COTTON DISEASES

by Melvin A. Newman

Cotton is a major crop in parts of the African Tropics, Australia, China, Egypt, India, Mexico, Pakistan, Soviet Union, the Sudan, United States, and warmer regions of Central and South America. Diseases have always been a problem wherever cotton is grown. Toward the end of the 19th century, concern was voiced about the increasing toll taken by diseases each year in the U.S. In 1887, studies were undertaken to determine the loss to Phymatotrichum root rot in the black lands of Texas. In 1899, Atkinson reported in detail the serious damage caused in Alabama by Fusarium wilt, anthracnose, bacterial blight and nematodes. These pioneering works have been followed by nearly a century of research and education on cotton diseases. In 1936 in Jackson, Mississippi, a small group of cotton pathologists organized the Cotton Disease Council, which has met annually except during World War II. This group shares information concerning the control of cotton diseases and studies ways to estimate disease losses. It has developed general lines for assessing yield reduction in cotton-growing states.

SEEDLING DISEASES

Seedling diseases are presently causing great losses to cotton producers in Tennessee. They comprise the number one disease problem. The estimated loss is an average of 8.6 percent annually based on a range of five to 18 percent since 1989. The average seedling disease loss for the U. S. Cottonbelt is only 3.0% annually for the same period. During cool, wet planting seasons, such as 1989, 1990, 1993, 1997, 2001, and 2003 seedling diseases can become severe. Loss estimates do not include the cost of replanting or losses due to lateness of replanted cotton. Table 1 gives the average loss from the major diseases over the past 13-year period.

CAUSE

A number of organisms are associated with cotton seedling diseases. The organisms include both seed- and soil-borne fungi and bacteria. The soil-borne fungi, ***Rhizoctonia solani*** and ***Pythium*** spp**.,** are the most important causes of seedling diseases in Tennessee. ***Rhizoctonia solani*** is the fungus most commonly associated with seedling diseases; however, during cool, wet seasons ***Pythium*** spp**.** may become more prevalent. ***Thielaviopsis basicola*** is being found to cause seedling diseases more frequently each year.

SYMPTOMS

The various phases of seedling diseases include seed-rot, root-rot, preemergence damping-off, and postemergence damping-off. The term "seed-rot" is used to describe the decay of seed before germination.

Root-rot (or black-root) may occur anytime after germination of the seed but may not become conspicuous or cause severe damage until after the emergence of the seedling. **Preemergence damping-off** refers to the disease condition in which the seedling is killed between germination and emergence from the soil. The death of seedlings resulting shortly after their emergence from the soil is termed **postemergence damping-off**. The latter is referred to as **"sore shin"** when only stem girdling occurs. ***Rhizoctonia*** is usually the cause of sore shin.

Table 1. Cotton Disease Loss Estimate for Tennessee
1989-2002

Disease	***Percent Loss to State Crop***													
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
SEEDLING DISEASES (*Rhizoctonia solani, Pythium* spp., *Fusarium* spp., etc.)	18.0	15.0	9.0	7.0	10.0	8.0	6.0	5.0	9.5	7.0	5.0	4.0	8.5	20.0
BOLL ROTS	5.0	2.0	4.0	5.0	3.0	2.0	3.0	4.0	3.0	3.0	2.0	3.0	5.0	5.0
VERTICILLIUM WILT (*Verticillium dahliae)*	0.4	0.2	0.15	0.3	0.1	2.0	1.0	1.5	1.0	1.5	0.75	0.25	0.1	0.1
FUSARIUM WILT (*F. oxysporium* f. sp. *vasinfectum)*	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	.01	.01
BACTERIAL BLIGHT (*Xanthomonas malvacearum)*	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASCHOCHYTA BLIGHT (*Ascochyta gossypi)*	0.2	0.1	0.1	.05	.05	.05	0.1	0	0.02	0.02	0.01	.20	2.0	2.0
NEMATODES	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.80	1.0	1.0	1.5
LEAF SPOTS (*Alternaria, Cercospora, Phomopsis,* etc.)	0.4	0.5	1.0	1.0	0.5	0.75	0.75	1.0	0.5	0.5	0.25	0.5	0.5	0.3
Total Percent Loss to Disease	24.21	18.01	14.46	13.56	13.86	13.01	11.06	11.7	14.23	12.43	8.82	9.06	17.11	28.91

COMMENTS: Loss estimates were taken from research and extension demonstrations and general observations taken across state by: Melvin A. Newman, Extension Plant Pathology and Albert Y. Chambers, Research Plant Pathology.

