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RELATIONSHIP BETWEEN COTTON PHENOLOGY AND BUG PRESSURE VS. YIELD AND QUALITY IN A PROGRESSIVE SPRAY ENVIRONMENT

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Abstract

In 2004 and 2005, a series of eight replicated “progressive spray” tests was conducted in NC and in GA, two in GA and six in NC. The goal of these tests was to gather information about the relationship between various spray protection levels for sucking bugs (primarily stink bugs), and its influence on boll damage and cotton yields and quality. To minimize the potential confounding effect of caterpillar damage, all tests were planted to a Bollgard II cotton variety. Each test consisted of 6 to 8 rows by 50 to 100 ft with four replicates, with initial sprays beginning at anthesis. This “most protected” treatment was sprayed weekly until the season’s end, and most often received seven applications of a high rate of dicrotophos (Bidrin 8E @ 0.5 lb. ai/acre) plus the highest rate of a pyrethroid. The next treatment was started one week later and protected for the remainder of the season, the third a week later, and so on. In most tests, weekly data were taken on square retention, percentage of dirty blooms, ground cloth sampling for all bug species and stages, internal damage to quarter-sized bolls, damage to bolls just prior to harvest, various measurements of boll diameters (an index of overall crop/boll development), yield and quality. In NC, green, *Acrosternum hilare* (Say) and brown stink bugs, *Euschistus servus* (Say), predominated, with greens more common, while in GA, southern green stink bugs, *Nezara veridula* (L.), were overwhelmingly the dominant species. Plant bugs, *Lygus lineolaris* (Palisot de Beauvois), added only minimally to the boll damage at most sites, generally being below dirty bloom and ground cloth thresholds. Additionally, most sites showed high square retention rates during the first 5 weeks of blooming. The relationship between both quarter-sized and year-end boll damage and yield was extremely variable between tests, varying from as little as 3.1 lb. of lint per 10% year-end boll damage in Union County, NC in 2005 to as much as 140 lb. of lint per 10% year-end boll damage in Tift County GA in 2005. At an Edgecombe County location, quarter-sized boll damage that averaged less that 10% during the season in the untreated check lost 106.3 pounds of lint, while the Union County location that averaged almost 25% quarter-sized boll damage only showed an 8 pound lint decrease. Protection from bug damage during the first 3 weeks of blooming appeared to have little impact on yields, while protection between weeks four and five showed a major impact on yield. This latter finding could have implications for higher thresholds during the first three weeks of blooming in situations where stink bugs are the predominant bug pest.

Introduction

Boll weevil eradication and *Bt* cottons are responsible for the current “low insecticide spray environment” that exists in most cotton acreage across the southeast. Stink bugs, and to a variable degree plant bugs, are now able to exist at much higher and more damaging levels on cotton, have become major pests in a relatively short time, and appear to be expanding their populations. Bugs can cause significant yield losses and reduce cotton lint quality (Barbour, et al. 1990, Bundy, et al. 1999, Greene and Herzog 2001, Willrich et al. 2003, Emfinger et al. 2004). Indeed, bugs are believed to be a major factor in Georgia’s recent “poor quality cotton problem” and, in fact, poor grades have led some cotton mills to reject lint grown in that state (Phillip Roberts, pers. com.). Additionally, insecticide use for stink bugs in GA has gone up dramatically (Fig. 1) (Williams 2005). In North Carolina in 2004, stink bug damage to bolls in a large random sample of producer-managed Bollgard cotton fields revealed a mean damage level five-fold higher than the average of the previous 8 years (Bacheler and Mott, 2005)(Fig. 2). New advanced *B.t.* cottons (e.g. Bollgard II® and Widestrike®) will require very little insecticide treatment for caterpillars, further worsening the potential damage from this complex of bugs. In recognition of the seriousness of this problem and to foster cooperation between scientists in the respective states, in 2005 Cotton Incorporated began funding a project entitled “Identifying Practical Knowledge and Solutions for Managing the Sucking-Bug Complex in Cotton: Research in the Southeast Region” through the Southeast Regional State Support Committee. One of the several sub projects of this grant is gaining a better appreciation of how cotton plant phenology various degrees of protection impact it’s susceptibility to the sucking bug complex as measured by yield and quality. A series of eight studies, one in 2004, and the remainder in 2005, were conducted in NC and GA to better understand the nature of these relationships.

