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2006 GEORGIA COTTON
RESEARCH AND EXTENSION REPORT

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Georgia Agricultural Experiment Stations
Georgia Cooperative Extension Service
University of Georgia College of Agricultural and Environmental Sciences

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- The Georgia Agricultural Commodity Commission for Cotton
- Cotton Incorporated
- The Cotton Foundation

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The 2006 Crop Year in Review

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The 2006 production season was nothing short of remarkable. It was truly the year of the "Comeback Crop" given the unexpected, unprecedented recovery from a horrendous summer drought. The Boll Weevil Eradication Program certified 1,379,746 planted acres as of August 10, 2006. Parts of the state suffered intense, prolonged drought from June through mid-August, and there were grave concerns about widespread crop failure and economic disaster. Rains that came in late August and early September seemed too little, too late, leading to predictions of a 500 lb/A average and 1.5 million bale crop. Late showers rejuvenated dryland, severely stunted fields, and many growers, having marginal yields or worse, chose to gamble on a late crop. In countless fields what was a half bale or worse crop in mid-September, rebounded to make respectable yields. Early harvest from dry land fields was typically 400 lb/A or less and irrigated fields produced 600 to 900 lb/A. Thereafter, yields began improving, and some producers even made their best-ever crop. Final yields will average about 825 lb/A and the total production will exceed 2.3 million bales. Given how poor the crop was in early September, how did such an unbelievable crop materialize? Possible explanations include (1) the scarcity of boll rot, (2) favorable autumn weather, (3) the full season maturity of DP 555 BG/RR, (4) the availability of fertilizer (which had not leached), and (5) the lack of late season insect pressure, particularly stink bugs.

Average Cotton Acreage and Production Since 1980

Time period	Planted acreage, x 1,000		Yield, lb/A		Total bales, x 1,000	
	Average	Range	Average	Range	Average	Range
1980-84	162	120-180	516	243-771	175	86-281
1985-89	269	225-350	573	395-696	321	185-370
1990-94	549	355-885	707	548–834	828	405-1,537
1995-99	1,426	1,350-1,500	610	512-739	1,810	1,542-2,079
2000-04	1,399	1,284-1,495	667	557-785	1,874	1,663-2,220
2005	1,214	—	849	---	2,140	---
2006	1,380	—	825	---	2,340	---

*Yield based on planted acreage and total bale production.

Quality of the 2006 crop was better than anticipated. Given the extreme heat and drought of midsummer, high percentages of short staple, high mic cotton were expected. Final numbers on both will be slightly greater than 20 percent. Color grade was quite good, but challenges still remain in regards to uniformity. Georgia still ranks at the bottom of the national average in uniformity.

Fiber Quality of Bales Classed at the Macon USDA Classing Office

Color Grade 31/41 or better (% of crop)	Bark/Grass/Prep (% of crop)	Avg Staple (in)	Avg Leaf Grade	Avg Strength (g/tex)	Avg Mic	Avg Uniformity
49 / 97	0.7 / 0.4 / 0.1	34.4	3.3	28.4	4.68	80.4
Based on 2.31 million bales classed through February 15, 2007. Bales classed: short staple (< 34)- 20%, high mic (>4.9) - 22%						

DP 555 BG/RR again dominated the state's acreage, with almost 77 percent of crop planted to that variety (USDA AMS Survey). The USDA Survey estimated that more than 98 percent of the Georgia crop was planted in transgenic varieties, primarily in Bollgard/Roundup Ready varieties. Other technologies, including Bollgard II, Widestrike, Roundup Ready Flex and Liberty, have been planted on limited acreage but will likely gain in future in seasons. 2006 was the "Year of the Pigweed," with serious escapes of Palmer amaranth across Georgia. Reasons for pigweed control failures include the influence of dry weather at planting and the failure to activate preemergence herbicides; the effects of dry weather on the efficacy of early postemergence herbicide applications; the widespread occurrence of ALS-herbicide resistance in Palmer amaranth; and the existence of glyphosate resistance in Palmer amaranth. Glyphosate-resistant Palmer amaranth has been confirmed in at least three counties beyond the original three county area in Central Georgia. Prevailing dry conditions also contributed to greater than normal problems with aphids, pests which are normally by the spread of a naturally occurring fungus.

Again, the most remarkable aspect of the 2006 crop was its comeback performance. Final yield and production numbers continue to amaze.

Technology Distribution of Cotton Planted in Georgia in 2006

Bollgard/Roundup Ready	Roundup Ready	Conventional	Other
89.1	5.6	0.2	4.6
USDA Agricultural Marketing Service Survey, August 2006.			

Report of Activities of the UGA Cotton Micro Gin
March 29, 2007

The following is a progress report from the UGA Micro Gin in Tifton. We finished our third year of ginning in March. The operation of the gin has come a long way three years. Understandably, there were many start-up problems and challenges during the initial season, but those problems have been resolved.

For the 2006-07 season, The ginning process was also streamlined by moving the suction pipe inside near the bale press. This allows more efficient use of time and energy by the gin workers. An additional telescoping suction pipe was added outside to facilitate ginning large samples from trailers. These two additions greatly improved our efficiency of handling samples. In previous years samples were ginned at a rate of 10 to 12 bags per hour. Currently we are able to handle bags at a rate of 16 to 18 bags per hour depending on the weight. The final addition for the '06 season was two saw type lint cleaners; these were installed late in the gin season. The new cleaners were not used much this season due to the time required to get them operating properly. We have since worked out the bugs with these new cleaners and will be putting them in to operation next season. The new lint cleaners will allow the option of using one or two lint cleaners similar to commercial gins. The next addition to the Micro Gin facilities will be the renovation of the support buildings. This will include a shop and storage area as well as offices, labs, and meeting rooms. This addition will allow for the facility to be used by researchers for lab experiments as well as provide space for groups to meet.

In 2006, the number of samples decreased slightly due to the loss of 2 researchers. The total number of bales produced was significantly lower this season due to not ginning large bulk samples as in the two previous seasons. This year we have ginned studies from farms here on the Tifton Campus as well as many other locations across the state, from Research and Education Centers and from county agents. In addition to Georgia cotton, samples have been received from Alabama, North and South Carolina, Virginia, Texas, Arizona, Florida, Louisiana and Mississippi.

In addition to ginning samples, the UGA Micro Gin has been a great educational tool. The Micro Gin has provided exposure to Georgia cotton by onsite tours with audiences including growers, educators, students, and governmental officials. We are also regular presenters at offsite learning experiences geared to elementary age school children. These presentations include history of cotton as well as production and use of cotton.

Season	# of Tours	# visitors	# Samples Ginned	# Bales	Lbs of Lint
2004	10 – 12		800	64	13824
2005	27	455	2296	105	28914
2006	15	202	1770	56	15675
Total		**657**	**4866**	**225**	**58413**

Personally, I have had opportunities to make presentations and to advance my professional training. I was invited to deliver a presentation at the 2005 Cotton Ginning Symposium, a training program led by the USDA Ginning Lab in Stoneville, MS, for county agents and other academic professionals (non-ginners) from across the entire Cotton Belt. I also presented a poster presentation at the 2006 Beltwide Cotton Conference. In addition to educating others about the merits of the UGA Micro Gin, I have tried to advance my own education. I have completed and passed the test for the Certified Ginner program lead by the National Cotton Ginners Association. I plan to continue in the continuing education portion of this program. I believe it is important for the advancement of the Micro-gin that I learn all I can about the process of ginning cotton and the industry as a whole.

I feel the UGA Micro Gin program provides an important research and educational service to the UGA Tifton Campus. I look forward to future opportunities to promote the UGA Micro Gin program as well as Georgia cotton in general.

Respectfully Submitted,
Andy Knowlton, Research Engineer and Gin Manager

Report forwarded to the Georgia Cotton Commission, Dr. Scott Angle, Dean of the College of Agriculture and Environmental Sciences, Assistant Dean for the UGA Tifton Campus, Associate Deans for Research and Extension, the Southeastern Ginners Association, and the UGA Cotton Team.

Early County Cotton Variety Trial

Brian Cresswell and Don Shurley
UGA Cooperative Ext. Early County and UGA Cooperative Ext. Ag. Economics

Introduction

Cotton is Early County's number one Agricultural commodity in both acres planted with 40,500 and farm gate value at $29,000,000.00 or 35% of total farm gate value. Producers are always looking ways to make a profit so variety selection is very important to them. Variety selection is one of the most important decisions a producer has to make. He must take into consideration not only yield but fiber quality as well, as both of these factors are used in determining value per acre. Since varieties are changing and producers need good local data these trials were put in and used to evaluate varieties for both yield and fiber quality.

Materials and Methods

Each variety evaluated in 2005 (planted 5-25) and 2006 (planted 5-26) consisted of 4 replications (plots) six rows wide by the length of the field. The two trials were ripped and bedded and planted by hill dropping two seed every ten inches. Fertilizer was applied according to UGA fertility recommendations. In 2005 a total of 100 units of Nitrogen was applied and in 2006 a total of 90 units of Nitrogen was applied. In both years each plot was treated identical with respect to weed and insect control. Each plot was machine picked with a John Deere six row cotton picker (in 2005 picked 11-14, in 2006 picked 11-21) and the seedcotton weighed. Samples were taken from the four reps to be ginned at the UGA microgin in Tifton and the lint weighed to determine the lint turn-out (lbs of lint per pound of seedcotton). This turn-out (%) was then applied to the seedcotton weight from each plot to determine the lint yield per acre for each of the 4 reps (plots) per variety. The yield reported for each variety was the average of the 4 reps.

From the ginned fiber for each variety, 3 samples were taken. Samples were sent to the Texas Tech International Textile Center for HVI classing. Each sample was graded for Color-Leaf, Staple, Strength, Micronaire, and Uniformity. The Loan Value (price per pound of lint) was determined for each of the 3 samples. The Early County base warehouse loan rate of 52.7 cents per pound was used and adjusted for Staple, Strength, Micronaire, and Uniformity. Although Color and Leaf grades were determined for each sample, a Color-Leaf grade of 31-3 was assumed for all samples for all varieties (assuming that Color and Leaf are predominately a function of weather and management compared to variety genetics and other characteristics).

The Loan Value per pound for each of the 3 samples was then averaged. This average price was multiplied by each of the 4 yield replications to result in 4 measures of Loan

Value Per Acre for each variety. The Loan Value Per Acre reported for each variety was the average of the 4 priceXyield calculations.

Results- Yield, Fiber Quality, and Value Per Acre

Numerically, the highest yielding variety in both 2005 and 2006 was DP555BR (Table 1). Statistically, however, there was no difference among the highest 5 yielding varieties each year. In 2005, a yield difference of 228 pounds per acre separated the highest and lowest yielding varieties. The average yield of all 11 varieties in the test was 968 pounds per acre.

In 2006, there were 21 varieties in the test. The yield difference between the highest and lowest yielding varieties was 833 pounds per acre. The average yield of all 21 varieties was 1,238 pounds per acre.

In 2005, the highest quality fiber as measured by the Loan Value per pound, was DP488BR followed closely by FM991B2R, FM960B2R, and DP543B2R (Table 2). The lowest fiber quality (Loan Value per pound) was DP555BR which was 2.55 cents per pound less than the highest quality fiber and statistically different. Varieties with the highest Loan Value tended to be those with longer Staple and higher Strength.

Although DP555BR was the lowest in fiber quality, due to high yield it gave the highest Value Per Acre. FM991BR, among the highest in fiber quality, was the lowest in Value Per Acre due to low yield. Statistically, there was no difference in Loan Value Per Acre among the top 5 varieties.

In 2006, the difference in fiber quality as measured by the Loan Value per pound was only 0.95 cents per pound (Table 3). Statistically, there was no difference in Loan Value (price per pound) among many of the varieties. Numerically, the highest quality fiber was DP117B2RF and lowest was DP555BR. The highest Value Per Acre, however, was DP555BR followed by ST5599BR and PHY485WRF. Value Per Acre varied from a high of $907.71 per acre for DP555BR to a low of $441.77 per acre for DG2100B2RF. The difference in Value Per Acre was due more to yield than fiber quality. Statistically, there was no difference in Value Per Acre among the top 7 varieties.

It was not the purpose of these tests to evaluate production systems (seed technology type). Yield and Value Per Acre were compared but costs of production and net return by technology type were not determined. Table 4, however, provides a summary of yield and per acre Loan Value by technology type for both 2005 and 2006. The summary shows the average Value Per Acre over all varieties within a technology type. Even within a technology type, yield per acre can vary widely by variety. The results suggest, as other studies have shown, that comparative profitability of various technologies is a function of yield as well as costs. The choice of variety within a system is as important as the choice of system—i.e. there may be differences in costs of production but such differences could be minor compared to yield differences.

Table 1. Early County Variety Trials
2005 and 2006 Yield and Gin Turn-Out by Variety

2005			2006		
Variety	**Lint Turn-Out (%)**	**Yield (Lbs Per Acre)**	**Variety**	**Lint Turn-Out (%)**	**Yield (Lbs Per Acre)**
DP555BR	40.4	***1,103***	DP555BR	39.3	***1,616***
DP488BR	38.9	***1,034***	ST5599BR	37.5	***1,567***
DP543B2R	36.7	***1,029***	PHY485WRF	38.6	***1,509***
DP449BR	36.2	***988***	DP454BR	38.6	***1,451***
PHY470W	36.0	***986***	DP164B2RF	36.1	***1,406***
FM960B2R	36.9	968	ST4554B2RF	37.5	1,379
FM960BR	36.5	955	DP488BR	35.9	1,336
DP455BR	39.4	928	ST6565B2RF	33.2	1,316
DP424B2R	33.6	904	FM991BR	36.3	1,314
FM991B2R	34.3	882	DP515BR	37.6	1,292
FM991BR	35.3	875	FM1880B2F	35.5	1,281
			DG2520B2RF	35.6	1,223
			DP143B2RF	35.5	1,126
			CG3020B2RF	35.1	1,120
			DP117B2RF	37.8	1.098
			DP455BR	39.1	1,090
			PHY480WR	36.1	1,071
			ST4357B2RF	36.8	1,023
			CG4020B2RF	35.1	1,003
			CG3520B2RF	35.8	1,000
			DG2100B2RF	34.3	783
LSD (p=.10)		*122*	*LSD (p=.10)*		*226*

Yields within the LSD lbs. of each other are not "statistically different" (90% confident that the yields are statistically the same). The top 5 yielding varieties in 2005 (in bold) were not statistically different. The top 5 yielding varieties in 2006 were not statistically different.

Table 2. 2005 Yield, Loan Value (Price) Per Pound, and Value Per Acre By Variety

Variety	Yield (Lbs Per Acre)	Loan Value (Cents Per Lb)	Value Per Acre
DP555BR	1,103	55.63	***$613.60***
DP488BR	1,034	58.18	***$601.58***
DP543B2R	1,029	57.68	***$593.53***
PHY470W	986	57.58	***$567.74***
FM960B2R	968	57.78	***$559.31***
DP449BR	988	56.00	***$553.28***
FM960BR	955	56.30	$537.67
DP455BR	928	57.02	$529.15
FM991B2R	882	58.10	$512.44
DP424B2R	904	55.88	$505.16
FM991BR	875	57.67	$504.61
LSD (p=.10)	*122*	*1.63*	*$69.21*

Loan Values Per Acre within the LSD of each other are not "statistically different" (90% confident that the Loan Values are statistically the same). The top 6 varieties in Value Per Acre (in bold) were not statistically different.

Table 3. 2006 Yield, Loan Value (Price) Per Pound, and Value Per Acre By Variety

Variety	Yield (Lbs Per Acre)	Loan Value (Cents Per Lb)	Value Per Acre
DP555BR	1,616	56.17	***$907.71***
ST5599BR	1,567	56.67	***$888.02***
PHY485WRF	1,509	56.53	***$853.04***
DP454BR	1,451	56.32	***$817.20***
DP164B2RF	1,406	56.55	***$795.09***
ST4554B2RF	1,379	56.55	***$779.82***
DP488BR	1,336	56.80	***$758.85***
FM991BR	1,314	56.82	$746.61
ST6565B2RF	1,316	56.63	$745.25
DP515BR	1,292	56.77	$733.47
FM1880B2F	1,281	56.75	$726.97
DG2520B2RF	1,223	56.55	$691.61
DP143B2RF	1,126	56.72	$638.67
CG3020B2RF	1,120	56.25	$630.00
DP117B2RF	1,098	57.12	$627.18
DP455BR	1,090	56.83	$619.45
PHY480WR	1,071	56.87	$609.08
ST4357B2RF	1,023	56.32	$576.15
CG4020B2RF	1,003	56.55	$567.20
CG3520B2RF	1,000	56.32	$563.20
DG2100B2RF	783	56.42	$441.77
LSD (p=.10)	*226*	*00.28*	*$154.37*

Loan Values Per Acre within the LSD of each other are not "statistically different" (90% confident that the Loan Values are statistically the same). The top 7 varieties in Value Per Acre (in bold) were not statistically different.

