2003 BELTWIDE COTTON CONFERENCES, NASHVILLE, TN – JANUARY 6-10

# MANAGEMENT OF HARDLOCK IN COTTON IN THE SOUTHEAST

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## Abstract

The harvest season of 2002 was one of the most severe for hardlock in the humid areas of the cotton belt in recent history. Hardlock has been known to be a problem for years with unknown etiology and without any apparent means of control. Symptoms do not appear until the boll opens and the locks of cotton look more like a slice of an orange than a fluffed out boll of fiber. In many cases the quality of the fiber is not severely affected, but yields are reduced by 50% or more because conventional cotton pickers either knock the hardlocks to the ground or do a poor job of picking them. Due to the common occurrence of hardlock along the Gulf coast, there has been interest in strippers in UNR that could harvest all of the cotton regardless of hardlock. However, gin deductions, higher seed costs, and poor stands in narrow rows especially with reduced tillage has led to less interest and the dilemma of how to harvest the cotton produced. Hardlock has been found to be associated with high nitrogen, and high plant density. Studies in Quincy, Florida in 2002 correlated weather data of high temperature and high humidity to the amount of hardlock on the day of pollination or white flower. This correlation indicated infection was occurring on the day of pollination even though symptoms do not show up until boll opening. This study showed that fungi, especially *Fusarium moniliforme*, were also associated with the disease and the amount of cotton harvested could be increased with applications of the fungicide Topsin M. Fungicide applications made during the 8 weeks of bloom were the most effective at controlling hardlock and resulted in a 100% yield increase over the unsprayed, while applications made during boll opening increased yield about 30%. Fungicide application made at both flowering and boll opening did not increase yield significantly but did result in healthier plants. The fungicide delayed boll opening and natural defoliation by 7-14 days. The amount of hardlocked bolls was directly correlated with yield. Cotton seed weight and fiber length were increased significantly with applications of fungicide during the bloom period, perhaps due to bolls staying closed longer and developing further.

## Introduction

Hardlock reduced yields in the panhandle of Florida by 50-60% in 2002. This varies from year to year but may typically result in 20% or more loss which is common to much of the Gulf region and along the Atlantic coast. It has been associated with high nitrogen, high plant density, high temperature and humidity, insect damage, and seed rot (Marois and Wright, 2002, and Wright et. al, 2002). Because hardlocked bolls are not harvested by conventional pickers, yields losses of 50 to 80% have occurred in the panhandle of Florida. A specific cause or cure of the disease has not been identified. Extensive studies coordinated by Clemson University linked the occurrence of seed rot with hardlock and isolated a large number of bacteria after extensive sampling. However, no specific bacterial or fungal pathogen was identified (Jones, et al, 2000). The purpose of this research is to expand upon the efforts under way over the past four years that has identified *Fusarium monliforme* as the likely casual agent and to identify time of infection and to develop effective control measures against the disease.

## Objectives

Objectives of this study were:

- to determine if *Fusarium moniliforme* was the causal agent of hard lock
- to determine if the mode of entry was through the flower as was our hypothesis,
- to determine if *Fusarium moniliforme* could be controlled by fungicide applications (Topsin M) made during the bloom period as compared to those made during boll opening, vs. applications made at both times and compared to no applications.
- to correlate weather data with occurrence of hard lock.

## Materials and Methods

The study was conducted on a Dothan sandy loam (fine loamy siliceous thermic Plinthic Kandiudult), at the North Florida Research and Education Center in Quincy, Florida in 2002. Before planting the soil contained 26 ppm P, 118 ppm K, 133 ppm Ca and a pH of 5.6. The plot was fallow in 2001 with weeds controlled chemically. Roundup Ultra Max @ 1 pt/A + Weedar 64 @ 1 pt/A were applied on 4 April for weed control followed by Roundup Ultra Max @ 1 ½ pts/A on 29 April. The field was stripped with a strip till rig on 7 June and planted with a Monosem planter a 4 seeds per foot of row. DPL 555 BG/RR cotton was used with Thimet @ 6oz/A in furrow. Cotoran @ 1 qt/A + Prowl @ 1 qt/A, were applied immediately after planting preemergence. The Study was irrigated with ¾ inch of water on 13 June. Roundup Ultra Max @ 1½ pt/A was directed sprayed on June 27. The study was side-dressed 34/0/0 @ 176.47 lbs/A or 60 lbs/A AIN on sides of cotton on 9 July. Irrigation @ 6/10" was applied on 22 July. PIX @ 1pt/A + Staple @ 1.2 oz/A + Induce @ 1 qt/100gals were applied on 26 July. On 29 July Roundup Ultra Max @ 1½ pts/A + Dual 2 @ 1½ pts/A were direct sprayed for morningglory control. Topsin M was broadcasted @ 1.25 lbs/A on the following dates during bloom: 31 July, 7 August, 14 August, 19 August, 28 August, 4 September for the bloom sprays. Mepex was applied @ 1 ½ pt/A on 06 August and again on 16 August. The study was irrigated on 04 September @ ¾". Decis was applied@ 2 oz/A + Aridex @1 ½ pts/A on 06 September. Topsin M fungicide was applied during boll opening on 09 October, 17 October and 25 October at 1.25 lbs/A. Finish @ 1.5 pts/A + Leafless @ 12 oz/A + Agridex @ 1pt/A were applied on 31 October to defoliate cotton. Finish @ 2¾ pts/A + Leafless @ 12 oz/A + Agridex @ 1pt/A were applied on 14 November. All treatments were rated for hard lock on 19 November and harvested with a plot picker. Seed cotton was weighed from the four replications and a 2.000 lb sub-sample was taken for ginning. Seed weights as well as lint were recorded. On 20 November 1 Row x 50' of cotton that was hard locked and knock to the ground was picked up by hand from the control plots and ginned; the seed and trash were weighed separate from the lint.