SEEDLING DISEASE CONTROL

Seed treatments: Fungicide seed treatments give control of seed-rot and some control of preemergence damping-off. However, seed treatments give little, if any, control of postemergence damping-off and root-rot. Seed treatment is quite effective in controlling seed-borne diseases.

Soil treatments: Postemergence damping-off and root-rot can be controlled to some extent by soil treatment (see Table 2). Three methods of applying soil fungicides are recommended in Tennessee. These methods are the **hopper-box method**, the **in-furrow spray method**, and the **in-furrow granule method. These methods should be used in addition to the recommended seed treatments. IN FIELDS WHERE SOIL-INCORPORATED, PREPLANT HERBICIDES OR GRANULAR, SYSTEMIC INSECTICIDES ARE USED, BE SURE TO USE A SOIL FUNGICIDE. Producers are advised to use the seedling disease point system on Table 3 to determine if fungicide application is necessary.**

Hopper-Box Method: Mix recommended fungicides thoroughly with fuzzy, reginned or acid delinted seed just before planting. Mixing may be done in a container, such as a tub, or alternating layers of seed and fungicide as they are placed in the hopper. **Application of the fungicide in the hopper-box may change the seeding rate, and recalibration of the planter may be required.** Because of handling and mixing the hopper-box materials, clogging of the planter and abrasive action of the chemical, this method is not as desirable as the in-furrow methods. Although less expensive, it is also less effective, but when used properly, gives better results than seed treatments alone, especially under lower disease pressure.

In-Furrow Spray Method: This method consists of applying a soil fungicide into the seed furrow and to the covering soil during the planting operation. Application is best accomplished with two spray nozzles mounted on the planter. A cone-pattern nozzle is suggested for applying the material into the furrow behind the planter shoe. This nozzle should be placed far enough behind the shoe to prevent wetting and clogging of the seed spout. The second nozzle should be placed so as to direct the spray into the covering soil in front of the press wheel. The recommended height for the front nozzle is 1½ inches above the original soil surface, with a TX6 tip and 2 to 3 inches above the soil for the back nozzle with a TX3 tip. Where space is limited and two nozzles cannot be used, substitute one nozzle with a TX8 or TX10 tip. Use 3-5 gallons of water per acre.

In-Furrow Granule Method: Granular fungicides or fungicide-insecticide combinations have given good control of seedling disease. They can be applied with applicators used for other granular chemicals and eliminate the need for additional spray equipment and water with the spray method. Effective control with granules depends on proper placement in the furrow between the seed spout and the covering device.

When using a single delivery tube, attach a flared baffle to the end approximately at a 45 to 90-degree angle to the row to obtain a 2-3 inch wide band. Granules then fall into the furrow from the seed drop to the covering device.

Cultural Practices: Certain cultural practices can help considerably in controlling seedling disease (see Table 3). Turning under crop residues as early as possible is suggested. Also, crop rotation with soybeans, corn, or grass will help prevent the buildup of organisms pathogenic to cotton seedlings. A well-prepared seedbed greatly enhances the chances of a good stand. Planting on beds has been shown to be of considerable value in some seasons by providing better drainage and warmer soil temperatures. Use certified seed or high quality seed with a germination of 80% or higher and plants only when soil temperatures reach 65-70°F and are expected to remain that high or higher for an extended period of time.