Table 4. Early County Variety Trial, Comparison By Technology Type

2005				2006			
Type	No. Varieties	Avg Yield	Avg Loan Value/Ac	Type	No. Varieties	Avg Yield	Avg Loan Value/Ac
BR	6	981	$556.65	BR	7	1,381	$781.62
B2R	4	946	$542.61	B2RF	12	1,147	$648.58
W	1	986	$567.74	WR	1	1,071	$609.08
				WRF	1	1,509	$853.04

ECONOMIC EVALUATION OF SEED TECHNOLOGIES: 2005 AND 2006 SYSTEMS TRIALS AT TIFTON AND MIDVILLE

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Introduction

The University of Georgia began conducting "systems trials" at Tifton in 2001 and at both Tifton and Midville in 2003. The purpose of this research has been to compare yield, fiber quality, costs, and net returns among cotton seed technologies (transgenic varieties) and non-transgenic (conventional) varieties and to determine the factors which contribute most to increasing net returns. Technology, variety selection within a technology, yield, cost, and fiber quality each impact profitability.

For most producers, seed has become the single most expensive input cost per acre in cotton production. Seed, including the technology fee associated with transgenic cotton, can cost over $400 per bag, or about $70 to $80 per acre or more depending on the number of seed planted per acre. Today, when a farmer purchases cotton seed, he/she is in essence buying into a production system which also includes herbicide and insecticide choices as well as yield and fiber quality potential.

Seed varieties and technologies continue to change rapidly. The farmers' choices among available technologies have also changed. As newer technologies become available, previous technologies and varieties may become less available.

Cotton is Georgia's largest crop in both acreage and value. The state ranks 2nd in acres planted in the US and typically 3rd or 4th in production. Georgia cotton producers have adopted transgenic cotton heavily. In 2006, 96% of the state's acreage was planted to transgenic varieties (USDA-NASS). The majority of the states' cotton acreage is planted to BR (Bollgard® + Roundup Ready®) varieties. Other technologies have not yet been widely adopted or are not widely available.

This paper presents results for 2005 and 2006, the most recent 2 years of the study. Results for 2001-2004 have been previously published (Jost, et.al. and Shurley, et.al.). This paper contains results of BR and RR (Roundup Ready) technologies as well as those of newer technologies such as B2 (Bollgard 2®), RF (Roundup Ready Flex®), LL (Liberty Link®) and W (Widestrike®)—the latter 2 types of varieties also were analyzed in 2003 and 2004. Conventional (non-transgenic) varieties, while no longer comprising a major share of Georgia's acreage, continue to be included in the study for comparison.

Methodology

In the "systems trial", each technology was produced in accordance with its respective herbicide and insect management regime following UGA Extension recommendations. All varieties within a technology group were produced the same way. A summary of the number of varieties in the study for 2005 and 2006 by technology group is shown in Table 1.

Each year varieties were selected based on the authors' best assessment of their relevance to future Georgia cotton production. In each year the varieties most commonly grown in Georgia in the previous year were included, as well as those with the best yields in the state variety trials, and certain experimental varieties representing new technology types that were similarly identified as most likely to be successful in future years. Because technologies and varieties changed rapidly over the course of the experiment (2001-2006), it was impossible to include the same varieties throughout the experimental period. The same varieties were always planted at both locations, the Coastal Plain Experiment Station at Tifton and the Southeast Georgia Research and Education Center at Midville, beginning in 2003. In 2005 and 2006, the seed technologies were:

Conventional (non-transgenic)
RR (Roundup Ready)
BR (Bollgard + Roundup Ready)
WR (Widestrike + Roundup Ready)
B2R (Bollgard II + Roundup Ready)
RF (Roundup Ready Flex)
B2RF (Bollgard II + Roundup Ready Flex)
WRF (Widestrike + Roundup Ready Flex)
LL (Liberty Link)
B2LL (Bollgard II + Liberty Link)

All varieties, except the conventional, were herbicide resistant (either glyphosate resistant (RR or RF) or glufosinate resistant (LL)). Bt transgenic varieties were either single gene (BR) or 2-gene technology (B2R, B2RF, B2LL, WR, and WRF).

All varieties at each location were planted in a randomized complete block design replicated 4 times (the 4th replication at Midville in 2005, however, was deleted from the study due to drainage problems resulting in very low yields compared to the other 3 reps). Each plot (replication) was machine picked and the seed cotton weighed.

The seed cotton from each replication was ginned at the UGA Microgin at Tifton and the lint weighed to determine gin turn-out (lint weight as a percentage of seed cotton weight). The cotton seed from each rep was also collected and weighed after ginning.

From each ginned replication, 3 sub-samples of lint were taken. These samples were sent to the Texas Tech International Textile Center for HVI (High Volume Instrument) measurement. Each sample was measured for Color-Leaf, Staple, Strength, Micronaire, and Length Uniformity. The measurements for each of the 3 lint sub-samples were then averaged to obtain the grades (Color-Leaf, Staple, Strength, Micronaire, and Length Uniformity) for each yield replication (plot).

Net Return was calculated for each variety and technology. Net Return was calculated for each replication (plot). Net Return for each variety is the mean (average) of all replications (plots) for that variety.

Net Return was calculated as follows:

$$NR_{xy} = (Y_x \times LP_{qx}) - ((Y_x \times GW) + (SY_x \times SP/2000)) - S_{xy} - H_y - I_y - A_y$$

NR = the Net Return for variety x, technology y
Y = the lint yield per acre for variety x
LP = the Georgia November spot price plus LDP, adjusted for quality q for variety x
GW = the cost per lb for ginning, warehousing, classing, and marketing/promotion
SY = the seed weight after ginning for variety x
SP = the Georgia November average price received per ton for cottonseed
S = the seed cost (including tech fee) per acre for variety x and technology y
H = the herbicide cost per acre for technology y
I = the insecticide cost per acre for technology y
A = the applications cost per acre for technology y

The November 2005 and 2006 average cash (spot market) price for base quality and monthly average fiber quality premiums and discounts were available in *Cotton Price Statistics* (USDA-AMS). The November average Loan Deficiency Payment (LDP) was added to the November average cash price. For 2005, the base price including LDP was 59.31 cents per pound. For 2006, the base price including LDP was 57.11 cents per pound. Each year, this price was then adjusted up or down to reflect the fiber quality of each variety.

The cost of ginning and warehousing, etc. (GW) was 12 cents per pound—9 cents per pound for ginning, plus $10 per bale (about 2 cents per pound) for storage ($2) and warehousing ($8), plus $5 per bale (about 1 cent per pound) total for classing and state and national boards. From this cost, the value of cottonseed was deducted. The November 2005 average price received for cottonseed was $74 per ton and the November 2006 average price was $93 per ton (USDA-GASS).

Seed cost each year was based on Georgia prices obtained from seed company representatives. Technology fees for Georgia were obtained from information released by technology and seed providers. Seed cost per acre was based on 3 seed per foot of row and 36-inch row spacing at Tifton and 38-inch row spacing at Midville. If a variety was in the study before actually being released and available to producers, its price was estimated based on similar varieties and/or price increases of other varieties and technologies.

Herbicide and insecticide costs each year were calculated based on the materials and rates used for the specific technology at each location and based on typical prices paid as reported by input suppliers. Application costs include machinery, equipment, and labor for herbicide and insecticide application based on the method of application and also includes cultivation on conventional cotton, if applicable. These costs were determined and based on UGA budget estimates (Shurley).

Results

<u>Yield Per Acre</u>

The highest yielding variety at Tifton in both years was DP 555BR (Table 2). The 4 highest yielding varieties in both years at Tifton were not statistically different, however. Both years at Tifton, a conventional (non-transgenic) variety was among the highest yielding. Two RF varieties were among the highest yielding at Tifton in 2005 and two B2R varieties among the top yielding in 2006. LL varieties were in the middle of the yield spectrum. WR and WRF varieties performed relatively well in 2005 but not as well in 2006.

At Midville in 2005, replicated yields were highly variable. Therefore, the average yield per acre among the top 10 of the 13 varieties was not statistically different (Table 3). In 2006, DP 555BR was the top yielding variety at Midville but statistically there was no difference in yield among the top 9 varieties. The top yielding varieties included 1 conventional variety, 1 RR, 3 BR, 1 WRF, 2 B2RF and 1 B2R variety. The LL varieties were at or near the bottom of the group both years at Midville.

<u>System Costs</u>

The price of a bag of seed comprises many attributes. The price, among other things, is a composite of its' perceived value based on yield and technology, fiber quality, supply and demand, typical seeding rate of producers, and quantity of seed per bag.

Seed of all varieties regardless of technology were planted at a rate of 3 seed per foot of row. Row spacing was 36 inches at Tifton at 38 inches at Midville. Seed costs were calculated based on the price per bag of seed, the number of seed per bag or lb, and the number of seed planted per acre.

Seed cost included technology fee when applicable. Conventional seed averaged $18.99 per acre at Tifton and $17.99 per acre at Midville (Table 4). The most expensive seed was B2RF which averaged $85.59 per acre at Tifton and $81.09 at Midville.

Using Tifton as an example (based on 36" rows), seed with B2R technology averaged $7.47 per acre higher than seed of BR varieties. Seed with RF technology averaged $10.62 per acre higher than seed of RR varieties. BR and WR varieties were priced about the same. LL varieties were $14.90 per acre less than RR varieties.

Herbicide-resistant technologies included RR (Roundup Ready), RF (Roundup Ready Flex), and LL (Liberty Link). In 2005 at Tifton there was little difference in herbicide applications and cost among the herbicide resistant technologies (Table 5). Herbicide cost for conventional (non-resistant) cotton was considerably higher. There was little or no cost advantage to the RF varieties compared to the RR and LL varieties. In 2006 at Tifton, conventional and LL cottons were cheaper than RR and RF cottons. There was no difference in herbicide use and cost between the RR and RF varieties. Over the 2 years of the study at Tifton, the LL technology offered the lowest herbicide cost—about $4.00 per acre lower than other technologies and conventional varieties. There was no cost difference between conventional, RR, and RF varieties.

Herbicide costs at Midville were high compared to those at Tifton due to weed pressure at that location. In 2005, the RF technology offered the lowest herbicide cost. This was due in large part to less glyphosate actually being applied to the RF varieties compared to the RR varieties. For non-herbicides-resistant varieties, the cost of cultivation if needed is included as Application cost. In 2006, herbicide costs were again lowest for the conventional and RF varieties compared to the RR and LL varieties. Over the 2 years of the study at Midville, the LL technology had the highest herbicide cost and the RF varieties the lowest.

Insect management technologies (Bt transgenic cottons) include B (Bollgard), B2 (Bollgard II), and Widestrike (W). In both years at both locations, insecticide costs were lower for all Bt technologies compared to non-Bt varieties (Table 6). Over 2 years at Tifton, insecticide costs for Bt varieties averaged $10.67 per acre less than non-Bt varieties. Both years, there was no difference in treatments (number of sprays and type of materials used), however, between B, B2, and W technologies.

Over 2 years at Midville, insecticide costs for Bt varieties averaged $9.10 per acre less than costs for non-Bt varieties. In 2005, there was no difference in treatments and cost among the B, B2, and W varieties. In 2006, insecticide cost for B2 varieties was lower than B varieties. Both received 3 sprays. B received 3 pyrethroid sprays while B2 received 2 pyrethroid sprays and 1 spray of Bidrin®.

In summary, considering both years and both locations, insecticide costs was lower for Bt varieties compared to non-Bt varieties but there was little or no difference in cost among the 3 insect management technologies (B, B2, and W).

<u>Total Cost and Net Return</u>

Income, costs, and net returns were determined each year for each variety and technology at each location (Tables 7 through 10). The income shown is the average of the yield for each replication times the price per pound based on the average fiber quality for each replication. Costs include "system costs" and ginning and warehousing after the value of cottonseed is deducted. System costs are those that depend on the variety and the technology. These costs were seed and technology fee if applicable, herbicides, insecticides, and machinery, equipment, and labor costs of application including cultivation for weed control if applicable. All other production practices and costs were the same regardless of variety and technology and thus do not need to be considered when making comparisons. Net Return was calculated as Lint Income minus System Costs minus Net Ginning and Warehouse charges (NGW).

At Tifton in 2005 (Table 7), the variety resulting in the highest Net Return was DP 555BR which was also the highest yielding. The top 5 varieties in Net Return, including 2 with RF technology, were not statistically different, however. B2R and B2RF varieties tended to be among the lowest in Net Return due to lower yield and higher costs. The exception was FM 960B2R which was a higher yielding variety and also had the highest fiber quality (a premium of 3.10 cents per pound). In 2006 (Table 8), the highest Net Return was for a conventional variety, DP 493. DP 493 was not the highest yielding but the conventional varieties were the lowest in cost. There was no statistical difference in Net Return among the top 4 varieties. RF technologies (RF, B2RF, and WRF) tended to fall in the lower level of Net Return with the exception of DP 143B2RF. DP 555BR was again among the highest in Net Return and FM 960B2R again also ranked high.

At Midville in 2005, there was no statistical difference in Net Return among 12 of the 13 varieties (Table 9). Net Return ranged from a high of $543.57 per acre for ST 4554B2RF to a low of $436.14 per acre for PHY 475WRF. The highest fiber quality was for FM 960B2R with a premium of 2.22 cents per pound followed by DP 543B2R and DP 555BR. In 2006 at Midville (Table 10), the variety with the highest Net Return was DP 493 at $702.95 per acre. DP 493 was not the highest yielding, but costs for conventional varieties were the lowest among variety types. DP 453 was also the highest in fiber quality (premium of 2.20 cents per pound). The top 14 of the 20 varieties were not statistically different in Net Return, however. DP 555BR was the lowest in fiber quality but was among the highest in Net Return because numerically it was the highest yielding variety.

Comparisons By Technology Type

An objective of this study is to compare seed technologies on the basis of yield, fiber quality, and net return. However, varieties and technologies can and have changed rapidly. Therefore, consideration must be given to three conditions: (1) Varieties within a technology vary in yield, quality, and net return. Thus there is a range of values for each variable for each technology group; (2) The individual varieties and the number of varieties studied within a technology type may not be the same each year; (3) In any given year, the number of variety types represented may not be the same.

Thirteen varieties representing 9 seed technology types were included in the 2005 study. In 2006, there were 20 varieties representing 10 technology types. All seed types evaluated in 2005 were also included in 2006 and B2LL was added in 2006. Although technologies were largely the same, there were only 7 varieties common to both years of the study.

In 2005 at Tifton, the BR technology had both the highest yield and highest Net Return (Table 11A). The only BR variety was DP555BR. In 2006, however, BR technology ranked 5th in Net Return (Table 11B). This was because 1 of the 3 BR varieties was the lowest yielding. B2RF was the second lowest in Net Return in both 2005 and 2006. Two B2RF varieties were in the study in 2005 and three in 2006. The average yield for B2RF was the second lowest both years and total costs the highest both years.

In both years at Tifton, conventional varieties did well. Three conventional varieties (1 in 2005 and 2 in 2006) had a 2-year average Net Return of $698.24 per acre—actually the highest 2-year average of any group at Tifton.

The WR and WRF varieties, as a technology group, did not rank near the top. WR (1 variety each year), ranked 7th out of 9 technologies in 2005 and last in 2006. WRF (also 1 variety each year), ranked well at 3rd in 2005 but 8th in 2006.

LL technology (1 variety each year) ranked 5th in 2005 and 6th in 2006. B2LL ranked 3rd in 2006. LL and B2LL varieties were not among the very highest yielding but were among the lowest in cost.

Results by technology type at Midville are shown in Tables 12A and 12B. The BR technology resulted in the highest average Net Return over the 2 years followed by the conventional, RR, and B2RF varieties. The B2RF varieties yielded relatively well at Midville and thus ranked higher at Midville compared to Tifton.

LL technology ranked 8th in 2005 and 9th in 2006. B2LL ranked last in 2006-- not as well as at Tifton. WR technology ranked 7th in 2005 and 5th in 2006. WRF ranked 9th in 2005 but 2nd in 2006.

Summary and Conclusions

The University of Georgia began conducting “systems trials” at Tifton in 2001 and at both Tifton and Midville since 2003. The purpose of this research has been to compare yield, fiber quality, costs, and net return of cotton seed technologies (transgenic varieties) to conventional or non-transgenic varieties. This paper presented results of 2005 and 2006- the most recent 2 years of the study.

Net Return was calculated for each variety and technology based on yield, costs specific to each variety and technology, and fiber quality (price per pound of lint adjusted for fiber quality parameters).

When comparing varieties and technologies, Net Return is a function of lint yield, cottonseed yield, cost of seed and technology fee if applicable, insect and weed management, and price (as influenced by fiber quality). Previous research (Jost, et.al.) has concluded that profitability (Net Return and difference in Net Return) is most closely associated with yield and not technology. The results of 2005 and 2006 studies at Tifton and Midville seem to support and further confirm this.