## Results and Discussion

Continued isolation of *Fusarium moniliforme* as the most common fungi found in association with the disease led us to test if it was one of the main causes of hardlock. Inoculation of peduncles in 2001 resulted in a significant increase in hard lock in a relatively light year for hardlock (Table 1).

Likewise, when fungicides were applied during boll opening of 2001, a yield increase was observed under high nitrogen rates (Table 2).

In 2002, we worked under the assumption that it was *F. moniliforme* infecting the boll through the flower on the day of pollination and not during the boll opening period, which has been widely accepted. *F. moniliforme* isolates were sprayed into white blooms in 2002 with a significant increase in hardlock (Table 3).

This assumption could be tested by applying a fungicide known to have activity against *F. moniliforme* during the flowering period as opposed to the boll opening period vs. application during both periods (Table 4).

Treatments were rated for hardlocked bolls on 19 November. Disease severity was correlated very closely with yield. However, (Fig. 1) fungicide applications made during bloom had a significantly higher yield than those made just at boll opening. When applications were made at bloom and boll opening or both, plants stayed green longer resulting in opening 7-14 days longer before bolls opened. The correlation between amount of hardlock caused by *F. moniliforme* and yield was highly significant. Fungicide treatments to control hardlock at time of bloom resulted in less hardlock and higher yield than applications made during boll opening indicating that point of entry into the boll could be through the bloom and that by protecting the bloom, less hardlock occurred. During 7 weeks of blooming, 20 blooms were tagged each week to determine the amount of hardlock. A weather station near the plots recorded temperature and relative humidity every 15 minutes throughout the season. A correlation of the amount of hardlock to temperature and relative humidity showed that temperature and humidity from 7 A.M. to 7 P.M. on the day of flowering (white flower) was highly correlated (Fig. 2). There was no apparent correlation for any other day to the amount of hardlock including the 2$^{nd}$ and 3$^{rd}$ day after bloom. This data seems to make it more likely that the plant is being infected during pollination.

Cotton from each of the treatments was ginned and graded. Only fiber length was significantly longer from the bloom and bloom plus boll opening applications of fungicides. Seed weights were also measured from each treatment. Seeds from plots with bloom time applications weighed significantly more than those made during boll opening which weighed more than seeds from unsprayed plots (Table 5). Cotton left on the stalk after picking with a mechanical picker were picked by hand and seed weights were compared with those that did get picked, weights of these seeds were significantly lower than from the unsprayed plots that were picked mechanically. This would indicate poorer quality seed and perhaps lint too from 2$^{nd}$ picking or scrapping operations.

## Conclusions

Hardlock is a very severe problem for the humid area of the cotton belt. The year 2002 was especially severe with uninoculated plots averaging more than 50% hardlock. Fungicide applications made during bloom resulted in doubling of cotton yields over unsprayed plots or those made during boll opening. Tagged bolls over 7 bweeks of bloom and subsequent hardlock was highly correlated to temperature and relative humidity on the day of flowering and not the next day or the day after. Grades of cotton from bloom fungicide treated plots had significantly longer fiber than the untreated and boll opening applications. Likewise, cotton seed weights from fungicides applied during bloom and bloom plus boll opening were significantly higher than unsprayed plots. This data indicates that weather models may be able to predict when or if fungicide applications are needed.

Studies need to be conducted to determine effectiveness of other materials and to look at rates and frequency of applications for those fields and locations that tend to have hardlock problems routinely.

## References

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Table 1.

## Inoculation Results 2001

| Isolate | % Disease |
|---|---|
| *Fusarium moniliforme* | 63 a |
| *Fusarium moniliforme* | 54 ab |
| *Fusarium moniliforme* | 53 ab |
| *Fusarium moniliforme* | 51 ab |
| *Fusarium moniliforme* | 41 b |
| Control | 18 c |

Table 2.

## Inoculation Results 2002

| Isolate | %Disease |
|---|---|
| *Fusarium moniliforme* | 82 a |
| *Fusarium moniliforme* | 81 a |
| *Fusarium moniliforme* | 81 a |
| *Fusarium moniliforme* | 80 a |
| *Fusarium moniliforme* | 79 a |
| Control | 55 b |

Table3. Effect of benomyl applications and nitrogen on yield of cotton in 2001.

| Nitrogen (lb/A) | Cotton Lint Yield (lb/A) | |
|---|---|---|
| | No Fungicide Applied | Four applications of benomyl |
| 0 | 1314 | 1300 |
| 60 | 1307 | 1354 |
| 180 | 1056 | 1208 |

Table 4.

