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Integrated Management of Southern Blight in Vegetable Production[1]

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Southern blight (caused by *Sclerotium rolfsii* Sacc.) is a serious fungal disease affecting diverse crops grown around the world, especially in tropical and subtropical regions. The disease has been a major problem in the production of row crops like peanut in the southern United States. However, the disease is becoming more of a problem in vegetable production with the phase out of methyl bromide (EPA 2009) and the adoption of organic and other low-input production strategies. The production of fresh market vegetables is vital to Florida's agricultural economy. As the industry transitions from methyl bromide to other soil fumigants, it will become important for vegetable growers to recognize and manage this and other diseases caused by soil-borne pathogens.

Symptoms and Signs

Early symptoms of southern blight begin with a discrete light brown, water-soaked lesion at the crown of the plant near the soil line (Fig. 1). Depending on environmental conditions, white mycelia may be seen on the soil surface surrounding the ground at the base of the plant, especially if plants are grown on plastic mulch (Fig. 2) (Ferreira and Boley 1992; Mullen 2001). However, the disease is often not recognized

in the field until the plant begins to wilt. Often the wilting is diurnal, with plants recovering at night. Under favorable conditions, however, the wilting can progress rapidly, become irreversible, and lead to death (Fig. 3).
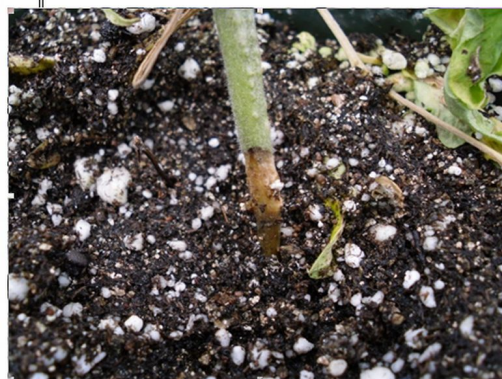

Figure 1. Development of southern blight on tomato. Image shows the initial necrosis and girdling of tissues at the crown of the plant. (Photo: Chenzhao Xie)

The fungus can attack seedlings, which quickly succumb to the disease. When the fungus attacks mature plants with woody tissue, growth is limited to

Figure 2. The development of a white hyphal mat of *Scerlotium rolfsii* around the base of an infected tomato plant and on the surrounding soil surface. (Photo: Gary Vallad)

Figure 3. The development of progressive wilting on a tomato plant inoculated with *S. rolfsii.* (Photo: Chenzhao Xie)

Figure 4. The formation of sclerotia (arrow) on infected crown tissues. (Photo: Gary Vallad)

Fruits can also be infected when in contact with soil or infected tissue, leading to a watery or mushy fruit rot with slightly sunken lesions on tomato, watermelon, and cantaloupe (Mullen 2001). Sclerotia can also develop on fruit (Figs. 5 and 6).

Figure 5. The formation of sclerotia on an infected tomato fruit.(Photo:http://erec.ifas.ufl.edu/tomato-scouting-guide/diseases/southern-blight.shtml)

the cortical tissues, leading to girdling of the plant (Ferreira and Boley 1992). Unlike wilts of flowering vegetables caused by *Fusarium* and *Verticillium* spp., the wilted leaves of affected plants generally remain green and hang on the plant. These symptoms can initially be confused with bacterial wilt caused by *Ralstonia* spp. However, unlike bacterial wilt, white mycelia can be seen near the soil line, often forming a mat around affected plant parts and serving as a clear sign of the pathogen (Fig. 2). In addition, numerous tan, round, or irregular mustard-seed-sized sclerotia are produced on affected plant parts and the surrounding soil surface shortly after mycelial growth is observed (Fig. 4).