Methods

Eight replicated small plot tests were conducted in NC and GA. One NC test was conducted in Wayne County in 2004 and five additional tests were carried out in 2005 in Edgecombe, Wayne, Scotland, Union, and Perquimans counties (Fig. 3). In GA, two tests were carried out in Tift County in 2005. To minimize the potential confounding effect of caterpillar damage, all tests were planted to a BG2 cotton variety. Each test was composed of 50 to 100 ft. rows of 6 to 8 rows per plot in a randomized complete block design with 4 replications. Most tests had eight treatments (Fig. 4). All sprays were with a tank mix of dicrotophos (Bidrin at 0.5 lb. active per acre) plus the highest labeled rate of a pyrethroid. Each treatment represented a different degree of “protection”. The initial “most protected” treatment began at anthesis, and was sprayed weekly until the season’s end, and most often received seven applications. The next treatment was started one week later and protected for the remainder of the season; the third a week later, and so on.

The following data were taken in five or more of these tests (a schematic of the data taken at each site is provided below).

<u>Species composition</u>- Assessments for species composition (mostly green, southern green and brown stink bugs) 2-3 days behind each progressive spray treatment (one per week) by counting all stink bug cadavers on the ground between the middle two to four rows in each recently spray plot (400 to 800 row-ft total). This assessment was conducted by crawling.

<u>Drop cloth sampling</u>- Beginning at first bloom, and just prior to spraying the next treatment, two drop cloth samples (6 feet/sample) per plot were taken in each replicate (48 row-feet total) from an untreated check. All plant bug and stink bug adults and nymphs were identified and counted.

<u>Plant bug-damaged squares</u>- The presence or absence (missing position) of 25 small terminal squares per plot was assessed weekly in the untreated plots to be treated next. Yellowish to blackened squares were counted as missing positions. One terminal square and a non-terminal square in an upper node with a total length of 1/8 inch, or greater, or its missing position (note that yellowed to blackened small squares my be greatly reduced in size) was assessed

<u>Dirty blooms</u>- Twenty-five blooms per plot (100 treatment) were evaluated weekly for presence of dirty blooms from a check plot as an additional measure of plant bug activity.

Boll size at 3.5 weeks - At anthesis, approximately 12 to 15 randomly selected white blooms from four of the protected plots (approx. 50 bolls total) was tagged and the largest outside diameters of 10 bolls per plot were measured with a digital caliper 3.5 weeks later to provide a comparison of boll growth rates between test sites. Three and one half weeks is generally regarded as the time beyond which a boll is “safe” from economic damage from stink bugs (Greene and Herzog 2001). At some locations, 50 additional white blooms were also tagged at 3 and 5 weeks after initial anthesis to gain an appreciation for growth rates of bolls derived later blooms.

Boll diameters- Beginning at bloom initiation in the most protected plots, the largest outside diameters of the first 25 bolls encountered were measured with digital calipers, beginning approximately 10 ft. into each plot, in each of the 4 replicates (100 bolls/week from the same plot). Each of the 4 starting points per plot was marked with a wire/plastic flag, and the distance required to obtain the 25 bolls was recorded. This provided an estimate of the number of bolls/acre of various sizes (and an indication of the level of bug-susceptible bolls over time). The same flagged starting point was used for the subsequent weekly “25-boll distance” counts from the same most protected plot (the end flag changed weekly).

