COTTON PHYSIOLOGY TODAY

Newsletter of the Cotton Physiology Education Program -- NATIONAL COTTON COUNCIL

Vol. 7, No. 2, March 1996

Combatting Seedling Disease - A Beltwide Challenge

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Establishing a healthy, uniform stand of cotton is every grower's goal. Healthy seedlings can be managed to achieve earliness, improve quality and maximize yields. Conversely, weakened seedlings affected by seedling disease never amount to much. Here we address just what the seedling disease complex is, how it affects your crop's productivity, and what steps can be taken to minimize its impact.

Seedling Disease Complex

The seedling disease complex kills or damages cotton throughout the Belt in a window of time between planting and about one month after emergence. Soilborne fungi are the primary cause of seedling diseases of cotton. *Rhizoctonia solani, Pythium ultimum* and *Thielaviopsis basicola* are usually the culprits which act alone, or in concert – hence, the term complex. In some fields *Fusarium spp.* may result in seedling blight and poor stands.

Impact

According to the Disease Loss Estimates published annually in the Beltwide Cotton Conference Proceedings, the seedling disease complex is the number one disease problem across the Belt. In 1995 Beltwide losses to this complex were estimated at 3.82%. This percentage equates to an estimated loss of 829,199 bales valued at $323.4 million. Nonlethal effects of the disease complex, which last throughout the growing season, are not included in these figures. Plants that are damaged, but survive the disease, are more susceptible to damage by drought and other pests. These plants take longer to mature and produce lower yields.

Whereas management practices are under our control, the weather is not. Weather affects development of the seedling disease complex, which in turn influences stand establishment. Consequently, greatest losses occur in the regions where environmental conditions favor the disease (Table 1).

Symptoms

Identifying the fungi causing specific symptoms in an affected field can be difficult because the pathogens (i.e. disease-causing fungi) produce similar symptoms, and sometimes more than one pathogen is involved. A firm diagnosis usually requires the isolation and identification of the fungi in a laboratory. After collection and field diagnosis, sections of the diseased seedlings should be plated on agar media which are selective for different pathogens to confirm the diagnosis.

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Table 1. Losses attributed to the seedling disease complex by state and region in 1995. Dollars lost estimates assume $0.80 per pound. Data are from the Disease Loss Estimates published in the 1995 Beltwide Cotton Conference Proceedings.

REGION	STATE	% LOSS	BALES LOST	$ LOST MILLIONS
WEST	Arizona	2.5	44,969	17.5
	California	3.0*	81,994	32.0
	Total		**126,963**	**49.5**
SOUTHWEST	New Mexico	2.0	1,838	00.3
	Oklahoma	2.0	4,353	01.7
	Texas	5.0	282,353	110.1
	Total		**288,544**	**112.1**
MID-SOUTH	Arkansas	4.0	37,209	14.5
	Louisiana	6.0	95,292	37.2
	Mississippi	3.0	62,197	24.3
	Missouri	1.0	5,437	2.1
	Tennessee	6.0	53,294	20.8
	Total		**253,429**	**98.9**
SOUTHEAST	Alabama	8.0	43,727	17.1
	Georgia	1.5	34,483	13.4
	North Carolina	5.5	60,000	23.4
	South Carolina	4.0	21,053	8.2
	Total		**159,263**	**62.1**

Rhizoctonia solani

Disease lesions mainly occur on the hypocotyl (seedling's stem below its cotyledons or seed leaves), but can occur on tap roots as well. Lesions vary from a water-soaked appearance to light tan, reddish-brown or dark brown. They are usually sunken and characterized by well-defined margins. Infection and lesion development occur below the soil line, but as hypocotyls elongate, lesions may be apparent at the soil's surface.

Careful removal of diseased seedlings from soil often leaves a certain amount of soil attached to the roots and hypocotyl (Figure 1). If the cotyledons are held between one's fingers, the attached soil on the hypocotyl tends to 'dance' because it is suspended by hyphal strands of *R. solani* (Figure 1). When lesions occur near the soil line, they may be confused with abrasions to the tissues caused by the whipping of seedlings in the wind in a crusted soil. The term 'soreshin' has been used to describe this symptom for both the damage caused by *R. solani* and by mechanical injury caused by wind and crusted soil. Frequently, the diagnosis may be complicated by the presence and pathogenesis of other soilborne fungal pathogens.