Pathogen Biology

When conditions are favorable, the vegetative growth of *S.rolfsii* consists of fluffy white mycelia on infected host tissues three to four days after infection. About seven days after infection, mycelia begin to produce hard, round sclerotia, which measure 0.3 to 2.0–3.0 mm in diameter (Punja and Rahe 1992). Sclerotia are initially white and become yellow and tan or brown as they mature. No asexual spores are

Figure 6. Cantaloupe infected with *S. rolfsii*. (Photo: Amanda Gevens)

produced by *S. rolfsii*. The teleomorph (sexual or perfect stage) of *S. rolfsii* is described as *Athelia rolfsii* (Curzi) Tu and Kimbrough (Tu and Kimbrough 1978). It produces a specialized structure (basidiocarp) that produces specialized spores (basidiospores) similar to other basidiomycetes (such as mushrooms, puffballs, stinkhorns, etc.). While it has been observed under lab conditions, it has rarely been observed in the field, and the exact role of basidiospores in disease epidemiology, if any, remains unclear (Punja 1985).

Disease Cycle

S. rolfsii overwinters as sclerotia and mycelia in or on infected plants and debris. As sclerotia have a high demand for oxygen, they commonly germinate when they are in the upper regions of the soil, explaining why the disease is more damaging in sandy soils (Punja 1985). Sclerotia can be disseminated through transplant seedlings, water, wind, or any cultural practice that moves infested soil or plant debris.

After winter, sclerotia germinate and hyphal growth resumes. Susceptible plant tissues, lower stems, roots, and fruit can be directly penetrated by hyphae contact under ideal conditions. Wounds can facilitate infection as well. During the infection process, the fungus secretes oxalic acid and endopolygalacturonase, an enzyme which degrades plant tissues and cells, eventually leading to decay (Mullen 2001; Punja 1985). Disease continues to spread when hyphae and sclerotia reach new susceptible plant tissues while warm and humid conditions persist.

Epidemiology

Southern blight favors warm and wet weather; therefore, it is more serious in tropical and subtropical areas. Ideal temperatures for mycelial growth ranges from 8°C to 40°C (46°F–104°F), and the optimal temperature for sclerotia production is between 27°C and 35°C (81°F–95°F) (Punja 1985). Both sclerotial germination and mycelial growth favor water-saturated soils with high temperatures. Such conditions are also favorable for rapid disease development and plant-to-plant spread of the pathogen.

Integrated Management

Southern blight is difficult to control because the fungus has a broad host range that includes over 500 plant species, and sclerotia can survive for several years in soil (Aycock 1966). However, some integration of management methods may help to reduce the impact of southern blight during vegetable production.

Use of pathogen-free transplants and resistant cultivars

Transplant nurseries should be located far from vegetable production fields, and avoid excess watering and high temperatures. Vegetable transplants should always be inspected for overall health prior to planting.

The use of resistant cultivars is always a preferred method of disease management. Unfortunately, resistance to *S. rolfsii* has not been identified or is limited for many host plant species, and it is currently not a viable option for most vegetables. Resistance has been identified for some hosts. Six tomato breeding lines—5635M, 5707M, 5719M, 5737M, 5876M, and 5913M—were released jointly from Texas A&M University Research Center, Coastal Plain Experiment Station and the University of Georgia (Leeper, Phatak, and George 1992). Recent attempts to reassess resistance to *S. rolfsii* in pepper confirmed some useful levels of resistance in several pepper species, including in the bell-type cultivar 'Golden California Wonder', which is

conferred by a single recessive gene (Dukes and Fery 1984; Fery and Dukes 2005).

Crop rotation

Although crop rotation is a traditional and preferred method to control disease, it is not very effective in controlling southern blight because of the broad host range of *S. rolfsii* and the survivability of sclerotia in the soil. Yet rotating with non-susceptible crops, such as corn or wheat, may help decrease disease incidence in following years by lowering initial inoculum (Mullen 2001).

Soil solarization

Sclerotia can be killed in four to six hours at 50°C (122°F) and in three hours at 55°C (131°F) (Ferreira and Boley 1992). Covering moistened soil with clear polyethylene sheets during the summer season can reduce the number of viable sclerotia if the soil temperature under the sheet remains high enough for an appropriate length of time. While effective for smaller areas, solarization is generally impractical for larger commercial operations. Refer to http://edis.ifas.ufl.edu/IN824 for more information about solarization.

