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## BOLL ROT


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*Boll rot is a problem that continues to frustrate growers. If conditions are right, the best bolls are at greatest risk. Once a boll is infected, it is too late to contain the disease. Because boll rot can severely undercut even the most intensive earliness management efforts, this newsletter will discuss this long-time cotton nemesis and emphasize methods to lessen its threat.*

### Occurrence

Boll rot is not a universal or consistent problem for cotton producers. Surveys of boll rot occurrences and loss estimates demonstrate strong regional and seasonal variability. Table 1 presents the yearly range in state average yield loss to boll rot. In any given year, some fields may lose more than a third of the crop to boll rot in threatened areas. Southeast and Mid-South producers must contend with the problem to a certain extent each season. In some years, such as 1988, yield reductions from boll rot can be devastating. In contrast, producers in the drier regions of the U.S. are seldom confronted with the problem.

### Disease Cycle

Boll rot is a generic term referring to a number of diseases whereby bacteria and fungi cause damage to bolls, lint and seed . The bacteria and fungi each have characteristic lifecycles and mechanisms of destruction. However, as with all bacterial and fungal pathogens, three conditions must be met for disease to occur.

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First, the microorganism responsible for a given disease must be present. Species capable of producing boll rot are widespread in both nature and cotton fields. They may be soil borne or found in plant debris. Most fungal causal organisms produce air borne spores or cells that infect the bolls. These infectious units are frequently referred to as inoculum.

The second condition necessary for disease occurrence is the presence of a susceptible host. With diseases in general, the list of appropriate hosts can be either quite extensive or limited to one or two species of plant or animal. The causal organism must be able to grow and develop on a prospective host. A complement of nutrients (carbohydrates, amino acids, etc.) necessary for growth of the bacteria or fungi must be available. At the same time, host plant or animal defenses must be overcome for the disease to develop.

Host susceptibility is not constant across a species. In the case of many crop plants, certain cultivars are inherently more resistant or tolerant to certain pathogenic organisms. These cultivars may occur naturally or be the product of intensive breeding efforts. Age or crop developmental stage also determines susceptibility to pathogens. The physiological makeup of plant tissue changes with age, with corresponding change in susceptibility to pathogens. In the case of boll rot, little progress has been made in the develop-

**Table 1.**
**Range in statewide yield losses (percent) to boll rot, 1981-93, by region.**

| YEAR | SOUTHEAST (AL, GA, NC, SC) | MID-SOUTH (AR, LA, MS, MO, TN) | SOUTHWEST (OK, TX) | FAR WEST (AZ, CA, NM) |
|---|---|---|---|---|
| 1993 | 1.0 - 4.7 | 1.5 - 3.0 | 0.1 - 0.5 | trace - 1.5 |
| 1992 | 1.0 - 4.7 | trace - 6.0 | 0.1 - 0.6 | trace - 0.5 |
| 1991 | 0.5 - 5.0 | trace - 4.0 | 0.3 - 0.5 | trace - 0.5 |
| 1990 | 0.5 - 5.9 | trace - 3.0 | 0.3 - 0.5 | trace - 0.1 |
| 1989 | 2.0 - 10.0 | 0.0 - 5.0 | 0.3 - 0.5 | trace - 1.0 |
| 1988 | 3.0 - 20.0 | 1.5 - 7.5 | 0.1 - 0.5 | 0.0 - 1.0 |
| 1987 | 1.5 - 5.0 | 1.0 - 4.0 | 0.1 - 0.5 | trace - 1.0 |
| 1986 | 2.0 - 8.8 | 0.5 - 4.8 | 0.2 - 0.5 | 0.5 - 1.0 |
| 1985 | 1.0 - 9.0 | 1.0 - 4.5 | trace - 0.2 | trace - 1.0 |
| 1984 | trace - 4.0 | 0.0 - 11.0 | trace | 0.7 - 1.5 |
| 1983 | 1.0 - 5.0 | 0.0 - 4.0 | trace | trace - 3.0 |
| 1982 | 1.0 - 5.0 | 1.0 - 6.2 | trace - 0.1 | trace - 3.0 |
| 1981 | 2.0 - 4.0 | 2.0 - 7.5 | 0.3 - 0.5 | trace - 4.0 |

ment of resistant cultivars. However, plant characteristics which may provide escape from boll rot are available.

Finally, environmental conditions must fall within a certain range for the pathogen to germinate, grow and develop within the host. The optimum temperature and relative humidity for growth range from 60-90°F and 95-100% RH. Outside of these ranges, growth slows or stops completely. For example, if the relative humidity drops to 80% most fungal growth ceases. The environmental requirement for heat plus humidity explains why the rainbelt is more likely to suffer substantial yield loss from boll rot. Insect damage to bolls creates an ideal environment for disease development. In more arid regions, boll rot is usually associated with insect feeding sites or occurs during the early stages of boll opening when the lint moisture content is still high.