## Inoculation Results 2002

| Isolate | %Disease |
|---|---|
| *Fusarium moniliforme* | 82 a |
| *Fusarium moniliforme* | 81 a |
| *Fusarium moniliforme* | 81 a |
| *Fusarium moniliforme* | 80 a |
| *Fusarium moniliforme* | 79 a |
| Control | 55 b |

Table 5.

## Influence of Fungicide on Seed Weight

| Fungicide App. Timing | Seed Weight Grams/50 seed |
|---|---|
| Control | 3.62 c |
| Bloom | 3.97 a |
| Boll Opening | 3.76 b |
| Bloom and Boll Opening | 4.06 a |

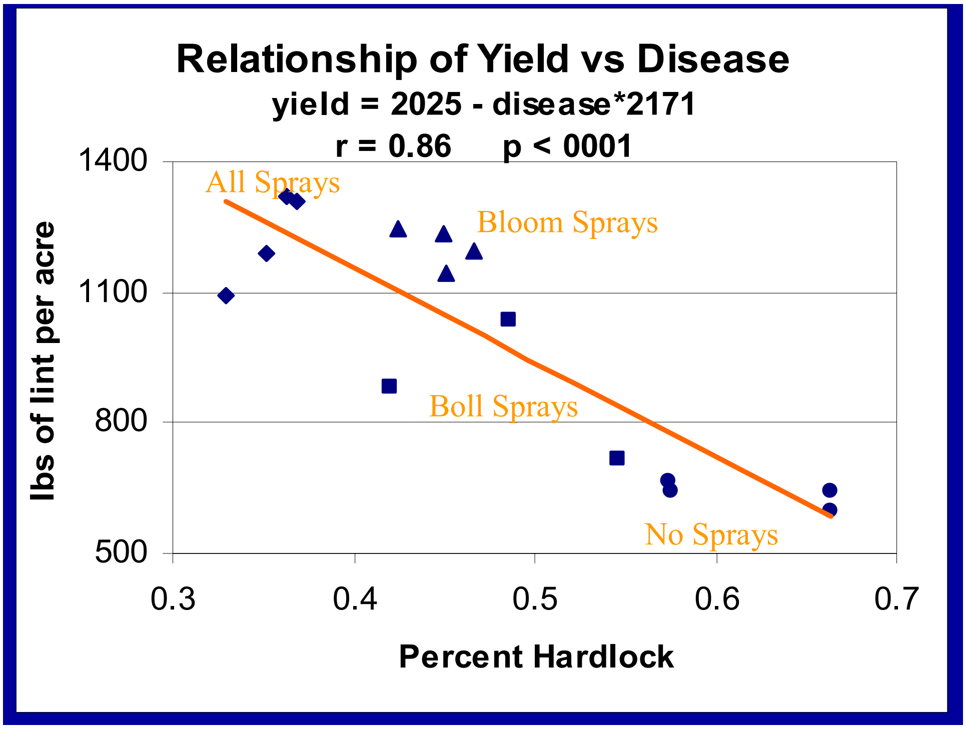
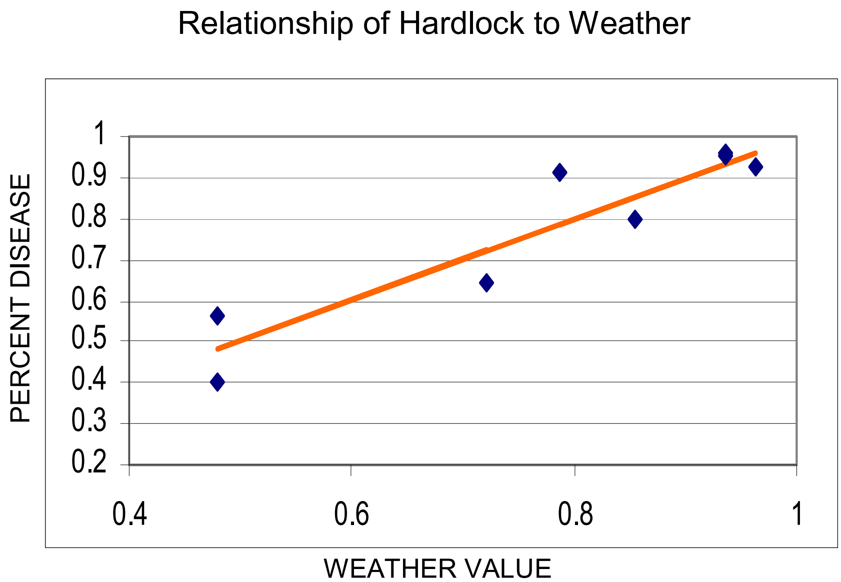



Figure 1.




disease = 0.67862+temp*0.08444+rh*0.01404 during 7 AM to 7 PM day of bloom $p < 0.005$, $r = 0.935$, $n = 7$

Figure 2.