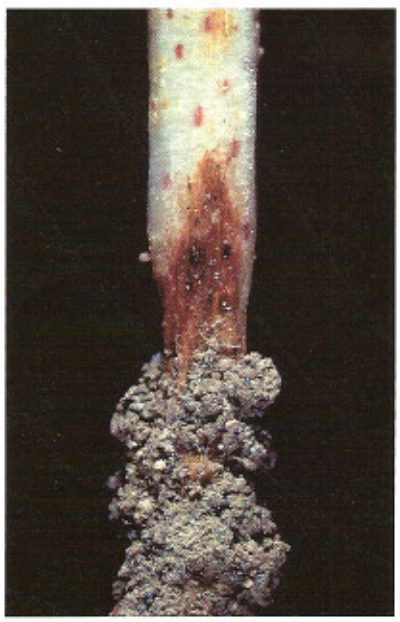

Figure 1. Hypocotyl lesion caused by *Rhizoctonia solani* on cotton. (Photo: J.E. DeVay)

Pythium ultimum

Seed rot and preemergence damping-off caused by *Pythium ultimum* are major problems in regions where soils at planting time and depth are often less than 60 °F. Seeds are rapidly invaded and rotted. Hypocotyls and roots of preemergent seedlings also are susceptible to infection and rot. Symptoms consist of root necrosis (death and decay) accompanied by light tan to dark discoloration of rotting roots and hypocotyl tissues (Figure 2). Accurate field diagnosis is difficult because the symptoms are often similar to lesions caused by other soilborne pathogens.

Figure 2. Root and hypocotyl rot of cotton seedling caused by *Pythium ultimum*. Diseased plant on left, healthy on right. (Photo: J.E. DeVay)

Pythium aphanidermatum also has been recognized as an important pathogen of cotton seedlings, but mainly in warm soils. Over much of the Cotton Belt, it has not been determined whether or not it contributes to seedling disease or merely nibbles at roots later in the season when soils are warmer. It is the species of *Pythium* principally involved in damping-off of cotton seedlings in West Africa.

Thielaviopsis basicola

Blackening of the tap root and rotting of lateral roots coupled with stunting of cotton seedlings are the main symptoms of black root rot caused by *T. basicola* (Figure 3). Development of black root rot is most severe where soils at planting time and depth are about 60 to 64 °F.

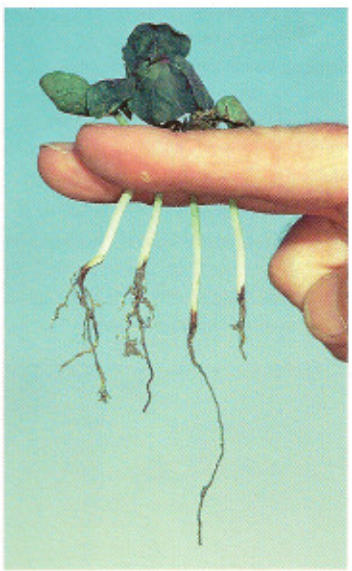

Figure 3. Cotton seedlings with symptoms of black root rot caused by *Thielaviopsis basicola*. (Photo: J.E. DeVay)

The causal pathogen infects and colonizes the epidermis and root cortex (Figure 4). Seedlings are not usually killed by black root rot, but are stunted in growth. The pathogen is associated with the rotting of the cortex tissue and loss of mycorrhizal symbionts, beneficial microorganisms associated with plant roots. Because the stele (central cylinder containing water and food conducting tissues) is usually not destroyed by *T. basicola*, a quick diagnosis for black root rot involves stripping away the blackened cortex tissues of the tap root between one's fingernails to expose the white tissues of the stele.

Pericycle cells within the stele are not destroyed by black root rot. As the soil temperature rises, new lateral roots and cortical cells are generated from the pericycle. Young tap roots quickly expand and shed the dead, blackened, cortical cells. During this period of a week or two, diseased seedlings appear to be idle and without noticeable shoot growth. Diseased seedlings seldom develop into plants with full productivity.