### Paths to Destruction

Pathogens that attack bolls may enter in three different ways. Commonly, wounds from insect or mechanical injury allow entry by fungi and bacterial pathogens. Pathogens also may penetrate bolls through the stomates, nectaries and opening sutures between the carpels. Several fungi are capable of direct penetration through the boll wall.

Once the pathogen has penetrated the plant tissue, it must be able to utilize available nutrients and colonize adjoining tissue to maintain this supply. The invader may not succeed if inhibitory compounds are present in the host environment. For example, phenolic compounds related to the anthocyanin pigment (responsible for leaf reddening) have been shown to inhibit fungal growth. Alternately, the host tissue may have a hypersensitive reaction that kills the surrounding tissue, which may deprive the pathogen of needed nutrients. The host also may have physical barriers that prevent further colonization and destruction. The separate locules within the boll may help accomplish this isolation.

If the host defenses are unable to prevent the establishment of the pathogen, further colonization and tissue destruction will occur. The pathogen may kill tissue in its advance by secreting substances that destroy the cellular integrity. The pathogen then lives on the dead remnants of the cells. Other pathogens feed directly on the living cells which may or may not die as a result.

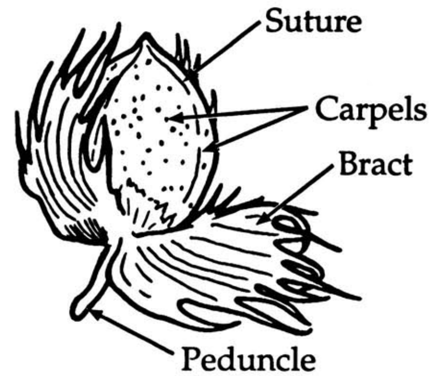
### Types of Boll Rot

At least 170 microorganisms are capable of causing boll rot. The majority of the damage in the Mid-South and Southeast can be attributed to the following species.

#### *Fusarium spp.*

Several species of *Fusarium* can invade bolls. These species often gain entrance to the boll through its base. The initial infection is seen on bracts surrounding bolls that are older than 35 days. The infection then spreads across the bracts to their attachment point at the base of the boll. Growth continues through the peduncle into the boll and progresses to the top. The rot may appear blue-black to brown on the inside of the boll. The outside surface often appears salmon-pink to white. The pink color on the surface indicates the presence of conidial spores.

**Figure 1**




#### *Diplodia spp.*

This fungus commonly attacks the bracts. With sufficient moisture *Diplodia spp.* can attack the boll through its basal connection with the peduncle, directly through the carpel wall or through the developing cracks at the sutures between the carpels. This fungus quickly can colonize the entire boll, producing a mat of black filaments and spores which in turn causes the boll to turn black. The boll then dries and splits open.

#### *Glomerella gossypii*

The initial symptom of attack from this fungus are small, reddish-brown spots with a central depression on the surface of the boll. In time, the spots enlarge and turn black forming spores that appear dirty gray to bright pink. More than half of the boll may become decayed. As the boll opens, the sutures open partially to the base, exposing the blackened lint in the affected locules.

#### *Xanthomonas spp.*

The same organism responsible for bacterial blight and angular leaf spot can cause boll rot. Symptoms of infection include a water soaked or greasy- appearing, circular, dark green region on the boll surface. This bacteria only can gain entrance into the boll through natural openings such as stomates, nectaries or insect feeding holes. The bacteria quickly colonize throughout the boll's fibers. Once infested, the affected lint "tight locks" or "hard locks." In harvested cotton, the lint will have yellow fiber spots. Contaminated seed will carry the disease to the next season.

### *Rhizoctonia spp.*

The same fungus responsible for "soreshin" in seedling cotton can cause boll rot near the soil surface. If the humidity is sufficiently high, filaments from the soil borne fungus extend up the stems and infest the bolls. *Rhizoctonia* boll rot produces a dull white mat of mycelium on the boll surface. It resembles *Fusarium* rot but the organism usually does not produce spores.

### *Alternaria spp.*

This fungus causes leaf spot in cotton as well as grasses and weeds. It is abundant on decaying debris in and around cotton fields. Released spores can penetrate bolls through the sutures of opening bolls. In regions with frequent dews and high humidity, the bolls in the lower portion of the plant are susceptible to this fungi. If moisture remains high, the entire boll may become infested and destroyed. If dry conditions return, the infected boll may "hard lock," preventing proper opening. Infected bolls are usually dull to dark brown when dried.

## Conditions Favoring Boll Rot

The primary factor controlling the prevalence and severity of boll rot is moisture. Microorganisms capable of producing boll rot can be found in virtually every cotton field. Ideal temperatures for boll maturation and opening also favor the growth and spread of boll rot. Persistent moisture and/or relative humidity predispose a crop to the full range of boll rot organisms.

