case, more sclerotia are produced within a few days after infection, thus completing the cycle.

Research in New York has resulted in accurate monitoring of environmental conditions favorable to the production of apothecia combined with scouting or apothecia. The system is based on daily measurements in the growing crop of rainfall, tensiometer readings, and blossom development stage. Such a system permits snap bean growers to make fungicide applications only when needed.

Control

1. Pasteurize the soil in greenhouses and plant beds using steam (180°F or 82°C for 30 minutes or 160°F or 71°C for an hour at the **coolest** spot). Where only a small patch of plants is infected in an outdoor bed, drench moist soil with formaldehyde. Mix 1 pint of 38- to 40-percent commercial formaldehyde in 6 gallons of water. Apply slowly using a watering can, ½ gallon per square foot

of bed. After the treatment, cover the soil with canvas or plastic for 48 hours to hold in the fumes. After 2 to 4 days, remove the cover, work the soil, and plant when all odor is gone. **WARNING**: Do **NOT** use formaldehyde in a greenhouse where plants are growing. Formaldehyde is irritating to the skin, eyes, nose, and mouth. Wear protective gloves and a respirator when handling the commercial concentrate. Avoid inhaling the fumes. Wash the chemical from the skin or eyes immediately.

Once partial sterilization is completed, every precaution must be taken to avoid recontamination of the soil by introducing sclerotia on dirty boots or uncleaned tools and farm equipment.

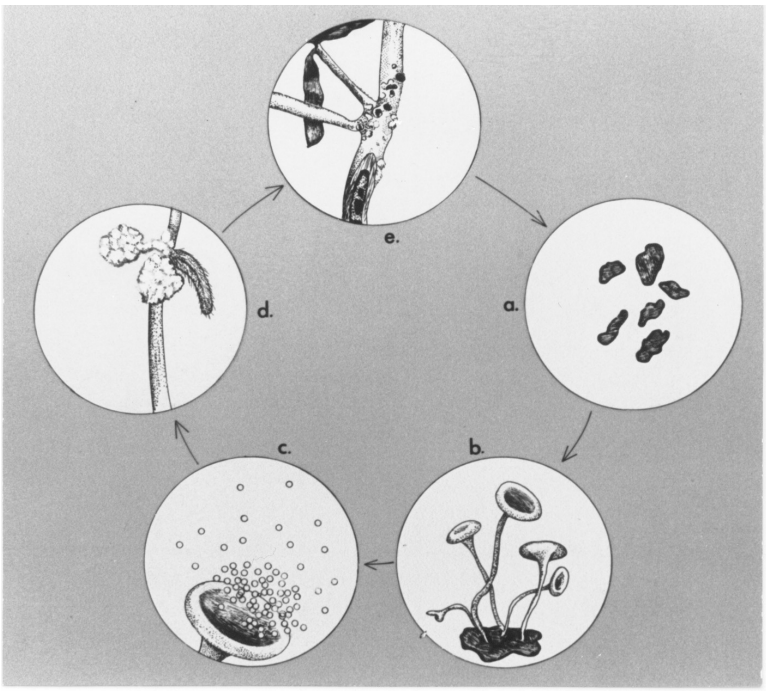


Figure 12. Disease cycle of Sclerotinia sclerotiorum. The fungus survives in or on soil and crop debris as black sclerotia (a). The sclerotia germinate to form trumpetlike apothecia (b), which discharge large numbers of ascospores (c). The microscopic spores are blown to susceptible plants where infection occurs that results in white, cottony fungal growth (d). Sclerotia later form in the cottony mycelial growth, both on and in infected tissues (e), thus completing the disease cycle.

2. Plant in well-prepared, well-drained soil on raised ridges or beds. Where feasible, cultivate the soil around the stems so it will dry rapidly. If mulching with an organic material is needed, avoid contact with the stems. Manure should also be kept away from the crowns of plants where stem rot is a problem.

3. In a small flower or vegetable garden, lighten heavy clayey topsoil by blending in sand, peatmoss, or well-decomposed organic matter; or replace the top inch or more of heavy topsoil with sand. Removing the infested soil and replacing it with new soil before seeding or setting out other plants in the vacant spot is another alternative.

4. Make every effort to prevent the fungus from forming sclerotia that will later contaminate the soil. Wherever feasible, collect and remove all diseased plant material promptly when infection is first detected. This refuse should be burned immediately, far away from the growing crop. Do NOT place the debris in a refuse dump or compost pile. The sclerotia can remain viable for 1 or 3 years, possible longer.