Table 2 **Soil Fungicide Treatment for Cotton**

Fungicide	*Formulation*	*[2]Rate/Acre*
		(Use higher rates where severe disease is expected)
In-furrow Granular Fungicides		
Terraclor Super X	18.8G	6 - 10 lbs.
[4]Terraclor	15G	5.5 - 10.6
Ridomil PC 11G	11G	7 - 10 lbs.
Ridomil Gold PC	10.5G	7 - 10 lbs.
In-furrow Fungicides + Insecticides Combinations		
Terraclor Super X-Di-Syston	6.5G-1.63G-6.5G	12 - 15 lbs.
[1]Terraclor Super X + Di-Syston EC	17.5-4.3-17.5	4 - 5.5 pts. (40 inch row spacing) (5-6 3/4 fl.oz/1000 row ft.)
In-furrow Sprays		
Ridomil Gold EC + Terraclor	4 EC + 2 EC	1 - 2 ozs. + 3 - 6 pts.
Ridomil Gold EC + PCNB2-E	4EC + 2EC	1 - 2 ozs. + 2 - 4 qts.
[3]Rovral	4F	3.4 - 6.9 ozs.
Terraclor Super X	2.5 EC	3-6 pts.
[3]Terraclor	2 EC	3 - 6 pts.
Ridomil PC Liquid (Twin Pak)	PCNB-24% @ 2 qts./A + Ridomil-25.1% @ 5 ozs./A	2 qts. and 5 ozs. (1 jug/5 acres)
[3]Quadris	2.08F	5.5 - 8.25 ozs.
Hopper-box Dusts and Slurries (not as effective as in-furrow methods under severe disease conditions)		
		Rate/100 lbs. seed
Delta Coat AD (HB Slurry)	3.5% - 30%	11.75 ozs.
Prevail (HB Dust)	15%-15%-3.12%	8-16 ozs.

NOTES: In-furrow spray treatments are recommended in 3-5 gallons of water per acre. In-furrow granules can be applied in-furrow with Temik 15G or Di-Syston with a split-box method. See pesticide labels for other use instructions and precautionary statement.

[1] In-furrow liquid application: Apply the specified dosage to the soil around the seed and to the covering soil as it fills the furrow. Do not apply directly to the seed. The soil around the seed and the covering soil should be thoroughly mixed with the product. Use the higher rates when weather conditions are expected to be unfavorable for rapid germination and in fields having a history of disease problems or in no-till situations.

[2] Dosage rate at 38" row spacing.

[3] Under cold, wet conditions where *Pythium* may be a problem, tank mix with Ridomil Gold 4EC or Terrazole 4EC for added control (see label for rates).

[4] Use where Pythium will not be a major problem.

Table 3

COTTON SEEDLING DISEASE POINT SYSTEM

by Melvin A. Newman, Professor
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Soil Temperature: 3-Day Average at 4 Inches	**Points**	_____
A. Less than 65 F	100	
B. 65 – 72 F	50	
C. Higher than 72 F	0	
Five-Day Forecast:		_____
A. Colder and wetter	100	
B. Colder	50	
C. Wetter	50	
D. Warmer	0	
Seed Quality: Cold Germination Value.		_____
A. Less than 59%	100	
B. 60-69 %	50	
C. Higher than 70%	0	
Field History: Based on Seedling Disease in Previous Years.		_____
A. Severe	100	
B. Moderate	50	
C. Low	0	
Tillage: Based on Field Preparation		_____
A. No-till	100	
B. Minimal tillage	50	
C. Conventional	0	
Row Preparation		_____
A. Firm beds present	0	
B. Beds not firm	50	
C. Bed absent	100	
Seeding Rate: Number of Seeds Per Row Ft.		_____
A. Low – 3 and lower	100	
B. Moderate: 5-6	50	
C. High: 7 and higher	0	
In-furrow Insecticide/Nematicide Applied: Temik, Di-Syston, Thimet, etc.		_____
A. Yes	100	
B. No	0	
Total: If Point Total Exceeds 150 In-Furrow Fungicide Application is Suggested.		_____

This point system is a modified version from a three-year regional cotton project. It should be used as a guide to determine the need for an in-furrow fungicide. It is not a guarantee of economical return.

The point system (See Table 3) was tested in 1996-1998 by scientists, consultants, and growers in most areas of the Cotton Belt. One version of the system is not likely to fit all beltwide conditions. The seedling disease complex can vary greatly from field to field, and from year to year, depending upon several cultural and environmental conditions in Tennessee. See cotton seedling diseases on the Cotton Pickin' web site – ipmwww.ncsu.edu/cottonpickin.