At Tifton in 2005, yield per acre ranged (from high to low) by 515 pounds. System costs ranged by $41.93 per acre or the equivalent of 71 pounds of lint per acre at the 2005 base November price with LDP. In 2006, yield ranged by 634 pounds per acre. System cost ranged by $61.25 per acre (the equivalent of 107 pounds per acre).

At Midville in 2005, yields among 10 of the 13 varieties were not statistically different. Yields ranged by only 233 pounds per acre. System cost ranged by $37.45 per acre or the equivalent of 63 pounds of lint per acre at the base price with LDP. In 2006 at Midville, yields ranged by 438 pounds per acre. System cost ranged by $39.63 per acre or the equivalent of 69 pounds per acre.

This study has attempted to evaluate seed technologies based on Net Return. Such an evaluation is difficult because technologies and varieties continue to change.

Georgia cotton producers have demonstrated their acceptance of seed technologies as evidenced by acres planted to these seed types. Likewise, the industry and availability of seed types has moved in this direction. There is little doubt that cotton producers find value in seed technologies although this value may be lessened recently due to concerns for glyphosate resistant Palmer Amaranth (pigweed) in Georgia.

Costs were not analyzed statistically. In general, there are differences in cost. Difference in seed cost (including tech fee) is a function of technology—the more traits or higher the perceived value of the technology, the more expensive. The cost savings in herbicide and insecticide use that the technology offers, however, has proven variable from year to year depending on the degree and type of weed/grass and insect pressures present. The differences in cost have been noted and discussed.

While there are differences in cost, higher cost can also mean higher Net Return depending on yield and fiber quality. Thus, the following conclusions are noted:

- Seed technology alone is not sufficient for high Net Return. New and improved does not necessarily mean higher Net Return.
- Choice of variety within a technology is important. Yield is the most important factor in Net Return.
- Differences in cost do exist but appear small relative to differences in yield. Seed technologies, while offering value and benefit at an added cost (tech fee), result in higher Net Return when total cost is reduced and/or when yield is increased.
- Newer technologies have been developed in recent years and no doubt will continue to be developed. Some technologies have yet to gain wide use by Georgia cotton producers. Technologies are still evaluated largely based on yield potential. Technology that does not also come with high yield or cost savings may struggle to be widely accepted.
- Fiber quality alone has not been demonstrated to be a major factor in Net Return when comparing seed technologies. High fiber quality can, however, be an important factor in variety and technology selection if accompanied by high yield.

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References

Jost, P., D. Shurley, S. Culpepper, P. Roberts, R. Nichols, J. Reeves, and S. Anthony. "Economic Comparison of Transgenic and Non-Transgenic Cotton Production Systems in Georgia", *Agronomy Journal*, Revision in review 2007.

Shurley, Don. *2006 Cotton Cost and Return Estimates For South and East Georgia*, Department of Agricultural and Applied Economics, University of Georgia, February 2006.

Shurley, Don, Phillip Jost, Stanley Culpepper, Phillip Roberts, and Bob Nichols. "Yield, Cost, and Net Return of Seed Technologies and Production Systems: A Four-Year Summary", *Cotton Research-Extension Report 2005*, University of Georgia, May 2006.

USDA-AMS. *Cotton Price Statistics*, November 2005 and November 2006.

USDA-Georgia Agricultural Statistics Service. *Georgia Farm Report*, December 2006.

USDA-NASS. *Acreage*, Cr Pr 2-5, June 2006.

Table 1. Number of Varieties in Systems Trials, By Technology Type

Seed Type	2005	2006
Conventional	1	2
BR	1	3
B2R	3	2
B2RF	2	3
RR	1	3
RF	2	3
LL	1	1
B2LL		1
WR	1	1
WRF	1	1
Total	**13**	**20**

Table 2. Yield Per Acre By Variety, Tifton 2005 and 2006

2005		**2006**	
Variety	**Yield (Lbs Per Acre)**	**Variety**	**Yield (Lbs Per Acre)**
DP 555 BR	1,754	DP 555 BR	1,491
PHY 475 WRF	1,621	DP 493	1,444
PHY 425 RF	1,589	FM 960 B2R	1,324
DP 491	1,585	DP 543 B2R	1,316
DP 494 RR	1,539	FM 960 BR	1,271
FM 960 B2R	1,516	DP 143 B2RF	1,258
PHY 470 WR	1,486	FM 960 RR	1,230
FM 966 LL	1,473	DP 491	1,229
ST 6611 B2RF	1,415	DP 494 RR	1,209
ST 4554 B2RF	1,409	PHY 425 RF	1,197
ST 6622 RF	1,368	PHY 410 R	1,178
DP 543 B2R	1,367	FM 988 B2LL	1,168
ST 4646 B2R	1,239	PHY 485 WRF	1,130
		FM 966 LL	1,129
		DP 147 RF	1,103
		ST 6622 RF	1,043
		FM 9063 B2RF	999
		PHY 480 WR	995
		ST 6565 B2RF	936
		DP 445 BR	857
LSD (p=.05)	*171*	*LSD (p=.05)*	*182*

Yields separated by less than the LSD in yield, are not "statistically different"—probability is 95% that the yields are the same. In 2005, the top 4 varieties (in bold) were not statistically different. In 2006, the top 4 varieties were not statistically different.

Table 3. Yield Per Acre By Variety, Midville 2005 and 2006

2005		2006	
Variety	**Yield (Lbs Per Acre)**	**Variety**	**Yield (Lbs Per Acre)**
DP 494 RR	1,344	DP 555 BR	1,648
ST 4554 B2RF	1,341	FM 960 RR	1,593
DP 555 BR	1,318	DP 493	1,573
ST 6611 B2RF	1,310	DP 143 B2RF	1,566
ST 4646 B2R	1,253	PHY 485 WRF	1,536
FM 960 B2R	1,234	FM 960 BR	1,529
ST 6622 RF	1,221	FM 9063 B2RF	1,499
PHY 470 WR	1,209	DP 543 B2R	1,486
PHY 425 RF	1,207	DP 445 BR	1,475
DP 543 B2R	1,195	DP 147 RF	1,469
PHY 475 WRF	1,158	PHY 480 WR	1,448
DP 491	1,139	DP 494 RR	1,441
FM 966 LL	1,111	FM 960 B2R	1,440
		DP 491	1,436
		PHY 425 RF	1,427
		PHY 410 R	1,356
		FM 988 B2LL	1,351
		FM 966 LL	1,345
		ST 6622 RF	1,244
		ST 6565 B2RF	1,210
LSD (p=.05)	*167*	*LSD (p=.05)*	*174*

Yields separated by less than the LSD in yield, are not "statistically different"—probability is 95% that the yields are the same. In 2005, the top 10 varieties (in bold) were not statistically different. In 2006, the top 9 varieties were not statistically different.

Table 4. Seed Cost Per Acre By Type, Year, and Location

Seed Type	Tifton (36-inch rows)		Midville (38-inch rows)	
	2005	2006	2005	2006
Conventional	$17.42	$20.55	$16.50	$19.47
BR	$68.96	$70.33	$65.33	$66.63
B2R	$74.48	$79.75	$70.56	$75.56
B2RF	$83.28	$87.90	$78.89	$83.28
RR	$46.46	$48.42	$44.02	$45.87
RF	$58.28	$60.51	$55.21	$57.32
WR	$67.59	$69.28	$64.04	$65.63
WRF	$79.01	$80.70	$74.86	$76.45
LL	$32.15	$32.94	$30.46	$31.20
B2LL		$58.05		$55.00

Cost includes technology fee, if applicable.

Table 5. Herbicide Cost Per Acre By Seed Type, Year, and Location

Technology	Tifton		Midville	
	2005	2006	2005	2006
Non-RR/Non-LL	$33.80	$22.92	$55.56	$42.16
RR	$23.45	$32.73	$57.81	$48.00
RF	$23.76	$32.73	$52.12	$44.38
LL	$25.95	$22.92	$59.94	$55.63

Cost shown excludes Application costs and cultivation, if applicable.

Table 6. Insecticide Cost Per Acre By Seed Type, Year, and Location

Technology	Tifton		Midville	
	2005	2006	2005	2006
Non-Bt/Non-W	$24.11	$30.74	$16.13	$29.25
B	$15.44	$18.08	$11.05	$17.53
B2	$15.44	$18.08	$11.05	$15.42
W	$15.44	$18.08	$11.05	$15.42

Cost shown excludes Application costs.

Table 7. Yield, Costs, and Net Return By Variety, Tifton 2005

Variety	System	Yield	Price	INCOME	System Costs					NGW	NET RETURN
					Seed	Herbicides	Insecticides	Application	TOTAL		
DP555BR	BR	1754	61.39	1076.73	68.96	23.45	15.44	27.13	134.97	102.54	839.22
DP491	C	1585	61.45	973.92	17.42	33.80	24.11	24.09	99.42	84.39	790.12
PHY425RF	RF	1589	60.93	968.14	57.88	23.76	24.11	18.22	123.98	76.35	767.81
PH475WRF	WRF	1621	60.64	983.01	79.01	23.76	15.44	18.22	136.44	80.01	766.56
DP494RR	RR	1539	61.55	947.19	46.46	23.45	24.11	27.13	121.15	84.38	741.66
FM960B2R	B2R	1516	62.41	946.10	73.20	23.45	15.44	27.13	139.21	68.96	737.93
FM966LL	LL	1473	61.61	907.58	32.15	25.95	24.11	24.09	106.30	70.10	731.18
PHY470WR	WR	1486	61.17	909.00	67.59	23.45	15.44	27.13	133.61	70.32	705.08
ST6611B2RF	B2RF	1415	61.12	864.79	83.28	23.76	15.44	18.22	140.70	55.06	669.03
ST6622RF	RF	1368	61.18	836.96	58.68	23.76	24.11	18.22	124.77	62.35	649.85
ST4554B2RF	B2RF	1409	60.75	856.02	83.28	23.76	15.44	18.22	140.70	71.22	644.11
DP543B2R	B2R	1367	61.53	841.14	75.33	23.45	15.44	27.13	141.35	63.26	636.53
ST4646B2R	B2R	1239	59.80	740.90	74.90	23.45	15.44	27.13	140.92	59.73	540.25
LSD (p=.05)	*171*										*99.04*

Net Returns separated by less than the LSD in Net Return are not "statistically different"—probability is 95% that Net Returns are the same. In 2005, the top 5 varieties (in bold) were not statistically different. The base price plus LDP for 2005 was 59.31 cents per pound. Fiber quality premium is the difference between the price shown and 59.31 cents per pound.

Table 8. Yield, Costs, and Net Return By Variety, Tifton 2006

Variety	System	Yield	Price	INCOME	System Costs					NGW	NET RETURN
					Seed	Herbicides	Insecticides	Application	TOTAL		
DP493	C	1444	57.96	836.89	20.55	22.92	30.74	25.93	100.14	85.88	650.88
DP555BR	BR	1491	58.68	874.87	71.41	32.73	18.08	22.67	144.90	93.03	636.94
FM960B2R	B2R	1324	59.34	785.72	82.27	32.73	18.08	22.67	155.76	67.44	562.53
DP491	C	1229	59.64	732.97	20.55	22.92	30.74	25.93	100.14	71.01	561.82
FM960BR	BR	1271	59.27	753.26	68.70	32.73	18.08	22.67	142.18	66.85	544.23
DP543B2R	B2R	1316	57.81	760.82	77.23	32.73	18.08	22.67	150.72	66.70	543.41
DP143B2RF	B2RF	1258	59.09	743.40	86.76	32.73	18.08	22.67	160.25	62.39	520.76
FM960RR	RR	1230	59.18	727.92	50.22	32.73	30.74	25.93	139.62	68.40	519.90
FM988B2LL	B2LL	1168	58.87	687.64	58.05	22.92	18.08	22.67	121.73	53.50	512.41
DP494RR	RR	1209	58.57	708.07	49.23	32.73	30.74	25.93	138.63	68.05	501.39
PHY410R	RR	1178	58.11	684.54	45.79	32.73	30.74	25.93	135.19	57.66	491.68
FM966LL	LL	1129	58.20	657.07	32.94	22.92	30.74	25.93	112.53	56.52	488.02
PHY425RF	RF	1197	57.68	690.37	59.87	32.73	30.74	25.93	149.27	61.25	479.85
DP147RF	RF	1103	59.37	654.83	60.99	32.73	30.74	25.93	150.39	55.61	448.82
PHY485WRF	WRF	1130	57.73	652.40	80.70	32.73	18.08	22.67	154.18	58.41	439.81
ST6622RF	RF	1043	58.66	611.86	60.66	32.73	30.74	25.93	150.06	42.31	419.49
PHY480WR	WR	995	58.03	577.43	69.28	32.73	18.08	22.67	142.76	47.20	387.46
FM9063B2RF	B2RF	999	58.70	586.41	91.40	32.73	18.08	22.67	164.88	49.34	372.19
ST6565B2RF	B2RF	936	58.76	549.96	85.55	32.73	18.08	22.67	159.03	34.02	356.90
DP445BR	BR	857	58.47	501.08	70.89	32.73	18.08	22.67	144.37	42.97	313.73
LSD (p=.05)		*182*									*103.50*

Net Returns separated by less than the LSD in Net Return are not "statistically different"—probability is 95% that Net Returns are the same. In 2006, the top 4 varieties (in bold) were not statistically different. The base price plus LDP for 2006 was 57.11 cents per pound. Fiber quality premium is the difference between the price shown and 57.11 cents per pound.

Table 9. Yield, Costs, and Net Return By Variety, Midville 2005

Variety	System	Yield	Price	INCOME	System Costs					NGW	NET RETURN
					Seed	Herbicides	Insecticides	Application	TOTAL		
ST4554B2RF	B2RF	1341	60.11	806.09	78.89	52.12	11.05	27.13	169.19	93.34	543.57
DP555BR	BR	1318	61.13	805.63	65.33	57.81	11.05	33.91	168.10	96.60	540.93
ST6611B2RF	B2RF	1310	60.11	787.48	78.89	52.12	11.05	27.13	169.19	82.67	535.62
DP494RR	RR	1344	57.22	768.99	44.02	57.81	16.13	36.95	154.91	96.00	518.08
FM960B2R	B2R	1234	61.53	759.34	69.34	57.81	11.05	33.91	172.12	81.71	505.51
PHY425RF	RF	1207	59.79	721.69	54.83	52.12	16.13	30.16	153.25	78.23	490.20
ST4646B2R	B2R	1253	59.71	748.18	70.96	57.81	11.05	33.91	173.74	85.58	488.86
DP491	C	1139	60.50	689.10	16.50	55.56	16.13	37.46	125.64	79.00	484.46
ST6622RF	RF	1221	58.72	716.99	55.59	52.12	16.13	30.16	154.00	83.29	479.70
PHY470WR	WR	1209	59.93	724.59	64.04	57.81	11.05	33.91	166.81	78.84	478.94
DP543B2R	B2R	1195	61.29	732.44	71.37	57.81	11.05	33.91	174.14	80.41	477.90
FM966LL	LL	1111	60.98	677.51	30.46	59.94	16.13	30.16	136.69	72.95	467.87
PHY475WRF	WRF	1158	58.63	678.96	74.86	52.12	11.05	27.13	165.16	77.66	436.14
LSD (p=.05)		*167*									*98.44*

Net Returns separated by less than the LSD in Net Return are not "statistically different"—probability is 95% that Net Returns are the same. In 2005, 12 of 13 varieties (in bold) were not statistically different. The base price plus LDP for 2005 was 59.31 cents per pound. Fiber quality premium is the difference between the price shown and 59.31 cents per pound.

Table 10. Yield, Costs, and Net Return By Variety, Midville 2006

Variety	System	Yield	Price	INCOME	System Costs					NGW	NET RETURN
					Seed	Herbicides	Insecticides	Application	TOTAL		
DP493	C	1573	59.43	934.85	19.47	42.16	29.25	44.97	135.85	96.05	702.95
FM960RR	RR	1593	58.73	935.54	47.58	48.00	29.25	36.50	161.33	87.33	686.88
DP555BR	BR	1648	58.14	958.16	67.65	48.00	17.53	36.50	169.69	102.35	686.12
DP143B2RF	B2RF	1566	58.65	918.41	82.20	44.38	15.42	29.19	171.19	77.06	670.16
PHY485WRF	WRF	1536	58.87	904.26	76.45	44.38	15.42	29.19	165.44	80.40	658.42
FM960BR	BR	1529	58.18	889.60	65.08	48.00	17.53	36.50	167.12	79.41	643.08
FM9063B2RF	B2RF	1499	59.12	886.19	86.59	44.38	15.42	29.19	175.58	70.62	639.99
DP491	C	1436	59.33	852.03	19.47	42.16	29.25	44.97	135.85	79.94	636.24
DP543B2R	B2R	1486	59.14	878.80	73.17	48.00	15.42	36.50	173.09	75.52	630.18
DP147RF	RF	1469	58.99	866.51	57.78	44.38	29.25	29.19	160.60	76.47	629.45
PHY480WR	WR	1448	59.24	857.80	65.63	48.00	15.42	36.50	165.56	68.22	624.02
DP445BR	BR	1475	58.31	860.07	67.16	48.00	17.53	36.50	169.19	77.47	613.41
DP494RR	RR	1441	59.35	855.17	46.64	48.00	29.25	36.50	160.39	81.66	613.11
PHY425RF	RF	1427	58.90	840.55	56.72	44.38	29.25	29.19	159.53	70.38	610.64
FM960B2R	B2R	1440	59.13	851.52	77.94	48.00	15.42	36.50	177.87	74.12	599.53
PHY410R	RR	1356	58.71	796.16	43.38	48.00	29.25	36.50	157.14	66.26	572.77
FM966LL	LL	1345	59.02	793.85	31.20	55.63	29.25	36.50	152.58	69.08	572.19
FM988B2LL	B2LL	1351	58.66	792.49	55.00	55.63	15.42	36.50	162.55	64.59	565.35
ST6622RF	RF	1244	59.01	734.07	57.47	44.38	29.25	29.19	160.29	56.73	517.05
ST6565B2RF	B2RF	1210	58.58	708.76	81.05	44.38	15.42	29.19	170.04	49.04	489.68
LSD (p=.05)		*174*									*93.62*

Net Returns separated by less than the LSD in Net Return are not "statistically different"—probability is 95% that Net Returns are the same. In 2006, the top 14 varieties (in bold) were not statistically different. The base price plus LDP for 2006 was 57.11 cents per pound. Fiber quality premium is the difference between the price shown and 57.11 cents per pound.