5. Keep infested soils as weed-free as possible. Numerous common weeds are susceptible (Table 1), allowing the *Sclerotinia* fungi to build up to high levels in the soil in the absence of a susceptible crop plant.

6. Make a clean and **deep** plowdown of infested soil in gardens or fields immediately after harvest. This buries most of the sclerotia to a depth of several inches where they will decompose and cease to be a source of infection for future crops.

7. Place root and other crops in storage immediately after harvest. Dipping or spraying the produce with a suggested fungicide at the time of cleaning will often sharply reduce losses in harvest and storage. A fungicide should be used only when labeled. The manufacturer's directions should be carefully followed.

   The storage area should be clean, cool, and dry without free moisture on the walls, ceiling, or floor and with a humidity of 90 to 95% to prevent shriveling and shrinking. Store only fully mature, blemish-free plant material without bruises or cuts. The temperature should be as close to freezing as possible, while still maintaining good eating quality.

8. Follow other cultural practices that promote the drying of soil and plant surfaces. Wherever possible: (1) avoid small fields surrounded by dense woods that restrict air circulation; (2) plant row crops in the direction of prevailing winds; (3) avoid excessively high plant populations and narrow-row spacing; (4) rotate with nonsusceptible crops, such as corn, grasses, and cereals, for at least a year; (5) avoid excessive watering that would keep the soil near the saturation level for 10 days.

9. There is **no** cure for the disease once plants are infected. Where chemical control is needed, apply a suggested fungicide as a soil drench to ornamentals and certain vegetables **before** planting or apply to the base of established plants as new growth appears. Spray the stems and soil surface of ornamentals and certain vegetables at 1- to 4-week intervals during cool, rainy periods in spring and early summer. Suggested fungicides are listed in University of Illinois Extension Service Pest Management Guide, revised annually. The timing and placement of fungicide applications will vary with the crop.

   When using any fungicide, carefully follow the directions and precautions as printed on the container label. The application of fungicides is difficult. Foliar sprays require more or less complete coverage of all above-ground plant parts, especially within the plant canopy. Thorough coverage and the proper timing of the first spray are essential in obtaining effective control.

10. There is **no** known commercial plant resistance to these Sclerotinia fungi so control measure depend on disease avoidance. It is vital to reduce the population of sclerotia surviving from one crop to the next to the smallest possible number.

Table. Plants Susceptible to *Sclerotinia sclerotiorum*[a]