Quarter-sized boll damage assessments- Twenty-five quarter-sized bolls/plot (100/treatment) were evaluated weekly for internal and external damage. In most tests, they were stratified into the following categories: no damage, external damage, internal warts only, stained lint only and warts plus stained lint. Each of the phased in treatments constituted the plot from which the damaged assessments were made just prior to that treatment’s initial application.

Year-end boll damage assessments- Just prior to boll opening, 25 randomly selected bolls/plot were assessed for damage. (100/treatment). Four hundred bolls per treatment were assessed in the 05GA1 test. These bolls were selected from rows adjacent to the middle two harvest rows. Each boll was evaluated separately for: no internal damage, internal warts only, stained lint only, and stained lint plus internal warts. The picked bolls were placed into labeled bags and taken to a lab or other indoor facility for the damage assessments. In most cases, the bolls were frozen for later assessments. The bolls were then later thawed prior to the damage assessments. This approach did not appear to compromise the boll damage evaluations.

Yield and fiber quality assessments- Cotton yields were harvested from the middle 2 rows of each plot with a mechanical harvester (except at the 05PQ location), weighed, stored, and transported to the research gin in Tifton, GA to be ginned under “real world” ginning conditions prior to fiber analyses. Fiber samples will be sent to the Cotton Incorporated facility in Cary, NC for analyses. As of this Jan 1 writing, the harvested seed cotton has been weighed and taken to the research gin. Therefore, yield adjustments based on gin turnout for the various treatments have not yet been made, and well as fiber quality parameters.

Checklist of data taken by location (Y- data taken; N- data not taken; P- data partially taken)

Data	04NCW	05NCE	05NCW	05NCS	05NCU	05NCP	05GAPR	05GAJR
Square retention	N	Y	Y	Y	Y	N	Y	N
Dirty bloom counts	Y	Y	Y	Y	Y	Y	Y	N
Beat cloth samples	N	Y	Y	Y	Y	Y	Y	Y
Damaged quarter-sized bolls	Y	Y	Y	Y	Y	Y	Y	Y
Size of bolls @ 3.5 weeks/ 1 week tag	N	Y	Y	N	Y	Y	Y	N
Size of bolls @ 3.5 weeks/ 2 week tag	N	Y	N	N	N	N	N	N
Size of bolls @ 3.5 weeks/ 3 week tag	N	Y	Y	N	N	N	Y	N
Size of bolls @ 3.5 weeks/ 5 week tag	N	Y	Y	N		N	Y	N
Cadaver counts	P	Y	Y	Y	Y	N	Y	1 Time
Boll sizes in most protected plot	Y	Y	Y	Y	Y	Y	Y	N
Row length/ 25 bolls	N	Y	Y	Y	Y	Y	Y	N
Final boll damage	Y	Y	Y	Y	Y	Y	Y	N
Yields	Y	Y	Y	Y	Y	Y	Y	Y
Variety	DP 960	DP 969	DP 960	DP 543	DP 444	ST4646	DP 543	DP 424

	BG II R	BG II R	BG II R	BG II R	BG II R	B2R	BGII R	BGII R
Plot size # rows x length	6 x 50 ft	6 x 50 ft	6 x 50 ft	6 x 50 ft	6 x 50 ft	8 x 75 ft	6 x 50 ft.	6 x 90 ft
Notes: planting date, Rows picked & Surrounding vegetation	May 10 Center 2 rows. Cotton & soybeans.	May 11 Center 2 rows. Corn.	May 11 Center 2 rows. Wheat early, cotton late.	May 9 Center 2 rows. Corn and cotton	June 3 Center 2 rows. Cotton.	May 12 Handpicked 17 ft./. Cotton and ~ 100 ft from corn field.	May 19 Center 4 rows. Large peanut field. 6 trts.	May 19 Center 2 rows. Peanuts 6 rows on each side.