Table 11A. Summary By Seed Technology Type, Tifton 2005

Technology	No. Varieties	Yield	INCOME	System Costs					NGW	NET RETURN
				Seed	Herbicides	Insecticides	Application	TOTAL		
Conventional	1	1585	973.92	17.42	33.80	24.11	24.09	99.42	84.39	790.12
BR	1	1754	1076.73	68.96	23.45	15.44	27.13	134.97	102.54	839.22
B2R	3	1374	842.71	74.48	23.45	15.44	27.13	140.49	63.98	638.24
B2RF	2	1412	860.40	83.28	23.76	15.44	18.22	140.70	63.14	656.57
RR	1	1539	947.19	46.46	23.45	24.11	27.13	121.15	84.38	741.66
RF	2	1479	902.55	58.28	23.76	24.11	18.22	124.37	69.35	708.83
WR	1	1486	909.00	67.59	23.45	15.44	27.13	133.61	70.32	705.08
WRF	1	1621	983.01	79.01	23.76	15.44	18.22	136.44	80.01	766.56
LL	1	1473	907.58	32.15	25.95	24.11	24.09	106.30	70.10	731.18

Table 11B. Summary By Seed Technology Type, Tifton 2006

Technology	No. Varieties	Yield	INCOME	System Costs					NGW	NET RETURN
				Seed	Herbicides	Insecticides	Application	TOTAL		
Conventional	2	1337	784.93	20.55	22.92	30.74	25.93	100.14	78.44	606.35
BR	3	1206	709.73	70.33	32.73	18.08	22.67	143.82	67.62	498.30
B2R	2	1320	773.27	79.75	32.73	18.08	22.67	153.24	67.07	552.97
B2RF	3	1065	626.59	87.90	32.73	18.08	22.67	161.39	48.58	416.62
RR	3	1205	706.85	48.42	32.73	30.74	25.93	137.82	64.71	504.32
RF	3	1115	652.35	60.51	32.73	30.74	25.93	149.91	53.06	449.39
WR	1	995	577.43	69.28	32.73	18.08	22.67	142.76	47.20	387.46
WRF	1	1130	652.40	80.70	32.73	18.08	22.67	154.18	58.41	439.81
LL	1	1129	657.07	32.94	22.92	30.74	25.93	112.53	56.52	488.02
B2LL	1	1168	687.64	58.05	22.92	18.08	22.67	121.73	53.50	512.41

Table 12A. Summary By Seed Technology Type, Midville 2005

Technology	No. Varieties	Yield	INCOME	System Costs					NGW	NET RETURN
				Seed	Herbicides	Insecticides	Application	TOTAL		
Conventional	1	1139	689.10	16.50	55.56	16.13	37.46	125.64	79.00	484.46
BR	1	1318	805.63	65.33	57.81	11.05	33.91	168.10	96.60	540.93
B2R	3	1227	746.65	70.56	57.81	11.05	33.91	173.33	82.56	490.76
B2RF	2	1325	796.79	78.89	52.12	11.05	27.13	169.19	88.00	539.59
RR	1	1344	768.99	44.02	57.81	16.13	36.95	154.91	96.00	518.08
RF	2	1214	719.34	55.21	52.12	16.13	30.16	153.63	80.76	484.95
WR	1	1209	724.59	64.04	57.81	11.05	33.91	166.81	78.84	478.94
WRF	1	1158	678.96	74.86	52.12	11.05	27.13	165.16	77.66	436.14
LL	1	1111	677.51	30.46	59.94	16.13	30.16	136.69	72.95	467.87

Table 12B. Summary By Seed Technology Type, Midville 2006

Technology	No. Varieties	Yield	INCOME	System Costs					NGW	NET RETURN
				Seed	Herbicides	Insecticides	Application	TOTAL		
Conventional	2	1505	893.44	19.47	42.16	29.25	44.97	135.85	88.00	669.60
BR	3	1551	902.61	66.63	48.00	17.53	36.50	168.67	86.41	647.54
B2R	2	1463	865.16	75.56	48.00	15.42	36.50	175.48	74.82	614.85
B2RF	3	1425	837.78	83.28	44.38	15.42	29.19	172.27	65.57	599.94
RR	3	1463	862.29	45.87	48.00	29.25	36.50	159.62	78.42	624.25
RF	3	1380	813.71	57.32	44.38	29.25	29.19	160.14	67.86	585.72
WR	1	1448	857.80	65.63	48.00	15.42	36.50	165.56	68.22	624.02
WRF	1	1536	904.26	76.45	44.38	15.42	29.19	165.44	80.40	658.42
LL	1	1345	793.85	31.20	55.63	29.25	36.50	152.58	69.08	572.19
B2LL	1	1351	792.49	55.00	55.63	15.42	36.50	162.55	64.59	565.35

COTTON BASIS: REGIONAL AND SEASONAL DIFFERENCES

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Introduction

The United States is a major cotton producer, accounting for about 20 percent of total World production annually. US cotton is used both domestically by US mills and exported to foreign mills. Domestic mill use was the leading use for U.S. cotton until 2001. US mill consumption has steadily declined since the late 1990's accompanied by a steady increase in U.S. cotton exports as foreign textile production has increased. Major importers of U.S. cotton are China, Mexico, Korea, Turkey, and Indonesia. Most U.S. cotton exports are shipped through ports along the Pacific and Atlantic coasts. Although the Southeast and the MidSouth regions still enjoy proximity to domestic mills, the dramatic fall in domestic consumption makes cotton from all US cotton-producing states more dependent on the export market.

Research Objective

The objective of this research is to explore possible effects on the monthly cotton basis that may have resulted from the major market shift from domestic mills to the export market. The monthly cotton basis is calculated for seven regions for the most recent six crop years, August 2000 to July 2006. Regional and seasonal patterns from this period are compared with results for an earlier period, August 1988 – July 1998 (Seamon, Kahl, and Curtis, 2001). Statistical tests are conducted and findings reported for differences or changes in regional and seasonal monthly basis patterns between the 2 time periods.

Results and Discussion

Calculating Cotton Basis

The USDA Agricultural Marketing Service (USDA- AMS) reports daily and monthly cotton cash prices for seven regions:

Southeast-- Alabama, Florida, Georgia, North Carolina, South Carolina, Virginia.
North Delta-- Arkansas, Tennessee, Missouri.
South Delta-- Louisiana, Mississippi.
East Texas-Oklahoma-- East Texas, Oklahoma.
West Texas-- West Texas except El Paso area.
Desert Southwest-- Arizona, New Mexico and far West Texas.
San Joaquin Valley-- San Joaquin Valley of California.

The monthly cotton basis for each region as reported by USDA-AMS is calculated averaging the daily average cash price minus the "nearby" daily closing futures price on the New York Board of Trade. Although the nearby future contract is usually used for calculating the basis, the July contract was used by Seamon et al. (2001) to more clearly identify seasonal/regional patterns from August 1988 to July 1998.

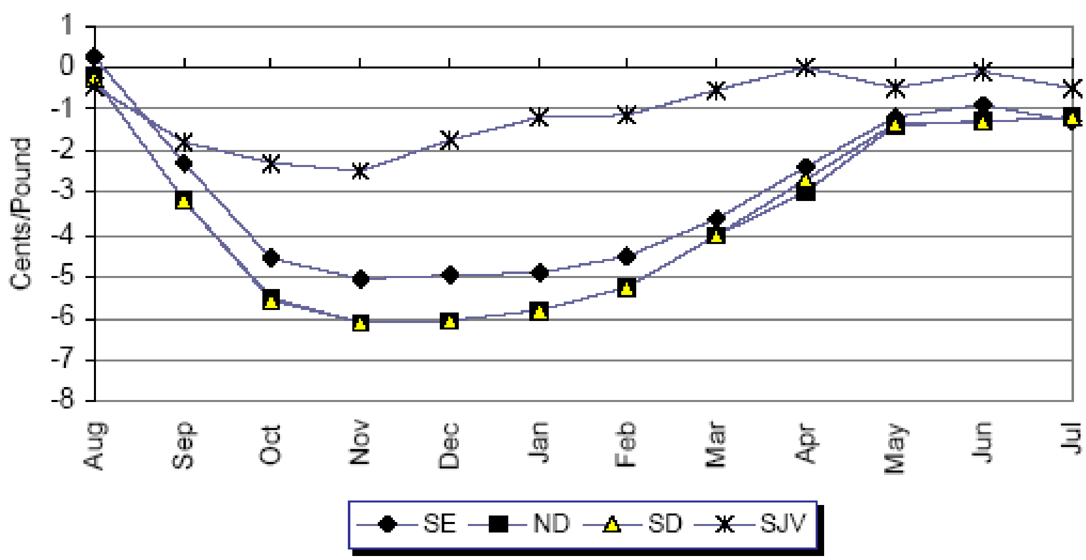
In order to examine possible changes in basis patterns, the same basis calculation was used for this study. For our updated analysis the basis is calculated for each region and month from August 2000 to July 2006 - the six most recent complete crop years.

Regional Cotton Basis in Two Time Periods

Basis is the difference between the local cash price and the futures price, usually defined as the local cash price minus the futures price. For a seasonally produced storable commodity with stable demand, the cash price and the futures price will converge as the futures contract nears maturity. Regional differences in the basis are expected to reflect differences in transportation costs. Seamon, Kahl and Curtis (2001) indicated that the Southeast, San Joaquin Valley, North Delta and South Delta regions had a stronger basis than other regions during their study period from August 1988 to July 1998, due to their proximity to domestic mills or western ports. Since they incur higher costs to transport cotton to eastern domestic mills or western ports, the East Texas-Oklahoma, West Texas and Desert Southwest had a weaker basis.

Seamon, Kahl and Curtis (2001) suggested the cotton basis calculated using the futures contact expiring in July theoretically should have a seasonal pattern which weakens from July until harvest and then strengthens afterward. However, this theoretical seasonal basis pattern relies on the assumption of stable monthly demand. The cotton basis in the Southeast, North Delta and South Delta were consistent with the theoretical seasonal pattern (Figure 1.1).

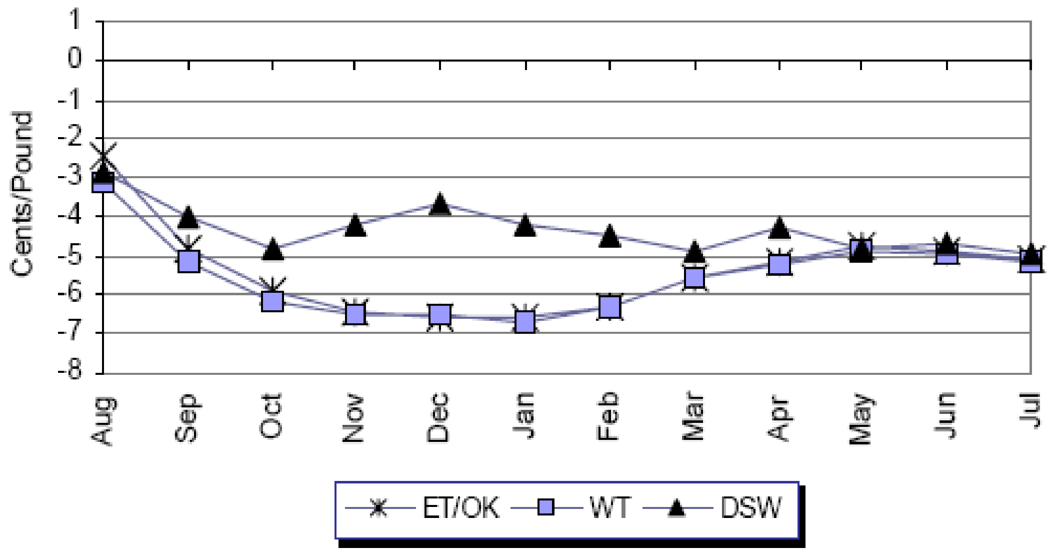
Figure1.1 Average Monthly Cotton Basis for SE, ND, SD, and SJV, August 1988—July 1998



Source: Seamon et al. (2001), Journal of Agribusiness.

Within the study period from August 1988 to July 1998, most cotton from these regions went directly to domestic mills which had relatively stable demand. Seasonal patterns for regions more dependent on export markets, such as San Joaquin Valley and Desert Southwest, were less apparent (Figure 1.2).

Figure1.2 Average Monthly Cotton Basis for ET/OK, WT and DSW, August 1988—July 1998



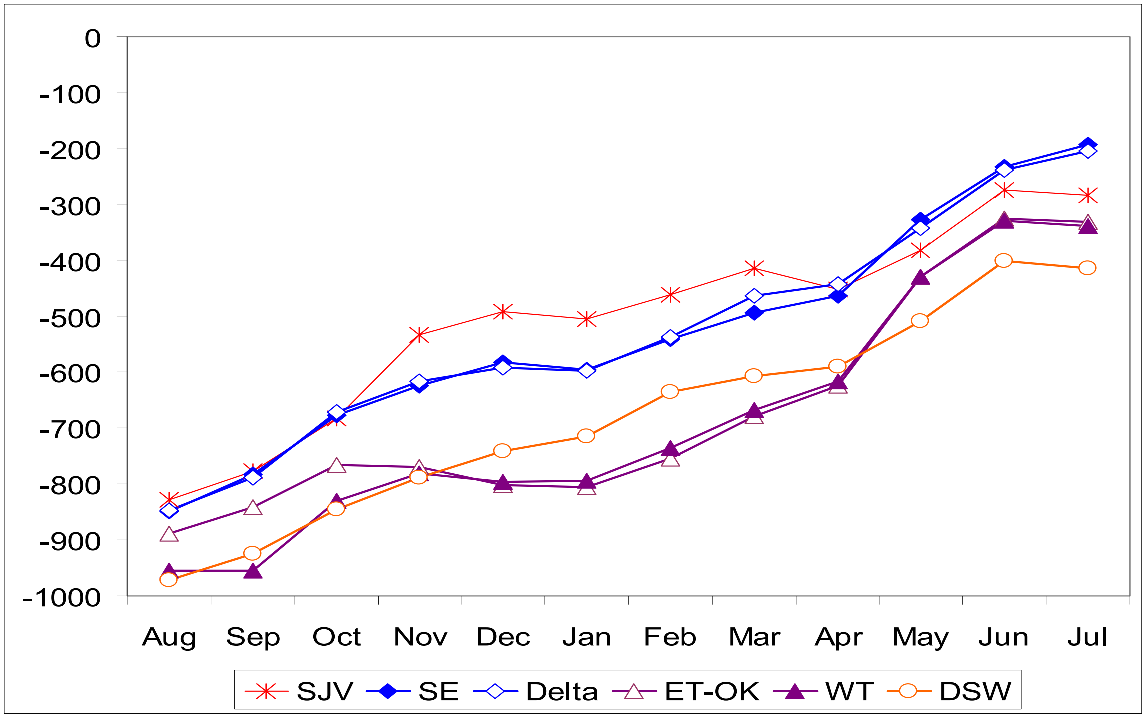
Source: Seamon et al. (2001), Journal of Agribusiness.

The average monthly cotton basis for each region from August 2000 to July 2006 is shown in Figure 2. The average monthly basis for North Delta and South Delta were almost identical, so these regions were averaged and combined into a single Delta region to simplify Figure 2. A comparison of Figures 1.1, 1.2, and 2 reveals apparent differences in regional and seasonal basis patterns for the two data periods. Changes in the regional basis patterns will be discussed first, followed by a discussion of changes in the seasonal basis patterns.