Aconite
Acrodium
Alfalfa or lucerne
Alkanet
Almond
Amaranthus
Anemone (poppy)
Angelica
Anise
Apple
Apple-of-Peru
Apricot
Artichoke
Asparagus
Asphodel
Aster
Avocado
Babysbreath
Bachelors-button
Banana (Candish, common)
Barberry
Barley
Basil
Bean (Adzuki, black gram, civet, kidney, or dwarf, lima, mung, scarlet, runner)
Bedstraw (Catchweed)
Beet (garden, sugar)
Begonia
Bellfloer (chimney and willow)
Birsfoot-trefoil
Bittercress
Black-salsify
Bleedingheart]
Bluebells
Bristlegrass (green)
Broadbean or vetch
Broccoli
Broomrape
Brussels sprout
Buckhorn
Buckwheat
Burclover or toothed medic
Buttercup (Persian, wild)
Butterfly-flower
Cabbage
Calendula
Camellia
Candytuft
Cantaloupe
Canterbury-bell
Cape-gooseberry
Cape-marigold
Caraway
Carnation
Carrot
Castorbean
Cauliflower
Celeriac
Celery
Chamomile
Charlock
Chickpea or garbanzo bean
Chickweed (common)
Chicory
China-aster
Chinese cabbage
Chinese gooseberry
Chokeberry (red)
Chrysanthemum
Cineraria (florists')
Citron
Clover (alsike, crimson, Egyptian, holy, least hop, red, sierra, subterranean, white, zigzag)
Cockscomb
Columbine
Colza
Coriander
Cornflower
Corn salad
Cosmos 9common)
Cow-parsnip
Cowpea or black-eyed pea
Crabapple
Crabgrass
Crownvetch
Cryptomeria
Cucumber
Cynoglossum
Cypressor white-cedar (lawson)
Dahlia
Daisy (African, English, oxeye, Shasta, Swan river, Transvaal)
Dandelion 9common, Russian)
Deadnettle 9red)
Delphinium
Dill
Dock (yellow or curled)
Dutchman's-pipe
Eggplant
Endive
Escarole
Eucalyptus or gum
Euonymus
Evening-primrose
Fals-dragonhead
Fennel
Fenugreek
Fig (cultivated, magnolia-leaf)
Fireweed
Firewheel
Flax (common, flowering)
Forget-me-not
Forsythia
Foxglove
Freesia
Fuchsia
Gaillardia
Galinsoga (small-flowered)
Garden Cress
Garlic
Gayfeather
Fazania
Gentian
Geranium (fish, florists')
Gerbera
Gherkin (West Indian)
Ginseng (American)
Gladiolus
Globeflower
Gloxinia
Goldenbell
Goldenglow
Goldenrod
Gourd (yellow-flowered)
Goutweed
Granadilla (purple-flowered)
Grape (European wine)
Grapefuir
Groundnut or wildbean
Groundsel 9ragwort)
Guayule
Hebe
hedgemustard (tall)
Hemp
Henbane
Heuchera
Hibiscus (Chinese)
Hollyhock (Antwerp, common)
Hop (common or European)
Horsechestnut
Horseradish
houndstongu
Hyacinth
Hydrangea
Iris (English, German, Siberian)
Jamaica sorrel
Jerusalem-artichoke
Jute
Kale
Kale (tree)
Kenaf
Kohlrabi
Lambsquarter (c0mmon)
Larch (Japanese)
Larkspur (bouquet, candle, garland, rocket)
Lawson cypress
Lemon
Lentil
lettuce (head, leaf, prickly Romaine)
Lilac (common)
Lily (Easter, Madonna)
Lime
Lobelia (edging)
Lotusspecies
Lupine (blue, European blue, sundial, Washington)
Malvaviscus
Mangel
Marigold
Matilija-poppy
Medic (black)
Milk-thistle
Milkvetch
Milkweed
Monarch of the veld
Monkshood (azure)
Mountain-bluet
Mouse-ear cress
Mulberry (white)
Mullein (MOTH)
Muskmelon
Mustard (black, leaf, white, wild)
Myoporum
Narcissus
Nasturtiaum (garden, wild)
Nemesia
Nettle
New Zealand spinach
Nightshade (beaked or buffalo-bur, silverleaf)
Oak
Oats
Okra
Onion
Orange (common or sweet, Mandarin, sour or Seville)
Pak-choi
Pansy
Parsley

Parsnip
Papaw\Pea (field, garden)
Peach
Peanut
Pear
Pelargonium
Pennycress (field)
Peony
Pepper (chili, red or sweet)
Peppergrass
Peppermint
Periwinkle (common, Madagascar)
Pe-tsai
Petunia (garden, wild)
Phlox
Pigeonpea
Pigweed (rough, redroot)
Pine (Japanese red)
Plantain (broadleaf)
Plum (American, garden or prune)
Poinsettia
Poison-hemlock
Poppy (California, opium, wild)
Potato
Primrose
Proboscis flower
Pummelo
Pumpkin
Pursland (common)
Pyrethrum (common, dalmatian)
Quickweed
Radish (garden, wild)
Ragweed
Rape
Rape (bird)
Raspberry (red)
Rhubarb
Rice
Rocket-salad
Rock melon
Rose
Roselle
Rutabaga (swede)
Rye
Safflower
Sage
Salsify
Scabious (sweet)
Shepherds-purse
Slipperwort
Snapdragon
Soybean
Sowthistle
Spiderflower
Spikenard
Spinach
Spurge (thyme-leaved, toothed)
Squash (summer, winter)
Stephanotis
Stock (common, intermediate)
Strawberry
Strawflower
Sugar-apple
Sunflower
Sunn-hemp
Sweet alyssum
Sweetclover (annual yellow, yellow, white)
Sweetpea
Sweetpotato
Sweet sultan
Swiss chard
Tansymustard
Teasel (common, Fuller's)
Thistles
Tickseed
Toadflax
Tobacco (common, flowering, wild)
Tomato
Tree-tomato
Tulip
Turnip
Udo
Valerian (comon or garden-heliotrope)
Vetch (common, hairy)
Wallflower
Watercress
Watermelon
Wheat
Wildginger
Wintercress
Yardlongbean
Yellow rocket
Zinnia

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[a]Much of the host range of *Sclerotinia sclerotiorum* was compiled from a literature search (1938-1974) by Dr. Howard F. Schwartz.