The use of soil fungicides should be determined by the **presence and intensity** of the following factors:

- **Soil Temperature**. Low soil temperatures create conditions that will slow seed germination and seedling emergence, thus extending the vulnerable period for infection. Many soil-borne pathogens are active at lower temperatures.

- **Five-Day Forecast**. Environmental conditions during the first week of planting are important to consider. A critical factor to evaluate is the combination of low soil temperatures and high soil moisture. Any condition that slows germination and growth of the seedling favors the seedling disease complex.

- **Seed Quality**. Poor quality seeds germinate and emerge slower than good qualify seeds under similar conditions. Slow germination and emergence extends the period seeds are vulnerable to infection.

- **Field History**. The history of each field should be evaluated to determine if it has had a stand-establishment problem, which may have been caused by factors including: soil type, drainage, soil pH, and levels of organic matter.

- **Tillage**. A no-till, or stale seed bed has a tendency to be slightly cooler and wetter than a conventional seed bed. This combination may be conducive to a carryover of disease inoculum on the past year's crop debris.

- **Seeding Rate**. Recommended seeding rates have gradually declined in most parts of the Cotton Belt. This increased the importance of getting a high percentage of seeds to germinate, emerge, and become established.

- **Insecticide/Nematicide Use**. Experience shows that the use of a soil fungicide can be a **"safening"** factory when certain soil-applied insecticides/nematicides are used.

- **Soil Moisture**. When soils are saturated with moisture for prolonged periods, seeds and seedlings are adversely affected. These conditions are ideal for the growth of several soil pathogens.

- **Planting Date**. A field planted prior to normal planting dates for its area will have conditions that **favor greater seedling disease pressure**.

VERTICILLIUM WILT

Verticillium wilt is one of the important diseases affecting cotton in Tennessee. It is the most damaging of the two wilts that occur on cotton. This disease is widespread in the cotton-growing area and is most severe during cool, wet growing seasons.

Verticillium wilt is caused by the soil-borne fungus, *Verticillium dahliae*. This fungus can survive in the soil for many years even in the absence of cotton.

Cotton seedlings infected with *Verticillium* usually turn yellow, dry out, and die. Plants, which become infected later in the season, are stunted and exhibit a yellow condition along the leaf margins and between the major veins. This yellow imparts a mottled appearance to the plant. Severely affected plants will shed their leaves. Sprouts or new shoots may develop near the base of infected plants.

Positive diagnosis of Verticillium wilt in the field can be difficult because of its close similarity of Fusarium wilt. Both wilt diseases cause a brown discoloration of the interior of the stem. The discoloration associated with Verticillium wilt is usually more evenly distributed across the stem than that associated with Fusarium wilt. The browning of the stem tissues is also usually less intense where the wilt is caused by *Verticillium***.**

The most tolerant varieties available should be planted in fields that are infested with *Verticillium* (See Table 4). Crop rotations will help reduce losses to Verticillium wilt, but they must be four- to six-year rotations. Any practice, such as bedding, which permits more rapid warming of the soil will also help reduce some losses.

LEAF SPOTS AND BLIGHTS

Several leaf spot and blight diseases occur on cotton and under favorable conditions can cause considerable damage. The most important of these diseases are Ascochyta blight (wet weather blight), bacterial blight (blackarm and angular leaf spot), Cercospora leaf spot, and Alternaria leaf spot. These diseases cause various types of leaf-spot and blight symptoms. The following measures will help control these minor disease problems: (1) use a recommended fungicidal seed treatment, (2) destroy crop residue by chopping and plowing it under when not under no-till conditions, (3) use suitable rotations as prescribed for other diseases, (4) plant resistant varieties when they are available and (5) keep the potassium at a high level according to soil tests.