Changes in the Regional Basis

In the more recent period, the monthly cotton basis in the Southeast, the Delta, and the San Joaquin Valley were stronger than the basis in the other regions—East Texas-Oklahoma, West Texas and Desert Southwest. These regional differences are similar to what Seamon et al. (2001) found in their research for the period August 1988 to July 1998. Although domestic consumption fell dramatically since the late 1990's, the proximity to the domestic mills and eastern ports helped the Southeast and Delta regions keep a stronger basis. Furthermore, as the export market became more important and, more and more cotton exports are traded through the western ports, the monthly cotton basis of San Joaquin Valley continue to be strong. The monthly cotton basis for East Texas-Oklahoma, West Texas and Desert Southwest are still weakest of the seven regions since transportation costs to eastern/western ports for export or eastern domestic mills for domestic consumption continue to disadvantage these regions.

Figure 2. Average Monthly Cotton Basis for Six Regions, August 2000—July 2006



Source: AMS, USDA; NYBOT

Although visual examination of average monthly basis data suggests regional differences in the basis, these differences may not be statistically significant because the regional monthly patterns vary from year to year. Seamon, Kahl, and Curtis used Friedman tests to determine whether the apparent regional differences were statistically significant, and we employed the same tests for the more recent data.

Regional Differences

The Friedman test determines whether the observations differ by treatment after the effect of the blocks has been removed. Each region is treated as the treatment and each month of each crop year is the block. Since the cotton basis for seven regions and recent 6 crop years is used in this research, there are 7 treatments and 72 blocks included in this analysis. Each observation, B_{ij} with i=1,2,…,72 and j=1,2,…,7 represents the monthly basis of the month i and in region j. The seven observations within each block are ranked from smallest to largest with 1 assigned to the smallest and 7 assigned to the largest observation. When there are ties within each block, each observation receives the average rank they would have received. The rank sums for each treatment (region) are recorded in Table 1.

The cotton basis in at least one region is significantly different from any other region if there are significant differences in the rank sums for each region. The formula for the Friedman test statistic is as the following (Daniel, W.W., 1990):

$$X_r^2 = \frac{12}{bk(k+1)} \sum_{j=1}^{k} R_j^2 - 3b(k+1)$$

where b is the number of blocks, k is the number of the treatments and R_j is the rank sum of the region j. When ties occur, the test statistic need to be adjusted by dividing it by (Daniel, W.W., 1990):

$$1-\sum_{i=1}^{b}\frac{\sum t_i^3-\sum t_i}{bk(k^2-1)}$$

where t_i is the number of observations tied for a given rank in the ith block. The calculated Friedman statistic is 187.5266. Compared with tabulated χ^2 value with k-1 degrees of freedom, the null hypothesis is rejected at 99% confidence level which implies that cotton basis in at least one region is different from any other regions.

After the significant difference is observed by using the Friedman test, multiple-comparison analysis is applicable to determine the regions in which the cotton basis differs. The q value is defined as (Zar, J. H., 1984):

$$q=\frac{R_j-R_{j+1}}{\sqrt{\frac{bk(k+1)}{12}}}$$

where the R_j – R_{j+1} is the difference of the rank sum of any two regions. The third column of the Table 1 shows the results of the multiple-comparison. The regions found to have significantly different basis at 95% confidence level are identified by different alphabetical letters. For the study period from August 2000 to July 2006, there is no significant difference in the basis found for the following regions: a) North Delta, South Delta, Southeast and San Joaquin Valley; b) East Texas-Oklahoma, West Texas and Desert Southwest.

The result of the multiple-comparison coincides with Figure 2 which shows that the basis of Southeast, San Joaquin Valley, North Delta and South Delta are similar and stronger than the remaining regions through the crop year. Starting from the same level from the beginning of the crop year, the basis of Southeast and San Joaquin Valley are slightly stronger than the basis of the Delta regions for several months. Then the basis of the Delta regions becomes stronger later in the crop year. So the basis is not significantly different across these four regions. The basis for East Texas-Oklahoma, West Texas and Desert Southwest is generally weaker than that in the other four regions. While the basis of the East Texas-Oklahoma is stronger than the other two regions early in the crop year, the basis of Desert Southwest becomes stronger in the following several months and then becomes weaker later in the crop year. Overall, there is no significant difference among the basis for these three regions.

Table 1. Statistical Results of the Friedman Test for the Regional Differences in Monthly Cotton Basis for Seven Regions, August 2000—July 2006.

Region	Rank Sum	Q Grouping
North Delta	372	A
South Delta	370	A
Southeast	368	A
San Joaquin Valley	367	A
East Texas-Oklahoma	197	B
West Texas	174	B
Desert Southwest	170	B

This result is different from the results of Seamon, Kahl and Curtis (2001). They concluded there was no significant difference in the basis for the following regions: a) Southeast and San Joaquin Valley; b) North Delta, South Delta, and Desert Southwest; c) East Texas-Oklahoma and West Texas. The basis of Delta regions is no longer significantly different from the basis in the Southeast and San Joaquin Valley. The Southeast and San Joaquin Valley basis appear to have weakened from the earlier to the latter study periods, while the Delta regions basis has not weakened as much. Seamon, Kahl and Curtis (2001) attributed the strong San Joaquin basis during the November through March period to increased export demand during those months. The relative weakening of the San Joaquin Valley basis may be due to the end of this seasonal pattern in export demand and to the increased participation of all regions in the export market.

Changes in Seasonal Basis Patterns

The seasonal pattern of this most recent period (2000-2006) appears to be different from the seasonal pattern for the previous 1988-1998 study period. The theoretical seasonal pattern, which was to weaken from July to harvest time and then strengthen as the crop year progresses, generally applied for those regions which mostly supplied domestic mills. This seasonal pattern doesn't appear to hold for any of the seven regions any longer. As Figure 2 shows, the basis is weakest right after the July contract expires, and it then strengthens as the crop year progress to approach the strongest at the end of the crop year. The basis in August was almost always the strongest within the crop year in the earlier period. In the more recent period, however, the basis in August is the weakest within the crop year. This change may be partly due to the carry-over of larger U.S. cotton stocks than before, which can relieve the shortage of the cotton supply right before harvest, decreasing the cash price and basis in August.

To determine if the monthly cotton basis has a significant seasonal pattern, the Friedman test is used again. Table 2 presents the seasonal Friedman statistic for each region. After comparing the Friedman statistic for each region with the tabulated χ^2 values with k-1 degrees of freedom, the null hypothesis is rejected at 99% confidence level, implying that the monthly cotton basis is found to be different in at least one month for all these seven regions. The results of seasonal Friedman test coincide with Figure 2. Figure 2 shows that the monthly cotton basis of all seven regions follow a stable increasing pattern throughout the crop year, which indicates that the monthly basis is likely to be different early in the crop year from late in the crop year.

Table 2. Statistical Results of the Friedman Test for the Seasonal Differences in Monthly Cotton Basis for Seven Regions, August 2000—July 2006.

Region	Seasonal Friedman Statistic
North Delta	52.3846
South Delta	52.7102
Southeast	56.5627
San Joaquin Valley	37.6410
East Texas-Oklahoma	36.3609
West Texas	38.7631
Desert Southwest	43.9744

Since significant differences within the crop year for all seven regions are observed by using the Friedman test, multiple-comparison analysis is applied for each region to determine the months in which the cotton basis differs. The months found to have significantly different basis at 95% confidence level are identified by different letters. Table 3 reports the rank sums and the results of monthly differences in the basis for Southeast and San Joaquin Valley.

Table 3. Statistical Results of the Friedman Test for the Seasonal Differences in Monthly Cotton Basis for Seven Regions, August 2000—July 2006.

SOUTHEAST				SAN JOAQUIN VALLEY			
Month	Rank Sum	Q Grouping		Month	Rank Sum	Q Grouping	
June	68	A		June	63	A	
July	66	A		July	52	A	
May	60	A		May	50	A	
April	48	A	B	February	50	A	
March	45	A	B	March	49	A	B
February	41	A	B	December	43	A	B
December	34	A	B	November	42	A	B
November	30	A	B	January	37	A	B
January	29	A	B	April	36	A	B
October	26		B	October	24	A	B
September	14		B	September	14		B
August	8		B	August	8		B

The results for San Joaquin Valley indicate that the monthly basis in June, July, May and February is stronger than the monthly basis in September and August at the 95% confidence level. The results for the Southeast indicate that the monthly basis in June, July and May is stronger than the monthly basis in October, September and August at the 95% confidence level. The multiple-comparison analysis for the other five regions indicates a similar pattern as the two mentioned above. The monthly cotton basis for all seven regions follows the same pattern-- weaker at the beginning of the crop year and stronger as the crop year progresses.

Conclusions

As the major consumption market shifted from domestic mills to the export market, the cotton cash price and basis are more affected by demand and supply in the world market. Regional and seasonal differences in the monthly cotton basis are different from that earlier reported by Seamon et al. (2001) for an earlier period, August 1988 – July 1998.

Because of their proximity to the western or eastern ports, the Southeast, Delta, and San Joaquin Valley regions had a stronger basis than the East Texas-Oklahoma, West Texas and Desert Southwest regions for the period of August 2000 – July 2006. The basis in the Delta regions was weaker than the basis in the Southeast and San Joaquin Valley for the previous study period, but there is no significant difference found for these four regions for the current study period.

The monthly cotton basis for all regions is now mostly affected by export market demand. The seasonal basis pattern coincides with the monthly average cotton export pattern during the more recent study period and a similar seasonal cotton basis pattern exists for all regions.

References

Daniel, W. W. *Applied Nonparametric Statistics*, 2nd edition. Boston, MA: PWS-KENT Publishing Co. 1990.

Leuthold, R. M., Junkus, J.C., and Cordier, J. E. *The Theory and Practice of Futures markets*. Lexington, Mass. : Lexington Books. 1989.

New York Board of Exchange. Historical Data.

Seamon, V. F., Kahl, K. H., and Curtis, C. E. "Regional and Seasonal Difference in the Cotton Basis". Journal of Agribusiness 19,2 (Fall 2001): 147-161. Fall 2001.

Seamon, V. F., Kahl, K. H., and Curtis, C. E. "A Regional Comparison of U.S. Cotton Basis Pattern". Working paper. Department of Agricultural and Applied Economics. Clemson University. December 1997.

United States Department of Agriculture. *Cotton Price Statistics*. Monthly Report. Agricultural Marketing Service. August 2000—July 2006.

United States Department of Agriculture. *U.S. Trade Exports-FAS Commodity Aggregations*. Foreign Agricultural Service.

United States Census Bureau. *Consumption on the Cotton System and Stocks.* Annual Summary. Manufacturing, Mining, and Construction Statistics. 2001-2005.

Zar, J. H. *Biostatistical Analysis*, 2nd edition. Englewood Cliffs, NJ: Prentice-Hall, Inc. 1984.

APPLICATION OF WEATHER DATA FOR MANAGEMENT OF COTTON PRODUCTION IN 2006

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Introduction

The year 2006 was a very dry year when compared to 2005 and especially 2003 and 2004. All our weather observation sites showed a negative water balance, demonstrating the need for supplemental irrigation. However, during the last six years the availability of water for irrigation has become a critical issue for Georgia farmers due to the requirements for minimum water flows in the major rivers set by the neighboring states of Florida and Alabama. The future is not very bright, especially for farmers located in the Flint River basin. In 2000, the Georgia legislature approved the Flint River Drought Protection act. This act was implemented during the spring of both 2001 and 2002, when farmers were asked to bid for acreage that they were willing to remove from irrigation. Fortunately, the drought mitigation act has not been implemented since 2003 as the weather outlook provided for a wetter growing season compared to the previous years. However, the spring of 2006 was initially also relatively dry compared to previous years. It is highly likely that these drought episodes will repeat in the future based on the past weather history.

Access to near real-time weather data is critical for cotton production. This weather information can be used in various computer programs to help producers with their daily management decisions. There is a need to develop and implement computer-based information technologies for decision-making, using local weather data from Georgia and other input conditions such as soil and crop management. Although weather and decision support system have not been listed as one of the research needs for the Georgia cotton industry, it directly or indirectly affects many issues and decisions that are made on a daily basis by producers. These decisions relate planting date selection, deficit irrigation management, when to start and stop irrigation, replanting in case of establishment failure, irrigation timing and crop water use, and applications of pesticides and herbicides. The strategic plan of the Georgia Cooperative Extension Service has identified Information Technology as one of the critical issues for the near future for dissemination of knowledge and information to farmers, producers, growers, consultants, and other stakeholders.

Procedures

The College of Agricultural and Environmental Sciences of the University of Georgia has established an extensive network of automated weather stations that are located across the state of Georgia. There are currently 71 stations in operation in Albany, Arlington, Calhoun, Camilla, Cordele, Dublin, Newton, Statesboro, Vidalia, and many other locations (Figure 1). Several of these weather stations have been installed in farmers' fields, such as in Georgetown and Cordele. In 2006, three new weather stations were installed in Ty Ty at the Ponder Farm of the Tifton Campus of the University of Georgia to help support cotton research, in Tennille at the Washington County Farm Bureau Ag Center, and in Blue Ridge at Mercier Orchards. The weather variables that are collected include rainfall, air temperature, soil temperature, relative humidity, wind speed and direction, solar radiation, soil moisture, and barometric pressure. The data logger is the central core for operation of the weather station and storage of the data and it automatically records the weather data. Each weather sensors is scanned at a one-second frequency and every 15 minutes summaries are calculated for the previous period. At midnight, daily extremes, daily totals, and other summaries are determined.

Each weather station is a stand-alone unit, powered by a battery, which is recharged by a solar panel. Communications are handled through a dedicated telephone line or cell phone, which is connected to the modem of each weather station. A computer located at the Griffin Campus of the University of Georgia calls each station at hourly or more frequent intervals and downloads the data. After processing, error checking, and other procedures, all data are pushed to a web server. Users can retrieve various types of weather and climate data from www.Georgiaweather.net, including yesterday's conditions, weather conditions for the last 31 days, as well as historical data for temperature and rainfall. Weather data are also distributed to local news media, including television stations and newspapers, and to farmers and agribusinesses via electronic mail. Current weather conditions are now updated at least every 30 minutes for all sites and more frequently for some of the sites.
A key component for decision making by growers and producers is the suite of application programs that have been implemented on the web site (www.Georgiaweather.net). Users can calculate degree-days for any period of time until present. As part of the degree-day calculator, users can define the base temperature as well as a maximum temperature, above which no degree-days are calculated. During the winter months, users can calculate chilling hours for any period until present. A third calculator is the water balance calculator. It calculates total precipitation received for any period of time, as well as potential evapotranspiration. Potential evapotranspiration is the potential amount of water that can be lost by a crop that is grown under well-watered conditions. The difference between total precipitation and total potential evapotranspiration reflects the need for irrigation to avoid water stress. Recent additions include simple calculators to summarize soil temperature, air temperature, as well as rainfall. The newest tool has the capability to graph daily weather data, as shown for maximum and minimum temperature and daily total rainfall for Vienna in Figure 2 and Figure 3, and local temperature predictions up to 12 hours ahead.

Results

For this study, we compared the cumulative number of degrees days, using a base temperature of 60 degrees Fahrenheit. We did not use a maximum temperature cutoff in our calculators. The results for 2006 were compared with the previous growing seasons for 2001 through 2005. Please note that the automated weather station network is continuously being expanded and that we, therefore, do not have complete weather records for all sites. Recent installations include Albany, Tiger, and Clarks Hill, South Carolina in 2004, Moultrie, Unadilla, Vienna, and Woodbine in 2005, and Ty Ty, Tennille, and Blue Ridge in 2006. We defined the start of the growing season as May 1 and the end of the growing season as December 31. In reality, this can vary from location to location. Cumulative degrees days for the 2001 through 2006 growing seasons are shown in Table 1. The maximum number of degree-days for 2006 was found in Valdosta at 3384, Albany at 3253, and Moultie at 3136. The minimum number of degrees in 2006 was found in Rome at 2444, Watkinsville at 2487, and Pine Mountain at 2491. The same sites also had maximum and minimum values for degree-days in 2004 and 2005. For all sites, except for Alapaha, the cumulative total number of degree-days was very similar for 2005 and 2006. For the six-year period from 2001 through 2006, both 2001 and 2003 had the lowest number of degree days, except for a few sites, while the number of degree days for 2002, 2004, 2005, and 2006 was very similar.

Cumulative precipitation for May 1 until October 1 is shown in Table 2. Similar to the previous years, rainfall varied significantly across the state and among weather stations for this period. Fort Valley and Moultrie were the driest locations, with respectively 12.2 and 12.6 inches. Arlington, Attapulgus, and Plains had the highest amount of precipitation, with respectively 28.6, 27.8, and 27.1 inches of rain. When comparing the period 2001 through 2006, the growing season of 2006 was relatively dry and for some sites the driest for the past six years.