Locations: 04NCW- 2004 Wayne Co., NC; 05NCE - 2005 Edgecombe Co., NC; 05NCW - 2005 Wayne Co., NC; 05NCS - 2005 Scotland Co., NC; 05NCU - 2005 Union Co., NC; 05NCP - 2005 Perquimans Co., NC; 05GAPR - 2005 Tift Co., GA (P. Roberts); 05GAJR – 2005 Tift Co., GA (J. Ruberson)

Results

Species composition- The proportion of green, southern green and brown stink bugs is shown in Figure 5. In NC, the green stink bug is most often the dominant species, but brown stink bugs can at time be more plentiful. In GA southern green stink bugs are most often the most abundant species, then browns, with green sting bugs typically a distant third. In NC we seldom see the association of green stink bugs moving in high numbers from peanut into cotton, as is often the case with southern green stink bug in GA (Phillip Roberts, pers. com.).

Drop cloth sampling- At the seven test sites in which drop cloth samples were taken, plant bug levels (adults plus nymphs) were less than 0.5 per row foot, far less than any state threshold (Fig. 6).

Plant bug-damaged squares- The retention of upper squares was extremely high, especially given that these assessments were taken during the first 5 weeks of bloom (Fig. 7). As expected, but not shown in this figure, the retention of small squares dropped dramatically after the fifth week of blooming.

Dirty Bloom assessments- Of the 7 locations assessed, the mean percentage of “dirty blooms” in four of the tests was very low, averaging less than 4%, while the other three test locations (Scotland, Union and Perquimans counties, NC) had mean dirty bloom levels in the 13 to 16% range (Fig. 8). At the three locations of low dirty bloom levels, the 15% was not reached at any weekly assessment, while the other three locations had 2-4 times in which the 15% dirty bloom level was surpassed (Fig. 9). Overall, although upper square retention was high and the level of plant bug found at all locations low, plant bugs may have contributed to boll damage at three locations. .

Boll size at 3.5 weeks and boll diameters- Although extensive measurements of 3.5 week old bolls were taken from flowers tagged at 1, 2 and 3 weeks of anthesis in three tests, these data are not included herein. Also, the weekly measurements of the first 25 bolls per plot in the most protected plots in recorded row lengths were not presented in this paper.

Quarter-sized boll damage, year-end boll damage assessments and boll damage relationships, and yield relationships- In Fig. 10, the relationship between both damage to quarter-sized bolls and year-end damage to mature bolls and yield was extremely variable (fig. 10). For example, in Edgecombe County seasonally averaged quarter-size boll damage averaging less than 10% resulted in a 106 lb. lint decrease (protected vs. unprotected), while in Union County, with four weeks of boll damage of over 20%, only an 8 pound yield difference was found. Likewise year-end boll damage was sometimes not a reliable indicator of yield loss. For example, in the Roberts' GA test in 2005, a 54% year end damaged boll level accounted for a 762 pound yield decrease, while a 43% damaged boll level in Union County accounted for only about 1/10 that level. In trying to stratify the importance of protection from stink bug damage as a function of the time from anthesis, the advantage or penalty of progressive sprays was calculated. Under this year's conditions in seven tests, protection during the initial three weeks of blooming did not result in a yield increase (Fig. 11), while protection during the 3-4 week period after anthesis appeared critical. Less certain was the apparent yield increase due to protection during the 6 to 7 week period following anthesis.

Conclusions

The above series of eight tests represents the initial set of an anticipated three-year study and, as such will encompass additional locations, different agronomic conditions, and different stink bug and plant bug pressure. Also, a significant amount of the data taken in this test, such as the boll diameter information, the post-gin adjusted yields, and the impact of bug damage on various quality parameters, is still forthcoming.
Additionally, our data will be integrated with that of the other studies conducted under this regional grant. Finally, some adjustments to upcoming test protocols can be anticipated based on the previous year's experience. Conclusions made based on 2005 tests should be considered preliminary.