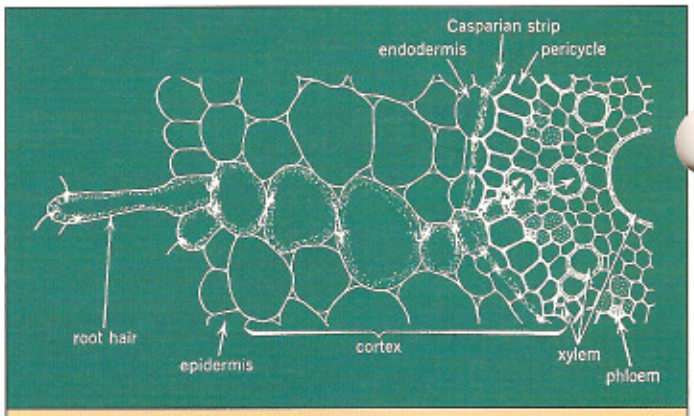

Figure 4. Root cross section showing outer epidermis, inner cortex and central stele containing xylem and phloem (water and food conducting cells, respectively). (Diagram: E. Epstein, 1972)

Control and Management

Early management decisions are aimed at improving conditions for seed germination and establishment, while reducing the chances of stand loss as a result of seedling disease. Key factors affecting the development of cotton seedlings include the following:

* general soil condition and environment
  - temperature
  - moisture
* weather for the 5 days following planting – especially hours of sunlight on the planted bed
* quality of seed
* technique used to plant
  - depth of covering soil
  - seed fungicides
  - soil fungicides.

Beltwide management of seedling diseases of cotton usually involves the treatment of seed with combinations of fungicides which are selective for the various soilborne pathogens. This approach is effective in seasons when weather conditions favor the development of cotton seedlings. However, if cold, wet weather (favoring the development of pathogenic fungi) follows planting of seed, damping-off or early death of seedlings often results.

In some regions chemical seed treatments are supplemented with soil treatments. These fungicides include those applied from a hopper box, or as in-furrow granules or sprays. Availability and rates often vary from state to state.

An overview of seedling disease in each of the four regions of the Cotton Belt is given here. Discussion includes the organisms responsible and specific control and management practices for minimizing the impact of early season seedling disease.

West (AZ, CA)

Pythium ultimum, Rhizoctonia solani and *Thielaviopsis basicola* are responsible for seedling disease in the West. Combinations of chemical seed treatments are useful for managing these diseases. Newly developed cotton varieties like Acala Maxxa, which are highly tolerant of *Pythium ultimum,* are the most economical and effective means of controlling damping-off. Additional varieties, such as Acala NemX, have high resistance to nematodes, and also have tolerance to *P. ultimum* and limited tolerance to *R. solani.* These new varieties are important breakthroughs in the management of seedling diseases.

The use of fungi such as *Trichoderma* species or bacteria as seed or in-furrow treatments for biocontrol of seedling diseases of cotton is frequently effective. This approach currently lacks the predictability of chemical seed treatments. Other management practices, including crop rotations with onions or small grains or soil flooding for control of *T. basicola* (black root rot), are useful where they can be applied.

Southwest (NM, OK, TX)

Cotton is grown over a wide range of conditions in Texas, yet seedling disease is a problem throughout the region. The greatest concentration of cotton is planted in the High Plains. Conditions at planting include variable moisture, cool soils and high winds. Approximately 45-55% of the cotton is dryland, which means that production costs are kept to a minimum. There is another heavy concentration of cotton in the Coastal Bend and lower Rio Grande Valley. Typically fields in these areas are planted into relatively warm and moist soils. Approximately one-third of the acreage is irrigated and two-thirds is dryland in South Texas. Planting rates are similar in much of Texas, often in the range of five to six seeds per foot. Only in far West Texas (Trans-Pecos area) are much higher seeding rates used.

Seedling disease in Texas is caused primarily by *Thielaviopsis basicola*, *Pythium spp.* and *Rhizoctonia solani*. *Pythium spp.* and *R. solani* predominate in South Texas. Black root rot caused by *T. basicola* is one of the most common seedling disease pathogens in the High Plains, though it is present throughout the state of Texas. In a cool year such as 1995, at least 60% of the fields in the High Plains will have moderate or severe seedling disease problems caused by black root rot. In years when rain occurs, damping-off (caused by *Pythium spp.* and *R. solani*) results in a high percentage of fields in the High Plains requiring replanting. When plants finally do emerge, black root rot still can cause delay in maturation.