The water balance for the same period is presented in Table 3. The water balance represents the difference between incoming water through rainfall and outgoing water lost through potential evapotranspiration for a well-watered crop. All sites had a negative water balance that ranged from -3.8 inches for Arlington to -25.6 for Vidalia. During the period from 2000 through 2005, four sites had a negative water balance for all six years. These include Cairo, Camilla, Dearing, and Fort Valley, while eight sites had a negative balance during five of the six years, e.g., Arlington, Attapulgus, Cordele, Dublin, Eatonton, Plains, Rome, and Valdosta. This is somewhat of concern and could mean that for these sites an investment in supplemental irrigation should be recommended. Unfortunately, the water balance does not provide much information with respect to both the rainfall distribution and intensity, and only provides a seasonal summary. Recent reports show that late rains really help boost cotton yields compared to the early estimates based on drought and heat stress, as shown in Figure 3 for Vienna during late August and early September.

Summary and Conclusions

Temperature and rainfall display a very strong annual variability, as well as among sites. Although this is not a new observation, it shows that the availability of local weather information is critical for day-to-day decision making by farmers. This weather information can be integrated in management and decision support tools, such as models, to provide alternate management options and solutions for farmers. Especially schedulers for irrigation management are needed if water for agricultural use will become restricted.

The automated weather station network will continue to collect local weather data as long as financial support will be provided by industry, government, and others interested in weather data to support their operation and management decisions. Weather information can be retrieved at no-cost via the world wide web at (www.Georgiaweather .net) and specific web pages have been developed for cotton producers to be able to quickly retrieve degree days (www.griffin.uga.edu/aemn/degreedays.htm) and cumulative rainfall (www.griffin.uga.edu/aemn/rainNOV.htm) for the main cotton producing areas in Georgia. The degree-day and water balance calculators can also be run interactively on the web, using local weather data as input. We feel that the combination of near real-time weather data and decision support systems is critical to maintain an economically sustainable farming operation.

Acknowledgments

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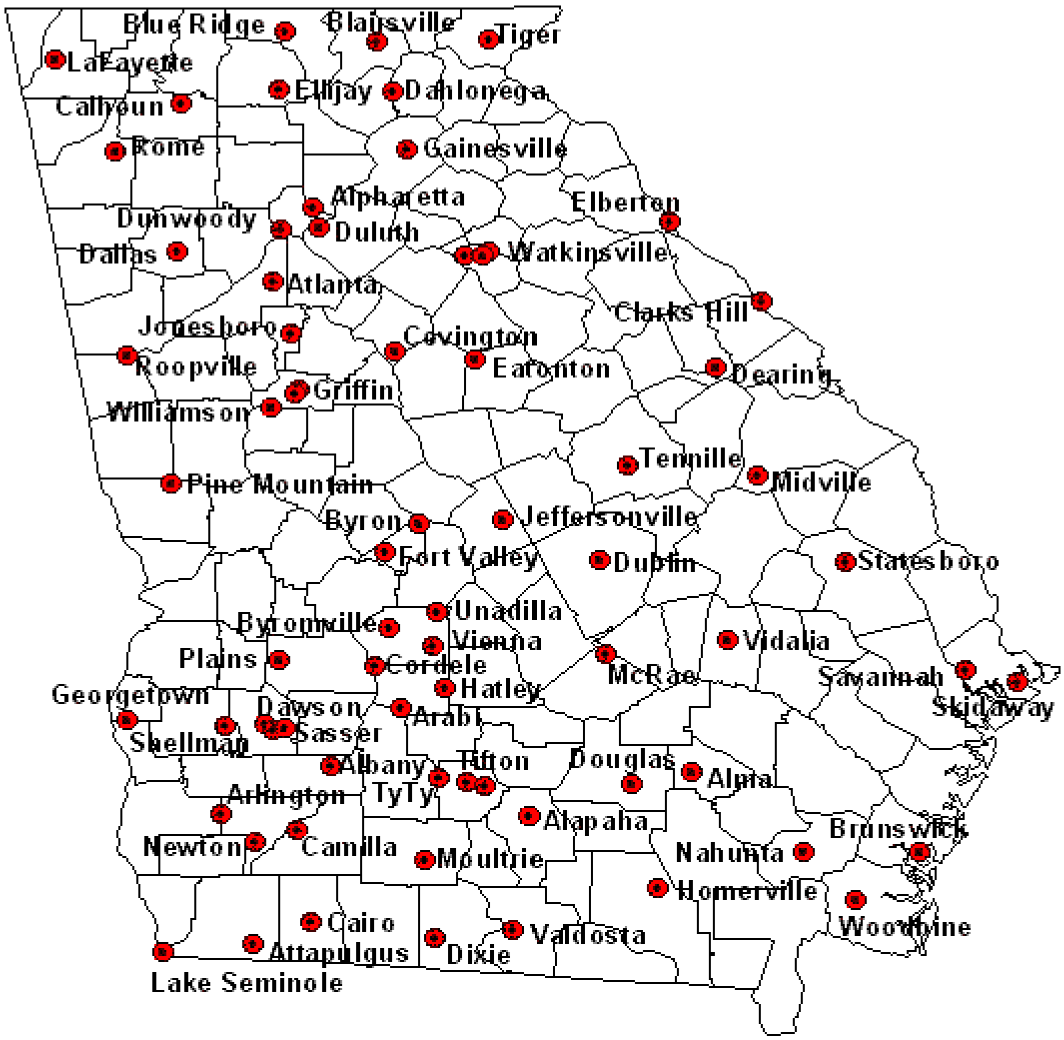

Figure 1. Location of the weather stations of the Georgia Automated Environmental Monitoring Network.

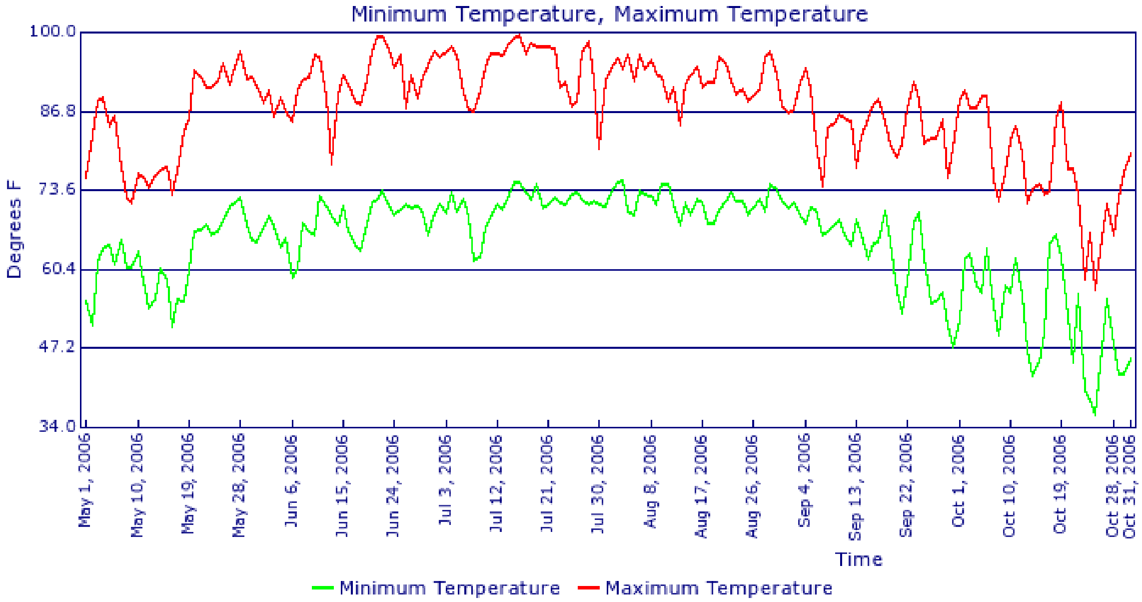

Figure 2. Daily maximum and minimum temperature for May 1 through October 31, 2006 for Vienna, Georgia.

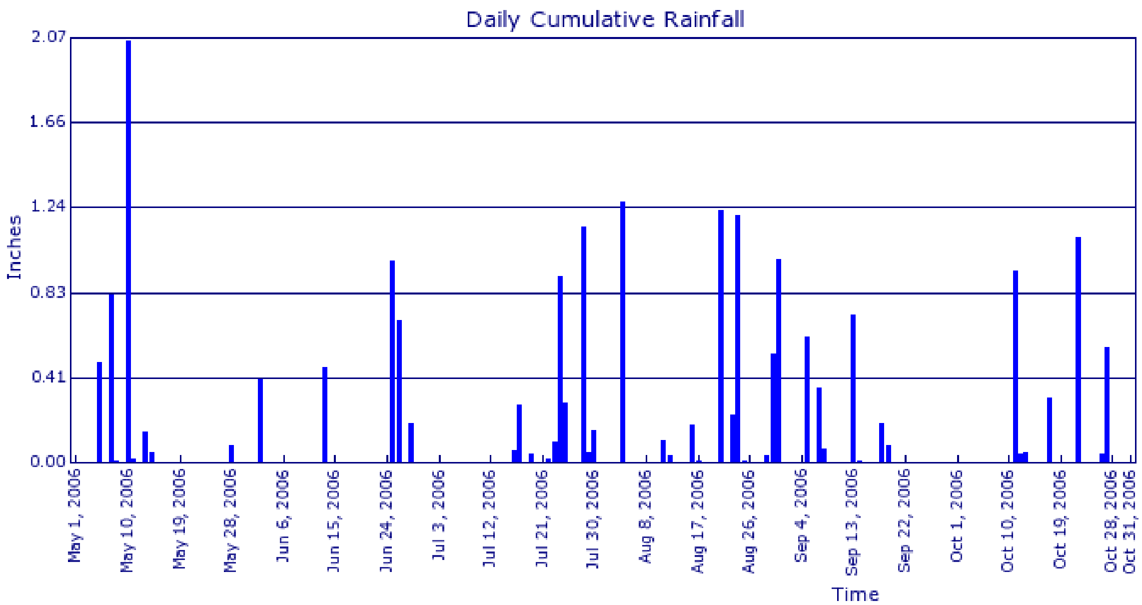

Figure 3. Daily total precipitation for May 1 through October 31, 2006 for Vienna, Georgia. (The weather station at Vienna is supported by AgAmerica Empowerment Agency, Inc.)

Table 1. Degree-days from May 1 until October 31 with a base of 60 degrees Fahrenheit.

Site	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Alapaha	N/A	N/A	2941	3052	3025	2600
Albany	N/A	N/A	N/A	3279	3250	3253
Alma	2904	3296	3030	3182	3162	3056
Arlington	2658	3207	2923	3067	3086	2985
Attapulgus	2852	3297	3023	3096	2850	3046
Cairo	2601	3327	3043	3275	3185	3120
Camilla	2886	3354	3026	3225	3133	3096
Cordele	2789	3210	2946	3124	3102	3020
Dearing	2694	2983	2676	2984	2898	2837
Dublin	2682	3127	2818	3077	3048	2993
Eatonton	2233	2601	2277	2540	2507	2553
Ft. Valley	2571	2893	2610	2889	2895	2910
Griffin	2213	2571	2269	2515	2495	2540
Jeffersonville	N/A	N/A	2597	2845	2780	2779
McRae	N/A	N/A	N/A	2934	2916	2798
Midville	2783	3097	2758	3010	3019	2904
Moultrie	N/A	N/A	N/A	N/A	3105	3136
Pine Mountain	2128	2615	2381	2534	2533	2491
Plains	2479	3016	2741	2938	2924	2847
Rome	2074	2610	2182	2430	2475	2444
Savannah	2631	3111	2936	2983	3251	3001
Statesboro	2506	3106	2818	3029	2724	2689
Tifton	2811	3252	2950	3196	3080	3025
Valdosta	3117	3437	3224	3467	3456	3384
Vidalia	2850	3147	2935	3129	3143	3082
Watkinsville	2269	2594	2294	2548	2497	2487

Table 2. Total Precipitation (Inches) from May 1 until October 31

Site	2001	2002	2003	2004	2005	2006
Alapaha	N/A	N/A	40.79	35.70	18.98	20.74
Albany	N/A	N/A	N/A	33.40	30.68	25.78
Alma	19.68	26.17	35.23	33.45	23.39	19.46
Arlington	16.23	28.36	23.49	32.61	28.56	28.62
Attapulgus	30.54	27.82	25.39	28.83	28.28	27.79
Cairo	26.23	19.99	27.29	28.11	27.85	19.76
Camilla	24.86	25.70	25.71	23.77	24.71	25.65
Cordele	18.47	19.40	27.71	34.72	19.81	17.16
Dearing	17.15	23.02	22.22	28.32	28.31	21.20
Dublin	16.55	22.95	32.42	31.73	17.93	17.06
Eatonton	18.46	17.48	25.11	32.95	23.33	15.96
Ft. Valley	14.04	24.40	17.04	20.56	23.94	12.20
Griffin	12.86	21.75	32.80	35.52	31.71	16.52
Jeffersonville	N/A	N/A	28.80	29.00	22.52	16.85
McRae	N/A	N/A	N/A	35.79	17.30	19.62
Midville	12.89	18.52	35.20	30.45	28.71	14.37
Moultrie	N/A	N/A	N/A	N/A	28.37	12.63
Pine Mountain	16.48	18.67	34.56	38.87	24.11	17.32
Plains	24.37	19.50	26.00	32.07	29.53	27.07
Rome	18.59	26.23	31.85	24.12	15.30	19.71
Savannah	22.54	38.28	24.52	37.85	31.00	18.48
Statesboro	13.89	25.67	36.34	24.37	28.86	19.28
Tifton	19.33	17.21	31.78	33.62	18.97	15.78
Valdosta	26.31	24.93	25.97	31.96	31.12	22.93
Vidalia	18.07	28.06	40.37	35.87	15.75	13.03
Watkinsville	22.39	19.48	34.27	30.36	29.02	17.70

Table 3. Water balance (inches) from May 1 until October 31. **(**The calculation of the water balance is based on [total seasonal rainfall - total seasonal evapotranspiration]).

Site	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Alapaha	N/A	N/A	14.35	9.69	-6.60	-6.13
Albany	N/A	N/A	N/A	1.40	-0.89	-7.72
Alma	-7.44	-3.29	5.82	2.50	-7.83	-14.13
Arlington	-14.11	-2.68	-5.22	2.62	-1.27	-3.80
Attapulgus	9.82	-2.54	-2.92	-2.08	-1.80	-12.85
Cairo	-3.22	-9.71	-1.16	-2.17	-1.80	-12.85
Camilla	-5.17	-7.21	-4.04	-8.08	-7.20	-7.76
Cordele	-12.92	-14.28	-3.64	1.21	-14.21	-16.82
Dearing	-8.93	-6.79	-5.67	-2.10	-0.89	-10.45
Dublin	-14.49	-8.83	3.04	-0.51	-12.72	-14.51
Eatonton	-10.81	-11.99	-1.16	3.91	-3.42	-14.98
Ft. Valley	-16.57	-4.28	-6.92	-3.90	-0.18	-20.15
Griffin	-17.48	-7.30	5.27	7.18	3.51	-15.21
Jeffersonville	N/A	N/A	2.21	-1.11	-8.10	-15.61
McRae	N/A	N/A	N/A	5.44	-12.28	-11.84
Midville	-18.74	-11.83	7.25	3.59	1.22	-18.93
Moultrie	N/A	N/A	N/A	N/A	-3.12	-21.43
Pine Mountain	-10.90	-8.58	9.24	13.42	-1.29	-8.95
Plains	-5.19	-9.70	-1.04	2.87	-1.27	-6.96
Rome	-7.36	-0.93	7.19	-1.41	-11.21	-9.07
Savannah	-7.28	7.06	-4.06	9.02	1.82	-13.34
Statesboro	-14.70	-2.70	8.59	-5.31	0.35	-12.29
Tifton	-12.48	-15.43	0.90	2.70	-12.02	-17.61
Valdosta	-4.49	-5.40	-2.85	0.06	-0.75	-10.32
Vidalia	-11.56	-2.41	11.35	2.47	-15.40	-25.64
Watkinsville	-7.48	-9.72	7.47	1.24	1.02	-11.44

MAPPING "RISK" AREAS FOR COTTON ROOT-KNOT NEMATODE BASED ON SOIL AND LANDSCAPE ATTRIBUTES

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Introduction

Cotton root-knot nematode (RKN) (*Meloidogyne incognita*) damage is considered one of the major limiting factors in cotton production across the United States. Due to limited public awareness and a reluctance to invest in costly, yet beneficial nematicides, nematodes are among the most under-managed cotton pests in Georgia today. An extensive survey in Georgia during the late 1990s determined that nearly 36% of cotton fields were infested with root-knot nematodes. In 2002, Georgia county agents conducted a random survey of nearly 1800 fields and found that 69% of the fields were infested with root-knot nematodes.

Over the last 20 years, rapid increases in the percentage of cotton acreage across the state have contributed to increasing nematode-related yield losses. Yield losses can range from 10% to 75% depending on soil properties and weather conditions. Sandier soils, prone to drought conditions, may experience yield losses as high as 80%. During the 2002 growing season, Georgia cotton producers spent nearly $8,000,000 on nematicides, yet nematode damage still resulted in yield losses totaling over $22,000,000.