With the above comments in mind, the following observations are made:

1. Significant variability in the relationship between both quarter-sized and year-end boll damage and yields was present between tests.
2. Stink bug thresholds may need to be adjusted upwards during the initial week of blooming.
3. In addition to whether a quarter-sized boll is either damaged or undamaged, the degree to which a boll is damaged may be important.
4. Whether an area has green (NC) or southern green (GA) stink bugs may have important management implications.
5. These results are preliminary and should only be considered suggestive.

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Acknowledgement

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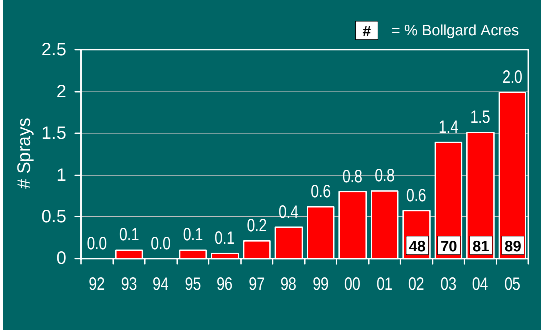

Fig. 1- Insecticide sprays for stink bugs in GA, 1992-2005

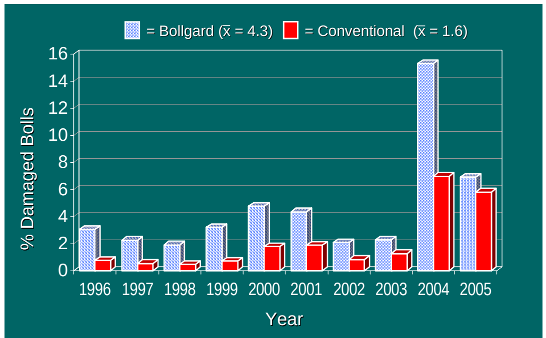

Fig. 2 - Stink bug damage to bolls in Bollgard vs. conventional cotton in NC, 1996-2005.

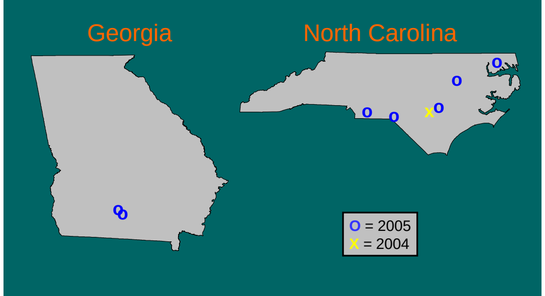

Fig. 3 - Test locations, 2004-2005.

Progressive Bug Protection Test: Diagram

- 6 to 8 rows / plot
- 50 to 100 ft. / plot
- Baythroid + Bidrin

0	7	3	6	1	2	4	5
2	4	6	5	7	3	0	1
0	2	1	3	6	4	5	7
7	6	5	4	3	2	1	0

Number of applications / plot

Fig. 4 – Diagram of test plots.

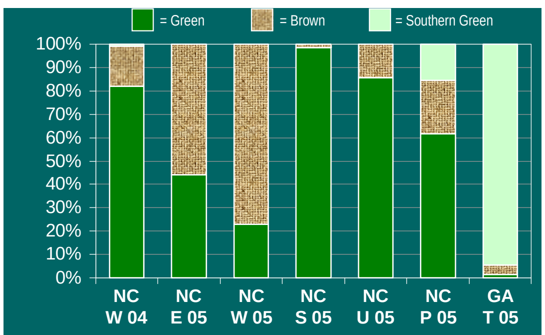

Fig. 5 – Percentage of stink bug species at seven test location, 2004-2005.