It should not come as any surprise that the Southeast and Mid-South are the regions most impacted by boll rot. These areas receive more frequent late summer rainfall with accompanying higher humidities. This predisposition can be further aggravated by a dense canopy that restricts air flow and drying potential.

## Control Measures

Boll rot control begins with field selection. Poorly drained soil will retain more water and have higher relative humidity. Variety selection will help determine plant growth potential and risk for rank growth. Other variety characteristics associated with reduced boll rot include okra leaf for improved sunlight penetration; Frego bracts with less complete boll enclosure and nectarless that reduce insect attraction.

Skip-row planting patterns and lower in-row plant density improves air movement and drying which reduces the relative humidity within the canopy. Balanced nitrogen fertilization can supply the developing crop without promoting excessive vegetation. Vigilant insect scouting and prompt response to confirmed outbreaks diminish injury and subsequent boll rot. Effective insect management also reduces the likelihood of fruit loss which promotes rank growth. Pix applications also are warranted to maintain desirable growth characteristics.

Attempts to stop boll rot episodes in progress are largely ineffective. While the relative humidity can be reduced in the canopy by bottom defoliation, the major difficulty lies in accomplishing this without defoliating the upper portion of the canopy. Entangled and lodged limbs prevent precision application to the lower leaves. Removing upper leaves hinders or eliminates upper boll maturation. Therefore, the benefits and risks associated with bottom defoliation must be weighed carefully.

## Boll Rot in Arid Regions

Irrigated cotton in the arid Southwest and West is less threatened by boll rot organisms. The low relative humidity coupled with extreme heat do not create conditions that support widespread boll rot. This is well documented (Table 1) with boll rot losses averaging less than 1% during most years.

However, insect feeding sites can create conditions that support boll rot development. The interior of the boll has a relative humidity close to 100%. *Nigrospora oryzae* is a fungus that helps supply the nutritional needs of a mite. When the mite transports fungus spores to moist, immature lint during the early stages of boll opening, the affected locules "hard lock" and appear gray.

## Aflatoxin

*Aspergillus flavus* is capable of attacking several crop species including corn, peanuts and cotton. In cotton, this fungus can rot the carpel wall but is more notorious for its affect on lint and seed. Damage to the lint weakens and stains the fiber. When the fungus penetrates the seed, quality and viability are lost. More importantly, aflatoxin, a metabolic byproduct of the fungus accumulates. Aflatoxin is an extremely toxic substance and a recognized carcinogen.

*A. flavus* is not able to penetrate carpel walls of sound, unopened bolls. Infection can occur as the carpels separate during early stages of boll opening. If the drying process is delayed by excessive canopy or untimely rainfall, infection is more likely to occur. This infection route is secondary to that provided by the pink bollworm. Recent work in Arizona indicates early bolls on the bottom half of the plant which are attacked by the pink bollworm may account for more than 90% of the aflatoxin contamination. This finding enforces the need to maintain effective management of the pink bollworm to reduce levels of this toxin.

## The Dilemma

Conditions favoring boll rot are heat and humidity while conditions favoring plant growth are heat and moisture. The management dilemma that growers, particularly in the rainbelt, must address is how to mature cotton during weather that is favorable for both cotton growth and boll rot. The body of reported data supports the value of timely management, sometimes interpreted as earliness.

In our efforts to maximize productivity, nitrogen and irrigation are applied sufficiently to avoid mid-season stress that may induce premature cutout. At the same time, short-season varieties with compact fruiting periods are selected to enhance maturity and reduce their exposure to increasing insect pressures.

These practices must be coordinated as part of an integrated management strategy to realize the greatest benefit without suffering unacceptable losses to boll rot. Insect management must be honed for early detection and quick response to spikes in pressure. Growth regulation is crucial to producing robust, well-fruited crops on compact plants without excessive vegetation.

The management strategy also must take into account acceptable boll opening windows that may require deliberate delays in planting and boll opening. During prolonged periods of rainy weather, boll rot can wreak havoc on the smallest of plants. In acknowledgement of this, planting in the southern coastal plain of Georgia may be delayed until May to avoid boll opening during rainy periods in August. This same strategy may need to be employed in other regions where the benefits of earliness are being compromised by the occurrence of boll rot.

Late season and post-harvest management topics were discussed in several other *Cotton Physiology Today* newsletters including:

- Contamination: An Industrywide Issue, Oct.,1990, Vol. 2, #1
- Cotton Stalk Management, Sept., 1991, Vol. 2, #10
- The Cotton Diary, Sept., 1993, Vol. 4, #8
- Conservation Tillage, Oct., 1993, Vol. 4, #9

To obtain copies of these issues, call or write Pat Yearwood at the National Cotton Council, PO Box 12285, Memphis, TN 38182-0285, phone: 901-274-9030.

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