During the 2005 and 2006 growing seasons, ten farm sites with a known history of cotton root-knot nematode infestations were used to evaluate a management zone approach to mapping high-risk areas for nematode related yield-losses. Thus, our primary objectives were to: 1) establish a relationship between cotton root-knot-nematode occurrence and soil or landscape attributes, and 2) utilize this relationship to develop risk-based management zones for directed sampling and nematicide management.

Materials and Methods

In 2005 and 2006, a total of ten farm sites with a known history of nematode infestations were evaluated. Farm sites were typically a component of cotton-peanut rotation with one to two years duration of cotton, followed by a year of peanut. Sites were located in the Southern Coastal Plain of Georgia and ranged in size from 40 – 60 acres

A series of ground truth measurements were collected at each site. Ground truth assessments consisted of two types: grid samples and continuous measurements used to recreate maps of soil features.

Nematode assays, soil pH, soil texture, soil nutrients, soil water content, depth to clay layer, and plant height were collected on a 50 x 50 m grid. Nematode samples were collected twice during the growing season, and once just after harvest (0-6 inch depths). All other grid samples were collected once, prior to planting.

Continuous variables included high-density measurements of soil and landscape attributes, which have been shown to be correlated with cotton root-knot nematode densities. These data included remotely sensed airborne/satellite imagery, real time kinematic (RTK) GPS (for elevation), and Veris electrical conductivity (EC) (0-30 cm, 0-90cm). Elevation and electrical conductivity were collected in tandem at a spatial resolution of 30 ft x 30 ft prior to planting at each site. Remotely sensed data were acquired using the aircraft mounted SpectraView® Multi-Spectral Imaging System and the Quickbird Multispectral Satellite. Each system collects data in the blue, green, red and near-infrared regions of the spectrum with a 1-3 m^2 spatial resolution. Images were acquired once during bare soil conditions and have continued on a monthly basis beginning at first flower.

Results

A detailed analysis for two 2006 farm sites were conducted to determine if remotely sensed data, topography and EC could be used to delineate risk zones for RKN control. A combination of electrical conductivity measurements at two depths, remotely sensed imagery of bare soil and topography were highly correlated with the presence of root-knot nematodes. Using all variables, a high correlation between soil-landscape attributes and the occurrence of root-knot nematodes was observed, ranging from 0.42-0.64. In most cases, the high risk zones could be characterized as low-lying, sandy areas and reaffirm the fact that root-knot nematodes prefer sandy soils.

Next, spatial analyses were conducted to confirm nematode populations were spatially dependent. This was necessary to ensure the development of “high-risk” management zones were appropriate for managing nematodes. Results indicated that distributions of root knot nematode populations were strongly spatially correlated. Based on these analyses a recommended sampling interval of 80 m was proposed. More importantly, the presence of a strong spatial relationship provided the foundation for the development of “high-risk” management zones.

Our data indicate that nematode prone areas may be identified based on EC, landscape position and surface reflectance patterns. This combination of variables reduced the overall variability in RKN distributions by as much as 30% and most accurately identified “high-risk” RKN zones. Electrical conductivity, in particular, was highly correlated with the presence of root knot-nematodes, and contributed greatly to the resulting “risk” map Figure 1.

Conclusion

Cotton root-knot nematode distributions are highly correlated with soil and landscape attributes. Based on this observation, a novel method of developing “high-risk” management zones for site-specific sampling and nematicide treatment has been developed. Our research indicates that field areas at the greatest risk of nematode related yield losses may be identified using a combination of electrical conductivity, topographical data and remotely sensed imagery.

Acknowledgements

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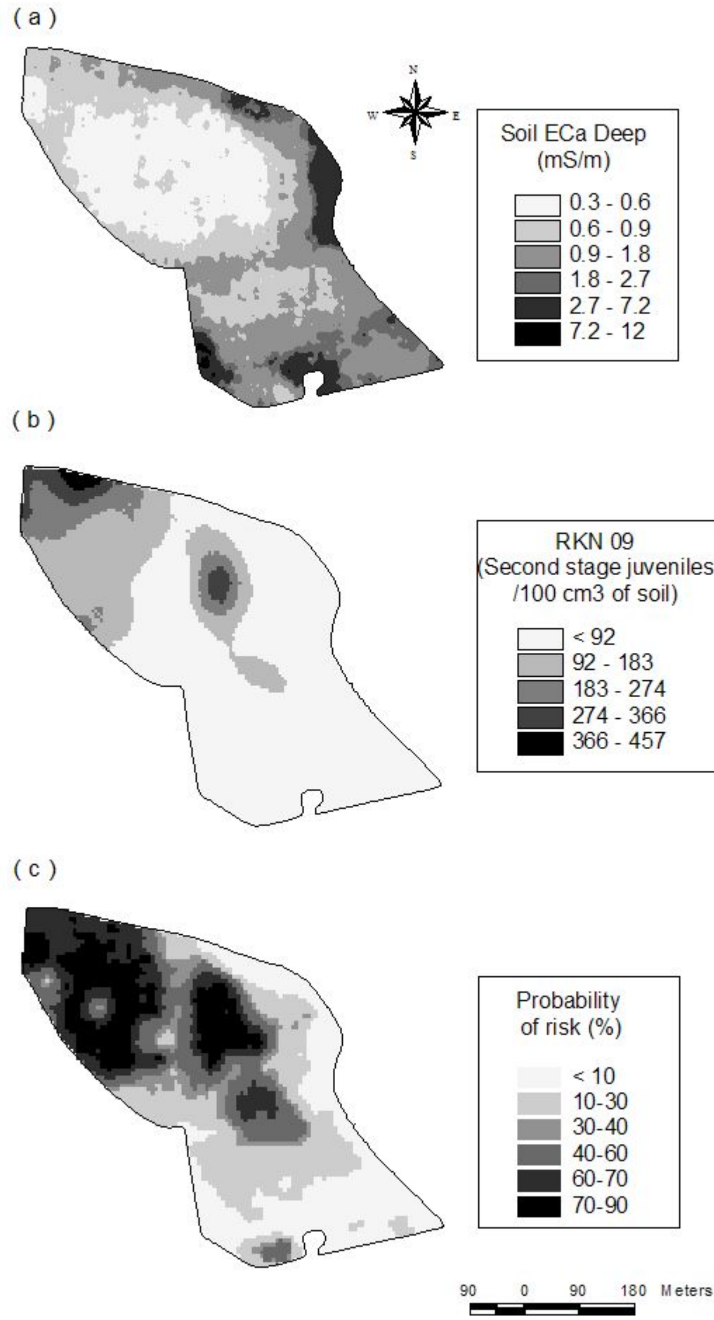

Figure 4. Analysis results from one field in study. A - Electrical conductivity (0-90 cm). B – RKN count. C – Probability of risk for RKN.

Management of Tropical Spiderwort in Georgia Cotton

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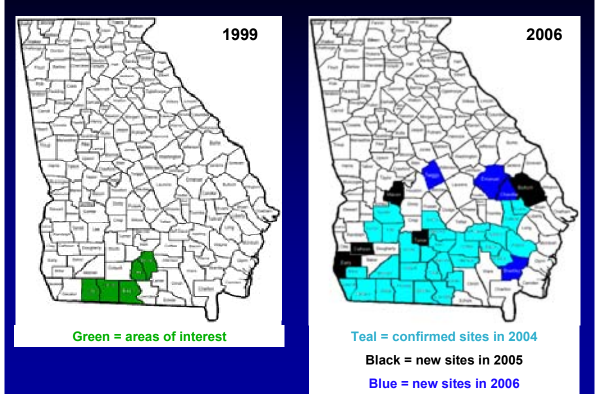
Introduction

Tropical spiderwort is among the world's worst weeds, and it is considered a weed in 25 crops in 29 countries (Holm et al. 1977). This weed was first observed in the continental U. S. in 1928 and was reported to be common through Florida by the mid-1930's (Faden 1993). In 1998, tropical spiderwort was present in Georgia but not considered a serious pest infesting cotton. However, by 2001, it had quickly become very problematic and was ranked as the ninth most troublesome weed. By 2002, tropical spiderwort was clearly the most troublesome weed facing Georgia producers in several southern counties. Although tropical spiderwort is no longer the most troublesome weed in Georgia cotton, it is extremely problematic and expensive to manage as it continues to spread throughout Georgia (Figure 1).

Figure 1. Tropical Spiderwort Infestations in Georgia



Preliminary data shows optimum temperatures for tropical spiderwort growth range from 30 to 35 C, indicating that the southeastern U.S. could provide an adequate environment for its rapid growth and reproduction (Burton et al. 2003). This, along with wide-spread planting of GR cotton and the heavy dependence upon glyphosate for weed management, suggests this problem is likely to increase across the region. The objective of our study was to determine the most effective weed management systems that should be recommended to manage this pest throughout Georgia.

Materials and Methods

Research studies were conducted in Georgia from 2001 to 2005 to determine the most effective herbicides needed in a systems approach to control tropical spiderwort. This previous research noted that Dual Magnum during early and late-season as well as Direx or Valor plus MSMA directed at layby were critical in the management of this pest. Research in 2006 was conducted to determine the most effective rates and applications timings of these herbicides. The study was conducted outside Cairo, GA on soils that were Tifton loamy sands (thermic Plinthic Kandiudults) with organic matter of 1.0% with a pH of 6.0.

The experiment compared 36 herbicide programs (Table 1). Prowl was applied preemergence over the trial area to remove other commonly present weeds, Prowl has no activity on tropical spiderwort. Topical applications were made when cotton had 3 leaves and spiderwort was one inch or less. Layby directed applications were made to 16 inch cotton and 1- to 6-inch tropical spiderwort.

Results and Discussion

Cotton injury was minor with all systems except for Valor mixtures applied at layby (data not shown). Valor mixtures caused up to 18% stem necrosis on younger, green-stem cotton plants. However within two weeks of application, no cotton injury was detectable on any plant.

Sequential glyphosate applications provided only 46% spiderwort control at harvest (Table 1). Glyphosate applied topically at early POST followed by (fb) glyphosate plus Direx, glyphoste plus Valor, or Direx plus MSMA at layby provided 57, 81 and 53% control of spiderwort, respectively. Poor late-season control by these systems was due to late-season spiderwort emergence. Adding 8 or 12 oz/A of Dual Magnum to the topical early POST glyphosate application or the layby directed application in the sequential glyphosate only program improved late-season control by at least 17%. However, these programs did not provide acceptable control with at most 78% control at harvest. Sequential applications including Dual Magnum applied at early POST and also at layby were generally the most effective programs.

Five herbicide programs provided greater than 90% control at harvest, four of which are currently labeled and will be recommended to manage tropical spiderwort. These systems included the following:

1) glyphosate + Dual Mag. 12 oz topical fb Direx + MSMA + Dual Mag. 8 oz layby
2) glyphosate + Dual Mag. 12 oz topical fb Direx + MSMA + Dual Magnum 12 oz at layby
3) glyphosate + Dual Mag. 12 oz topical fb glyphosate + Dual Mag. 12 oz
4) glyphosate + Dual Mag. 8 oz topical fb glyphosate + Dual Mag. 8 oz + Direx

Valor mixtures with Dual Magnum at layby were extremely effective controlling spiderwort but are currently not recommended for use because more research on crop response to this mixture at layby is required before obtaining labels.

No differences in cotton yields were noted among herbicide systems (Table 1). Lack of yield differences were noted because 1) tropical spiderwort emerged three weeks after planting and 2) the spiderwort was extremely small and controlled very effectively by topical glyphosate applications.

Table 1. Determining the most effective herbicide program for managing tropical spiderwort.*

Herbicide system		Control at harvest (%)**	Seed cotton yield**
Topical application	Directed application at layby		
WMax	WMax	46 n	1838 a
WMax	WMax + Dual Mag (8 oz)	63 klm	1929 a
WMax	WMax + Dual Mag (12 oz)	78 e-i	1992 a
WMax	WMax + Direx	57 lmn	1947 a
WMax	WMax + Dual Mag (8 oz) + Direx	76 g-j	1745 a
WMax	WMax + Dual Mag (12 oz) + Direx	83 b-i	1677 a
WMax	WMax + Valor	81 b-i	1480 a
WMax	WMax + Dual Mag (8 oz) + Valor	80 c-i	1636 a
WMax	WMax + Dual Mag (12 oz) + Valor	**93 a-b**	1626 a
WMax	Direx + MSMA	53 mn	1740 a
WMax	Direx + MSMA + Dual Mag (8 oz)	80 c-i	1723 a
WMax	Direx + MSMA + Dual Mag (12 oz)	84 a-i	1587 a
WMax + Dual Mag (8 oz)	WMax	76 g-j	1751 a
WMax + Dual Mag (8 oz)	WMax + Dual Mag (8 oz)	89 a-e	1543 a
WMax + Dual Mag (8 oz)	WMax + Dual Mag (12 oz)	89 a-e	1894 a
WMax + Dual Mag (8 oz)	WMax + Direx	81 b-i	1806 a
WMax + Dual Mag (8 oz)	WMax + Dual Mag (8 oz) + Direx	**92 ab**	1650 a
WMax + Dual Mag (8 oz)	WMax + Dual Mag (12 oz) + Direx	82 b-i	1854 a
WMax + Dual Mag (8 oz)	WMax + Valor	79 d-i	1629 a
WMax + Dual Mag (8 oz)	WMax + Dual Mag (8 oz) + Valor	77 f-j	1878 a
WMax + Dual Mag (8 oz)	WMax + Dual Mag (12 oz) + Valor	81 b-i	2966 a
WMax + Dual Mag (8 oz)	Direx + MSMA	74 h-k	1922 a
WMax + Dual Mag (8 oz)	Direx + MSMA + Dual Mag (8 oz)	88 a-g	1835 a
WMax + Dual Mag (8 oz)	Direx + MSMA + Dual Mag (12 oz)	88 a-g	1441 a
WMax + Dual Mag (12	WMax	66 jkl	1665 a

oz)			
WMax + Dual Mag (12 oz)	WMax + Dual Mag (8 oz)	81 b-i	1632 a
WMax + Dual Mag (12 oz)	WMax + Dual Mag (12 oz)	**91 abc**	1746 a
WMax + Dual Mag (12 oz)	WMax + Direx	76 g-j	1538 a
WMax + Dual Mag (12 oz)	WMax + Dual Mag (8 oz) + Direx	85 a-i	1767 a
WMax + Dual Mag (12 oz)	WMax + Dual Mag (12 oz) + Direx	80 c-i	1823 a
WMax + Dual Mag (12 oz)	WMax + Valor	74 ijk	1607 a
WMax + Dual Mag (12 oz)	WMax + Dual Mag (8 oz) + Valor	85 a-h	1640 a
WMax + Dual Mag (12 oz)	WMax + Dual Mag (12 oz) + Valor	89 a-e	1632 a
WMax + Dual Mag (12 oz)	Direx + MSMA	80 c-i	1671 a
WMax + Dual Mag (12 oz)	Direx + MSMA + Dual Mag (8 oz)	**95 a**	1596 a
WMax + Dual Mag (12 oz)	Direx + MSMA + Dual Mag (12 oz)	**91 a-d**	1754 a

*WMax = Roundup WeatherMax at 22 oz/A; Direx = 1.5 pt/A when mixed with glyphosate and 2.0 pt/A when mixed with MSMA; MSMA = 2.5 pt/A; and Valor 1.0 oz.
**Letters followed by the same letter are not different at P = 0.05.

Literature Cited

Burton, M. G., T. M. Webster, E. P. Prostko, A. S. Culpepper, A. C. York, and S. Sermons. 2003. Rapid increase of tropical spiderwort (*Commelina benghalensis* L.) in herbicide-resistant crops of southeastern USA agroecosystems. Proc. Ecol. Soc. Am. 88:51-52.

Faden, R. B. 1993. The misconstrued and rare species of *Commelina* (Commelinacea) in the eastern United States. Ann. Missouri Bot. Gard. 80:208-218.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The world's worst weeds: distribution and biology. Honolulu, HI: University Press of Hawaii. 609 pp.

EFFECTS OF MEPIQUAT REGIMES ON FIBER LENGTH AND UNIFORMITY

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Introduction

In recent years concerns have been expressed about fiber quality of Georgia cotton, specifically about the quality measure of fiber length uniformity or length uniformity ratio. The uniformity ratio measures the variation in the length of fibers within a bale and indirectly reflects short fiber content, a term referring to fibers less than 0.5 inch in length and reportedly, as short fiber content exceeds 8 percent, spinning efficiency of cotton yarn decreases dramatically.

The plant growth regulator mepiquat chloride (MC) has been used in cotton for almost 30 years to reduce canopy height, encourage rapid, early fruit set, and shorten the overall fruiting cycle.

Three irrigated studies involving varying MC programs were conducted to explore the effects of PGR applications on fiber length and fiber length uniformity. The first experiment included the use of MC to attempt to compact the fruiting period of two varieties that represent the broad range of maturity, from a very determinant (DP 444 BG/RR) to the most indeterminant (DP 555 BG/RR). The second explored the effects of the time of initiation of MC treatments and the third included the potential effects of misapplication of the new PGR Stance compared to standard treatments.