Deep plowing

Deep plowing in the fall or in the spring before bed preparation is another effective method. The ability of sclerotia to germinate is reduced with soil depths greater than 2.5 cm (1 in.). Soil depths of 8 cm (3.1 in.) or greater prevent germination completely due to the mechanical stress created by the soil over the sclerotia (Punja 1985). However, growers need to be aware that studies of other soil-borne pathogens have shown that deep plowing can spread the pathogen, changing the distribution of future disease outbreaks (Subbarao, Koike, and Hubbard 1996).

Soil amendents

Amending soils with organic fertilizers, biological control agents, and organic amendments—such as compost, oat, corn straw, and cotton gin trash—may help control southern blight. For example, the use of organic amendments, cotton gin trash, and swine manure was found to control southern blight through the improved colonization of soil by antagonistic *Trichoderma* spp. (Bulluck and Ristaino 2002). Deep plowing the soil combined with applications of certain inorganic fertilizers—like calcium nitrate, urea, or ammonium bicarbonate—was also shown to control southern blight on processing carrots (Punja 1986). Studies have proposed that the increased nitrogen inhibits sclerotia germination, whereas the increased calcium might alter host susceptibility. However, these approaches have not been tested in the sandy soils of Florida, and earlier studies indicated that the addition of inorganic fertilizers may be less effective in soils prone to leaching. Refer to http://edis.ifas.ufl.edu/VH037 and http://edis.ifas.ufl.edu/SS452 for more information about soil and water management and the use of soil amendments.

Chemical control

The use of soil fumigants, such as methyl bromide, chloropicrin, and metam-sodium, are the most practical means to treat seed beds and fields for a number of soil-borne pathogens, including *S. rolfsii* (Mullen 2001). They must be applied days to weeks before planting. However, the availability of methyl bromide is limited due to its status as an ozone-depleting material (EPA 2009).

Preplant fungicides, such as captan and pentachloronitrobenzene (PCNB), are effective in reducing disease severity. PCNB can effectively limit disease incidence when applied prior to infection and is registered for use on a limited number of vegetable crops. Some commercially available strobilurin fungicides (azoxystrobin, pyraclostrobin, and fluoxastrobin) are also labeled for the control of southern blight on certain vegetables and were found to provide some control of southern blight in peanut production (Culbreath, Brenneman, and Kemerait 2009; Woodward, Brenneman, and Kemerait 2007). Refer to http://edis.ifas.ufl.edu/PG100 for more information about the chemical control of vegetable diseases.

Biological control

Some biological agents, such as *Trichoderma harzianum*, *Gliocladium virens*, *Trichoderma viride*, *Bacillus subtilis*, and *Penicillium* spp., were found to antagonize *S. rolfsii* and could suppress disease. *Gliocladium virens* was found to reduce the number of sclerotia in soil to a depth of 30 cm, resulting in a decreased incidence of southern blight on tomato (Ristaino, Perry, and Lumsden 1991). *Trichoderma koningii* also reduced the number of sclerotia and the plant-to-plant spread of southern blight in tomato fields (Latunde-Dada 1993). However, there is evidence from a greenhouse study that *G. virens* has better biocontrol capability against *S. rolfsii* than *Trichoderma* spp. (Papavizas and Lewis 1989).

Summary

Overall, successful management of *S. rolfsii* in the absence of methyl bromide relies on the integrated use of several tactics. As with all diseases, always begin with healthy transplants. Avoid vegetable production in areas with infested plant debris or with a history of *S. rolfsii*. Once introduced into a field, *S. rolfsii* can be difficult to control, especially when environmental conditions favor disease development. Cultural practices, such as crop rotation, burial of inoculum through deep plowing, and the management of soil fertility, can help reduce disease development in problematic areas. Several fungicides and biopesticides are available for disease management, but should be used in concert with cultural practices to minimize the buildup of sclerotia in the soil. Several biopesticides are commercially available for use in organic vegetable production. While resistant cultivars are not an option for most vegetable crops, the loss of methyl bromide and increase in low-input and organic production has renewed interest in breeding efforts, including the use of resistant rootstocks to produce grafted vegetable transplants (Rivard et al. 2009).

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