These disease complexes are difficult to control because of the multiple organisms involved. Weather conditions often dictate which organisms are most obviously responsible for symptoms. Different patterns of rainfall and temperature favor development of different organisms.

New Mexico has few seedling disease problems because conditions at planting are usually dry with moderate temperatures. However, when problems do occur, they are due to *R. solani* and *T. basicola*.

Rotation is the only method which can be used to reduce damage by multiple pathogens. Generally rotation with small grains, sorghum, corn, etc. will reduce the seedling disease problems. However, they will not be eliminated. In a year with weather favoring the development of seedling diseases, even a little bit of *R. solani* and *Pythium spp.* can cause major losses. Planting wheat in the fall and following it by cotton the next spring is not what is meant by rotation. To be effective at reducing seedling disease, rotation requires a field to remain free of cotton (the susceptible host for these diseases) for a full year.

The easiest way to obtain a good stand of cotton is to use **high quality seed!** Experiment after experiment has shown that nothing else works to minimize seedling disease like using high quality seed. Trying to dress up low quality seed with fungicides is a waste of time.

Dr. Norman Hopper at Texas Tech University developed a test to look at seed germination at both warm and cool temperatures. When planting into cool soils, results of this test are quite useful. The Texas Agricultural Extension Service has guidelines available. Cotton producers in Texas use fairly high seeding rates to obtain a stand. Cutting back on the seeding rate and using high quality, fungicide-treated seed produce better stands than over-planting with low quality seed.

The most common method of managing seedling diseases in Texas and New Mexico is by fungicide seed treatments. In-furrow fungicide treatments can be used to increase the amount of product available to control *R. solani* and *Pythium spp.* In Texas and New Mexico, only 1% or less of the cotton acreage is treated with in-furrow fungicides. Research results have been highly variable as to the benefits of in-furrow fungicides. However, in fields with yearly damping-off problems, in-furrow fungicides may improve the stand.

If conservation tillage is practiced, seedling disease will increase, particularly if *R. solani* is present. Producers may want to purchase extra protection by using in-furrow fungicides.

In many parts of Texas it is necessary to plant cotton into cool soils, which aggravates seedling disease problems. The tools available to combat disease include rotation, high quality seed, in-furrow and seed fungicide treatments. It is important to protect against multiple organisms which can cause seedling disease under a wide range of conditions.

Mid-South (AR, LA, MO, MS, TN)

Rhizoctonia solani, Pythium spp. and *Fusarium spp.* are the predominant pathogens present in Mid-South cotton soils. *Thielaviopsis basicola*, a problem in some fields, appears to be on the increase across the Mid-South. In the absence of varieties with resistance to the seedling disease complex of organisms, control is approached through manipulation of the environment including use of seed treatment, planter box and in-furrow fungicides.

Whenever possible, a field with a history of severe seedling disease should be avoided. Crop rotation with small grains and corn is effective at reducing populations of these pathogens in the soil.

The importance of **environment**, in particular soil temperature and soil moisture, to the occurrence and severity of cotton seedling disease cannot be overemphasized. Good field preparation helps reduce seedling disease. Whereas a well-drained seedbed provides optimal conditions for rapid germination and seedling growth, compacted seedbeds keep seedlings in a susceptible stage longer by slowing germination and retarding seedling growth. Cool, wet soils generally favor seedling disease. Raised planting beds, which promote drainage and soil warming, are an important cultural practice for the Mid-South grower.

Because cotton germinates and grows slowly at soil temperatures below 68 °F, it should not be planted in the Mid-South until soil temperatures reach 68 °F and the five day forecast is for warm temperatures. The easiest way to control seedling disease in the Mid-South is to delay planting until the soils warm. For instance, in Louisiana seeds planted on April 15th often take 10 to 12 days to emerge from the ground. Cotton planted on May 5th takes only 5 to 7 days, a much smaller window of time for seedlings to become diseased.

Most, if not all, cotton planting seed used in the Mid-South is coated with two or more fungicides for control of seedling disease. The majority of seed is treated to control the seedling pathogens *Rhizoctonia solani* and *Pythium spp.* These seed treatments are not a substitute and cannot compensate for good seed quality. Using high quality seed with a high cold-germination rating and planting at a rate to ensure a good plant population also help reduce seedling disease.