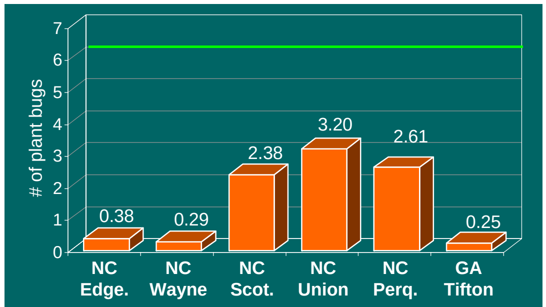

Fig. 6 – Average plant bug numbers per 6 row ft. in 2005.

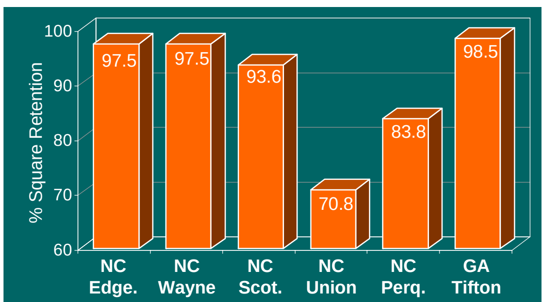

Fig. 7 – Mean percentage of upper squares retained, 2005.

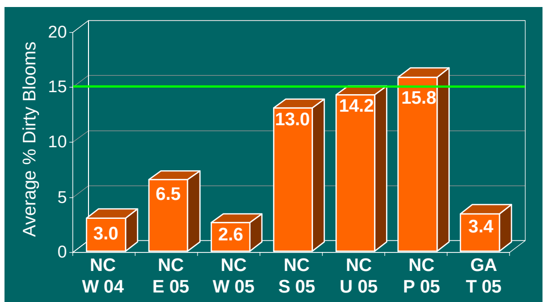

Fig. 8 – Average percent dirty blooms: during initial 5 to 8 weeks of blooming, 2004-2005.

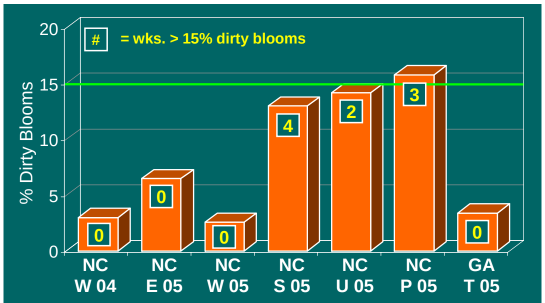

Fig. 9 – Number of times test sites exceeded 15% dirty blooms, 2004-2005.

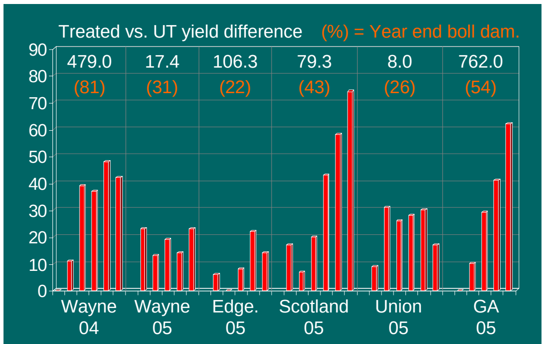

Fig. 10 – Relationship between stink bug damage to quarter-sized bolls & yield loss, 2004-2005.

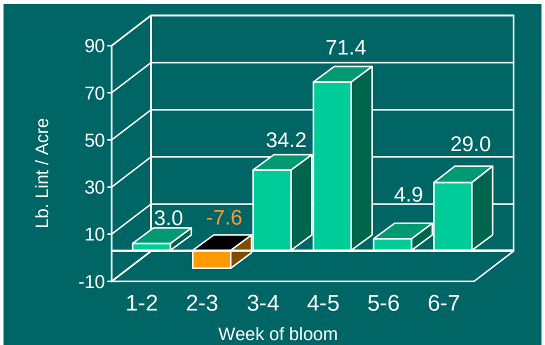

Fig. 11 – Value or penality of protection at various bloom intervals, NC & GA, 2004 - 2005 (n = 7 tests)