Table 4

REACTION OF COTTON VARIETIES TO VERTICILLIUM WILT
Milan Experiment Station, Milan, TN – 2000-2001

Variety	*2000-Wilt Rating (0-10)*	*2001-Wilt Rating (0-10)*	*2000-Total Yield lbs. Lint/A*	*2001-Total Yield lbs. Lint/A*
FiberMax 989 (ck.)	0.8	0.9	782 d[1]	771 hi
FiberMax 958	1.6	2.3	1298 a	900 f-i
FiberMax 966	1.6	1.5	1294 a	1105 b-f
Deltapine DP 436 RR	1.9	2.3	878 cd	941 d-h
Deltapine DP 388	2.1	2.1	911 cd	908 e-i
Deltapine DES 607	2.3	--	890 cd	--
Sure-Grow 747	2.3	3.0	878 cd	1006 d-g
Sure-Grow 501 BR	2.4	2.1	931 cd	1252 abc
Deltapine DP 451 B/RR	2.4	2.4	905 cd	1127 b-e
PhytoGen PCS 355	2.4	2.5	1082 bc	1044 c-g
AgriPro AP 7115	2.5	2.5	928 cd	716 i
Deltapine DP 422 B/RR	2.6	--	812 d	1058 c-g
Stoneville BXN 47	2.6	2.0	900 cd	861 ghi
Stoneville ST 474	2.8	1.8	813 d	1146 bcd
Stoneville ST 4892BR	2.9	1.8	964 cd	1288 ab
Stoneville ST 4691B	2.9	2.5	1088 bc	1237 abc
Sure-Grow 125 BR	3.1	2.1	810 b	1127 b-e
Paymaster PM 1560 BG	4.3	1.8	1071 bc	1285 ab
Paymaster PM 1218 BG/RR	4.6	2.8	1196 ab	1413 a
Paymaster PM 1244 RR (ck.)	5.1	2.8	921 cd	859 ghi
Agri Pro AP 1500 RR	–	2.1	--	772 hi
Deltapine DP 422 B/RR	–	2.1	–	1058 c-g
LDS 5% (2000)	0.5	–	192	--
LSD 5% (2001)	–	1.0	–	195

2000 - Planted May 12; plots rated for wilt injury on September 8 and 21 with a final rating October 10 (rated 0 - no wilt symptoms observed to 10 - all plants dead); harvested October 3 and 12. Ratings made by Albert Y. Chambers.

2001 - Planted May 4; final plot rating made on October 10 (rated 0 = no wilt symptoms to 10 = all plants dead) final harvest October 31. Rating made by Tracy Bush and Albert Chambers.

[1]Mean figures followed by the same small letter do not differ significantly (P = 0.50, Duncan's New Multiple Range Test).

BOLL ROTS

Boll rots have caused heavy losses to cotton producers during wet growing seasons. Damage from boll rots is most severe in fields where rank growth occurs. Rain and high humidity during late summer and fall are optimum conditions for boll-rot development.

A number of fungi and bacteria have been associated with boll rots. Some of these organisms invade the cotton bolls directly, whereas others enter through insect wounds or as secondary invaders. Boll rots cause losses by reducing yields, damaging the cotton fibers, and infecting seed planted. Infected seed will result in seedling blights the following season. Boll rots usually first appear as water-soaked spots. Later, as the infection spreads, the bolls turn black and may be covered with a moldy fungus growth. Badly infected bolls may drop from the plant.

To prevent boll rots, cotton growers should avoid excessive applications of nitrogen that promotes rank growth of cotton. It has been found that skip-row cotton provides better air drainage, resulting in less boll rot. Defoliation will also help reduce boll rots. Bottom defoliation followed by complete defoliation about two weeks later has given good control of boll rot. A good insect control program will prevent injuries, which serve as infection sites for boll-rotting organisms.

Plant growth regulators such as Pix can also be used where rank growth usually occurs and boll rot is likely to be a problem. Pix **should not be** used on cotton under stress, especially drought stress.

NEMATODES

For several years reniform nematodes *(Rotylenchulus reniformis)* have been a severe problem in cotton production in several states south of Tennessee. In the fall of 1997-2000 the reniform nematode was found in several fields in Madison and Crockett counties. This nematode is spread very easily on farm equipment. Producers should sample their cotton land for this nematode in the fall after harvest. High levels of reniform have been found as deep as 36 inches the soil making control difficult.

No current cotton varieties are resistant to the reniform nematode. If the reniform nematode is present producers should either rotate with a non-host crop such as corn or grain sorghum or with a soybean variety resistant to reniform. The winter grain crops such as wheat, rye, oats and barley also are non-hosts; however, legume winter cover crops such as vetch and clover are hosts.