Results from the National Cotton Seed Treatment Test conducted annually by the Cotton Disease Council clearly demonstrate improved plant stands associated with treating seed with a fungicide. The decision to apply fungicides may be viewed as an insurance policy to protect the crop against the possibility of adverse weather developing. Growers often use in-furrow fungicides to increase the amount of fungicide applied at planting, and thereby boost seedling disease control. It is particularly important to use in-furrow fungicides when soil temperatures are below 68 °F at planting, or when unfavorable weather is forecast. Planter box (hopper box) treatments also may be used to supplement seed treatments, but this practice is not as common as in-furrow treatments. Nematodes and early season insects such as thrips may increase the severity of seedling disease. Applying in-furrow insecticides/nematicides helps control these pests and reduce the susceptibility of seedlings to associated disease.

Stale bed culture and other reduced tillage management practices seem to be on the increase in the Mid-South. These beds warm more slowly in the spring. The increased amount of organic matter inherent with stale beds generally increases the severity of cotton seedling disease. An additional in-furrow application of fungicides is generally needed to obtain an acceptable stand. On the plus side, stale beds do not appear to be subject to the rapid drops in soil temperature that occur in conventional beds following the movement of cold fronts that sweep the Mid-South in April and May. Consequently because of more stable soil temperatures, stale beds should foster more consistent growth and development of young seedlings.

Southeast (AL, FL, GA, NC, SC, VA)

The primary pathogen causing pre- and post-emergence damping-off in the Southeast is *Rhizoctonia solani*. *Pythium spp.* and *Fusarium spp.* can induce seedling diseases, too. *Fusarium* rarely kills seedlings, but infected seedlings are often stunted and fail to thrive. Stand establishment is more difficult in cool, moist soils that occur more frequently in late March and early April plantings than in warmer soils typical of late April and May plantings.

Crop rotations and tillage practices influence the severity of seedling diseases. In research plots of late season cotton (planted after triticale), seedling disease severity was low to moderate with both conventional tillage using a moldboard plow, and with the conservation tillage practices of no-till, row-till or ridge-plant. However, in early-planted cotton, seedling diseases and post-emergence damping-off were increased by conservation tillage compared with conventional tillage of continuous cotton or cotton following peanut.

Populations of soilborne fungi potentially pathogenic to cotton seed and seedlings tend to increase following winter legume cover crops of crimson clover or subterranean clover. Numbers of pathogens tend to remain stable or decrease following fallow or rye. So it is not surprising that seedling disease severity is frequently greater in cotton following winter legumes than following small grains or fallow. Planting cotton following winter vegetables (or green-manure rye) may increase seedling diseases, especially if green decaying residues are adjacent to, or in contact with, cotton seed in cool soils.

Seed should be treated with labeled fungicides to help prevent seed rot. Soil fungicides labeled for in-furrow application to control *R. solani* and *Pythium spp.* in cotton may be beneficial in improving plant stand and root health in cool, wet soils in early-season plantings. Seed treatments alone may be adequate to control seedling diseases in warm soils, especially following mature small grains, unless the field has a history of seedling diseases.

Conclusions

The environment greatly impacts the development of seedling disease. Management practices to maximize chances of avoiding seedling disease include using high quality seed, combinations of chemical seed treatments, fungicides, in-furrow fungicides, rotations with other crops, and planting when soil temperatures are greater than 68 °F and when the five day forecast is for favorable temperatures and rainfall.

What's in the Research Pipeline?

Researchers are studying bacteria known to colonize cotton roots and aid their uptake of essential nutrients. Other researchers are looking into soilborne bacteria and fungi that compete with the fungi causing seedling diseases. Plant breeders are actively manipulating germplasm to include resistance to fungal pathogens. Chemical companies continue to develop new fungicides with different modes of action to stop pathogens. Expert systems being developed will provide tools to help growers target fields, portions of fields, or environmental conditions that warrant the use of fungicides to supplement standard seed treatments. Precision management has the potential to reduce the amount of fungicide needed while simultaneously maintaining or increasing seedling disease control.

The Cotton Physiology Education Program is supported by a grant to the Cotton Foundation from BASF Agricultural Products, makers of Pix® plant regulator, and brought to you as a program of the National Cotton Council in cooperation with state extension services.