Reniform nematodes can infect and reproduce on cocklebur, cowpea, crotalaria, sow thistle, jimson weed, Florida beggar weed, and Florida pusley. Temik 15G at 5 lb./acre applied in-furrow at planting will reduce the reniform nematode population for the early part of the season. An additional side-dress application of Temik 15G at 5 lbs/A can be made for better control at the pinhead stage or two applications of Vydate 14 days apart starting at pinhead.

MAJOR COTTON DISEASE IDENTIFICATION & CONTROL CHART

DISEASE	CAUSE	SYMPTOMS	CONTROL
SEEDLING DISEASES (seed-rot, root-rot, and damping off)	Rhizoctonia, Pythium, Thielaviopsis spp., and several other fungi and bacteria	Seed-rot, root-rot, preemergence and post emergence damping-off.	Fungicide seed treatments help control seed rots and some preemergence damping-off. However, an additional soil treatment of fungicide must be used to control root-rots and most damping-off. In addition, producers must follow all other recommended cotton production practices decreasing seedling diseases. Some of these practices include use of correct planting equipment and date of planting, good seed bed preparation, correct use of herbicides and insecticides and use of high germinating seed.
FUSARIUM WILT	Fusarium oxysporum F. vasinfectum	Plants become stunted, yellowed, followed by defoliation. Yellowing first occurs around leaf edges and advances inward. Cross sections of infected stems usually reveal a brown discoloration that is more intense in outer layers of tissue. Infected plants fruit earlier and produce smaller bolls.	Reduce nematode population. Crop rotations. Use resistant varieties.
BOLL ROTS	Several fungi and bacteria	Boll rots usually first appear as water-soaked spots. Later, as infection spreads, bolls turn black and may be covered with a moldy fungus growth. Badly infected bolls may drop from plant.	Avoid excessive rates of nitrogen. Practice skip-row planting. Timely defoliation will reduce boll rots. Reduce insects that injure bolls. Growth regulators such as Pix can be used effectively to reduce boll rots.
LEAF SPOTS	Ascochyta, Cercospora, Alternaria, spp. and some bacteria	Various types of leaf spots and blights. Many spots occur on leaves toward maturity, but these are not usually damaging to the plant at this stage of growth.	Use fungicide seed treatments. Destroy crop residues. Use crop rotations and plant resistant varieties when available (esp. when Bacterial Blight is severe). Keep potash levels at least medium too high.
VERTICILLIUM WILT	Verticillium dahliae	Seedlings may become infected and turn yellow, dry out and die. Plants that become infected later in the season are stunted and exhibit a yellow condition along leaf margins and between the major vein. Severely affected plants will shed their leaves. A brown discoloration of the interior of the stem can usually be found later in the season. This discoloration is distributed evenly across the inside of the stem.	Plant resistant varieties when Verticillium Wilt is severe. A variety that matures very early may in some years escape injury from Verticillium Wilt. (See wilt resistance chart)
RENIFORM NEMATODE	Rotylenchulus reniformis	Above ground: Infested plants are usually slightly stunted. Plants under stress may be severely stunted and show potassium deficiencies. Under ideal growing conditions plants may not show any detectable symptoms. Reniform nematodes may cause increased incidence and severity of seedling disease.	Yield losses can range from 10-50 percent depending on stress and nematode population. Crop rotation with corn or grain sorghum will help reduce the population of reniform. The longer the rotation is the better the result. But the population may rebound when cotton is planted back. Soil samples for reniform nematode should be taken each year. Nematicides can be profitable under stressful conditions.

COTTON DISEASE CONTROL GUIDE

1. PLANT HIGH-QUALITY seed with 80% plus germination.
2. TREAT SEED with a fungicide to avoid early losses.
3. SOIL TEMPERATURE should be 65-70°F before planting.
4. IN-FURROW SOIL fungicides should be used in addition to seed treatments, not in place of them.
5. ROTATE to avoid the build-up of disease organisms.
6. DISEASE-RESISTANT VARIETIES should be planted.
7. CULTURAL PRACTICES, such as planting on a bed also helps prevent disease.
8. SOIL SAMPLE for nematodes.

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