Materials and Methods

'DP 555 BG/RR' and 'DP 444 BG/RR' were planted on May 3, 2006, at the Lang Farm near Tifton, GA. MC regimes were imposed to seek (a) to compact the fruiting cycle or (b) to allow a more extended fruiting period.

'DP 555 BG/RR' was planted on May 3, 2006, at the Lang Farm near Tifton, GA. Treatments included the initiation of a three-application regime of MC at pinhead square, 10 days later, or at first bloom.

'DP 555 BG/RR' was planted on May 3, 2006, at the Lang Farm near Tifton, GA, and on May 5, 2006, at the Sun Belt Ag Expo near Moultrie, GA. Treatments included a standard MC program (8 oz/A applied three times), a Stance program (3 oz/A applied three times), and a Stance program with excessive rates (8 oz/A applied three times). Application times were match head square, 1st bloom, and 2 weeks after 1st bloom.

For each study, plot size was 4 or 6 rows (36 inch rows) by 40 feet and there were 4 replications. Treatments were applied with a high clearance small plot sprayer or a backpack sprayer. Plots were harvested on September 21 at Tifton and on September 28 at Moultrie. Machine-harvested samples from the center rows of each plot were processed at the UGA Cotton Micro Gin and associated fiber samples were analyzed by Star Labs in Knoxville, TN. Fiber length (staple or upper half mean length) and fiber length uniformity data are reported.

Results and Discussion

Efforts to compact the fruiting period with MC were frustrated by extremely hot, dry conditions and a week and a half break down of irrigation equipment during early to mid-bloom. As a result there was little separation among treatments for duration of fruiting period as indicated by nodes above white flower counts beginning at 1st bloom (data not shown). Differences in final plant height were achieved (Table 1). DP 555 BG/RR produced significantly greater yield and fiber length (upper half mean length or staple) than DP 444 BG/RR, while as expected the reverse was true for uniformity. MC regime did not affect yield or these measures of fiber length.

Time of initiation of MC programs on DP 555 BG/RR influenced final plant height but had little to no impact on yield or fiber length and uniformity (Table 2).

Standard applications of MC and Stance resulted in a significant reduction in plant height compared to the untreated control, while the excessive rate of Stance caused a further reduction in height (Table 3). Yields were not affected by any treatment at Tifton but the excessive rate of Stance reduced yields at Sun Belt. Stance resulted in greater fiber length compared to the untreated control and MC. Stance-treated cotton had higher uniformity than the untreated control at both locations.

Table 1. Effect of Fruiting Period Compaction on Final Plant Height, Yield, Fiber Length, and Fiber Length Uniformity, Lang Farm, 2006.

Variety	MC Program	Height, in	Lint, lb/A	Length, in	Uniformity
DP 444 BG/RR	Aggressive	31.0	1378.5	1.125	82.6
DP 444 BG/RR	Minimal	35.1	1382.0	1.118	82.6
DP 555 BG/RR	Aggressive	31.9	1837.3	1.138	81.6
DP 555 BG/RR	Minimal	35.6	1777.7	1.136	81.8
	LSD (0.10)	3.5	192.1	0.017	0.3

Programs for DP 444 BG/RR were: Aggressive - 16 oz/A at pinhead square and 1st bloom; Minimal - 8 oz/A at 1st flower.
Programs for DP 555 BG/RR were: Aggressive - 16 oz/A at pinhead square followed by 24 oz/A 10 and 25 days later; Minimal - 8 oz/A at pinhead square and 1st flower.

Table 2. Effects of the Time of Initiation of MC Treatments on Final Plant Height, Yield, Fiber Length, and Fiber Length Uniformity, Lang Farm, 2006.

MC Treatment	Height, in	Lint, lb/A	Length, in	Uniformity
None	39.7	1850.9	1.145	82.1
12 oz PHS 12 oz PHS+10d 12 oz PHS+20d	30.0	1814.3	1.155	81.9
12 oz PHS+10d 12 oz PHS+20d 12 oz PHS+30d	33.15	1943.1	1.147	82.0
12 oz 1st Blm 12 oz 1st Blm+10d 12 oz 1st Blm+20d	35.7	1861.3	1.157	82.3
LSD (0.10)	2.5	103.6	0.007	0.6

Table 3. Effects of High Rates of Stance Compared to Standard Rates of MC and Stance, Lang Farm and Sun Belt Expo, 2006.

MC Treatment	Height, in	Lint, lb/A	Length, in	Uniformity
Tifton, Lang Farm				
None	38.2	1768.1	1.122	82.0
MC 8 oz	29.9	1789.6	1.137	82.1
Stance 3 oz	29.2	1730.7	1.160	82.3
Stance 8 oz	26.6	1689.9	1.187	82.7
LSD (0.10)	1.0	121.8	0.010	0.2
Moultrie, Sun Belt Expo				
None	48.2	1895.4	1.113	80.3
MC 8 oz	34.9	1874.3	1.127	80.9
Stance 3 oz	36.2	2033.2	1.139	80.9
Stance 8 oz	31.6	1624.3	1.160	81.2
LSD (0.10)	2.6	182.9	0.013	0.6
Applications made at match head square, 1st bloom, and 2 weeks after 1st bloom.				

BREEDING GEORGIA-ADAPTED COTTON GERMPLASM AND CULTIVARS WITH EMPHASIS ON ROOT-KNOT NEMATODE (RKN) RESISTANCE

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Introduction

Poor profit potential of cotton production from yield stagnation and high pest management costs impels creation of cultivars with inherent genetic resistance to enhance economic returns for Georgia cotton producers. Insect, nematode, and weed pest management costs are among the highest expenditures growers face in cotton production (National Cotton Council, 2001), thus their reduction would enhance profitability of cotton production.

Surveys of the densities of root-knot nematodes (*Meloidogyne incognita,* RKN) reveal that the major cotton-producing counties in Georgia have damaging levels of root-knot nematodes (National Cotton Council, 1998). It is estimated that Georgia producers lose about 77,000 bales of cotton annually from RKN damage (Blasingame and Petal, 2001). Crop rotation, while a recommended cultural practice to lessen soil populations of RKN, is not an option for most Georgia growers because of the lack of suitable non-host crops with which to rotate their cotton acreages. Therefore, inherent genetic resistance provides an attractive alternative to pesticides and crop rotation.

Despite the widespread occurrence of RKN in most cotton production areas in the Southeast and that genetic resistance to RKN has existed since 1974 (Shepherd, 1974), private cultivar developers have exhibited little interest in fulfilling this need. Commonly cited reasons for the slow progress in developing RKN resistant cultivars is that the current screening process is costly, tedious, time consuming and destructive for identifying resistance genotypes. Further, most breeding stations neither have the facilities nor personnel with expertise in nematology to carry out the screening process to identify resistant material. Of those RKN-resistant (CPCSD Acala NemX) or tolerant cultivars (ST LA887 or PM H1560) that have been distributed by commercial cotton seed companies, none are adapted to the Southeast. Cotton cultivars adapted for the unique aspects of the Georgian environment, such as rainfall patterns, soils types and depth, and *presence of root-knot nematodes* must be developed to give the best available genetics to the GA producer.

Public breeders have historically been the pre-breeders; doing the challenging work of developing new acceptable parents that can then be directly used to make improved cultivars. Because the recent shift to patenting cultivars will slow the industry's overall development of enhanced cultivars, the seed companies will place a higher priority on the ongoing renewal of their gene pools as well as trying to locate other sources of adapted germplasm. In this seller's market, publicly released germplasm lines should have the leverage to ensure that the better adapted material developed by a state gets to that state's cotton farmer.

Taken as a whole, a UGA cotton breeding program with continuity provides the foundation to ensure that traits needed by the Georgia cotton growers such as increased yield and enhanced fiber quality in cultivars that are adapted to Georgia production conditions would not be overlooked. Specifically, the objective to develop Georgia-adapted cotton germplasm with RKN resistance will benefit the state's producers by providing increased yield and decreased production costs whereas the increased availability of RKN-resistant germplasm will benefit the cotton industry across the belt.

Materials and Methods

Drs. Chee, May, and Davis developed advanced RKN resistant parents from a backcross breeding population using M120RNR and M155RNR RKN resistant donor parent with the elite breeding line PD94042 (May, 1999).

Results and Discussion

RKN resistant BC3F3 lines have been further selected during the first quarter of 2006 in a 10 plant sub-sample that was inoculated twice with a very high rate of nematodes and evaluated for galling. About 1 out of 6 plants had near immunity just like M-120. Further field testing in 2006 rigorously selected 25 out of 176 entries which are being verified with additional testing in the greenhouse. Unfortunately, the growth of the RKN cotton population in the greenhouse was delayed due to some equipment problems that ended up keeping the greenhouse slightly cooler than desired. This led to a holdup in planting the 176 entry test in Dr. Davis' RKN infested field which, in turn, affected the nicking of the planned crossing in July to GA breeding lines. However, this missed crossing opportunity had an unexpected benefit since additional information from the 2006 yield tests indicated better parental selections than what we would have used in the summer. To ensure that the better yielding, value-added GA lines nicked with the RKN resistant parents, these parents were planted after harvest in the greenhouse.

We are planning to use the most up-to-date molecular markers from a companion project (Shen et al., 2006) in a three-cycle backcrossing program to insert the RKN resistance gene during 2007. We believe this approach should provide a more reliable insertion of the RKN resistance gene and, thereby, a more trustworthy release of the germplasm/cultivars. The chromosomal region bearing the RKN resistance that is indicated by these molecular markers has also been already verified independently (Ynturi et al., 2006), although our work appears to have markers that are, at present, closer to the RKN resistance gene. Our lab has also already found in some preliminary fingerprinting that the markers appear polymorphic between the Georgia lines and both parents of the RKN resistance donors. We plan to complete the backcrossing by the end of autumn 2007 so we can send the BC_2 population to the winter nursery in Mexico to obtain seed for the 2008 growing season. In the summer of 2008, we intend to plant an unreplicated modified augmented design yield test (with every 5th row in the trial assigned to a conventional check cultivar) in either Tifton or Plains to select for yield and to verify the homozygosity of the RKN resistance marker(s). The trial will be machine harvested and the seed-cotton yield of each F4 progeny row compared with seed-cotton yield of the nearest check row.

We will harvest boll samples for lint %, fiber quality, and for seed in a parallel increase field for the rows that significantly out-yield the nearest check plot. The preliminary trial (PT), which is the next step, will be conducted near Tifton or Plains, GA, depending upon land availability. Advanced generation germplasm lines promoted from the PT shall be tested in an Advanced yield trial (AT) in Plains and Tifton. Elite germplasm lines from a successful performance in the ATs will be tested in locations throughout the state in both dryland and irrigated fields in the University of Georgia Official Variety Trials. This approach should quickly provide a solid performing release of RKN resistant germplasm/cultivars.

References

Blasingame, D., and M.V. Petal. 2001. Cotton disease loss estimate committee report. p. 102-103. *In* Proc. Belt. Cotton Res. Conf. 2001. Anaheim, CA. National Cotton Council, Memphis, TN.

May, O.L. 1999. Registration of PD94042 cotton germplasm line with high yield and improved fiber maturity. Crop Sci. 39:597-598.

National Cotton Council. 1998. Nematode survey and education program. http://www.cotton.org/cf/nematodes/survey-6.cfm

National Cotton Council. 2001. Cotton costs and returns – southeast. http://risk.cotton.org:80/CotBudgets/seaboard.htm

Shen, X., G. Van Becelaere, P. Kumar, R.F. Davis, O. L. May, and P. Chee. 2006. QTL mapping for resistance to root-knot nematodes in the M-120 RNR Upland cotton line (*Gossypium hirsutum* L.) of the Auburn 623 RNR source. Theor. Appl. Genet. 113: 1539-1549.

Shepherd, R.L. 1974. Transgressive segregation for root-knot nematode resistance in cotton. Crop Sci. 14:827-875.

Ynturi, P., J.N. Jenkins, J.C. McCarty Jr., O.A. Gutierrez, and S. Saha. 2006. Association of root-knot nematode resistance genes with simple sequence repeat markers on two chromosomes in cotton. Crop Sci. 46:2670-2674.

BREEDING CULTRIVARS AND GERMPLASM WITH ENHANCE YIELD AND QUALITY, 2006

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Introduction

The classical breeding component of the University of Georgia cotton improvement program works to develop germplasm with traits that can be used to meet the requirements of both producers and consumers. Higher and more stable yields combined with the fiber properties requested by the yarn and textile manufacturers are the goals for profitable production and processing to support the Georgia Cotton Industry. The objective of this report is to update progress made toward meeting these goals during the 2006 season.

Materials and Methods

Our crosses mate elite University of Georgia breeding lines with promising germplasm and non-transgenic commercial cultivars to produce 10 sets of half-sib families. Forty-six F_2-bulk populations from F_1 crosses made in 2004 were evaluated for lint yield in 2-replicate, randomized complete block designs, with each set of half-sib F_2 families, the GA breeding line parent, and the check cultivar DeltaPEARL constituting a trial. Of the F_2-bulk populations evaluated in 2004, 11 were advanced in 2006 to F_3 for single plant selection. F_3 plants with lint fractions less than 39% were discarded and then further selected on the basis of HVI fiber properties. Six hundred F_3 plants selected in 2004 were advanced to F_4 progeny rows in Plains, GA, in 2006 for evaluation in an un-replicated grid design, with the middle row of each 5 row set of the trial assigned to D&PL DeltaPEARL. The trial was machine harvested and the seed-cotton yield of each F_4 progeny row was compared with the seed-cotton yield of the nearest row of DeltaPEARL. A separate, late-planted seed increase plot allows additional visual selection and hand harvest of seed-cotton to maintain genetic purity of the F_4, F_5, F_6, and elite generation experimental lines. Further selection are based mainly on the fiber quality measures of length, strength, and fineness and on lint percentage for promotion for testing in the F_5 preliminary yield trials (PTs) in 2007. The 2006 PTs were conducted at the William Gibbs Research Farm, UGA–Tifton campus, Tifton, GA (PTs 1-3 in fields 04211 and 04213; PT 4 in 04240; PT 5 and 6 in 04242 and 04243; PT 7 in 04250, and 04251; and PT 8 in 04253 and 04254). Each PT had 22 F_5 breeding lines and 2 commercial conventional checks in a three replicate, randomized complete block designs for a total of 176 experimental entries. The F_6 Advanced Trials (AT 1 & 2) were conducted at the University of Georgia – Tifton campus, Tifton, GA (William Gibbs Research Farm, fields 04260, 04261, and 04262) and Southwest Georgia Research and Education Center, Plains, GA (fields 14, 15, 16, and 17). The ATs each consisted of 22 experimental entries and two checks planted in a three replicate, randomized complete block design for a total of 44 F_6 breeding lines tested in both locations. Prior to machine harvest of all trials except the F2 and F4 generations, 25 unweathered, open bolls from the middle of the fruiting zone were harvested from each plot, and subsequently ginned on a 10-saw laboratory model gin to determine lint percentage. Fiber samples of the PTs and ATs were submitted to the Star Lab in Knoxville, TN for HVI analysis. The elite (material > F_7) germplasm lines with high potential were tested in the 2006 University of Georgia Strains (UGA) Tests and Official Variety Trials (Day et al., 2007)

Results and Discussion

Of the six elite lines that were advanced to the UGA Strains Trials for the 2006 season (Day and Thompson, 2007), the 5 top lines over locations were selected based on lint yield and acceptability of fiber traits to be advanced to the 2007 UGA Official Variety Trials (OVTs) for further testing. They are GA 2004232, GA 2004303, GA 2004356, GA 2004371, and GA 2004392.

The ATs revealed a number of promising lines with acceptable fiber quality packages that had lint yields that exceeded those of the checks (Table 1 & 2). The coefficients of variance for the ATs were between 11.7% and 6.4% thus indicating that the tests were managed well. The ATs did show a lot of variability between Plains and Tifton like we noticed in 2005. Of the 20 lines that were not significantly different from the best yielder in their respective test, only 5 (GA 2004230, GA 2004236, GA 2004358, GA 2004331, GA 2004181, and) were found in both locations. This is from genotype by environment (GxE) interactions which confounds clear selection of the best lines to be tested further. Additional research in GxE interactions is indicated. Six lines (GA 2004089, GA 2004137, GA 2004143, GA 2004230, GA 2004236, and GA 2004358) were stringently selected from the ATs to be advanced to the UGA Strains Trials.

Thirty two lines were selected for testing in the 2007 AT1 from the PTs based primarily on lint yield with acceptable fiber quality secondary. Twenty two lines were selected for testing in the 2007 AT2 based primarily on excellent fiber quality with acceptable yield performance secondary. This separation of selection criteria is being used to bring additional material forward with excellent fiber quality.

Based chiefly on lint yield comparisons, 190 F_4 progenies were sent for fiber testing for further selection for the 2007 PTs. About 750 single plants were selected in the F_3 populations and sent for fiber testing for selection to be placed in the F_4 plant-to-row yield test.

Fifty-four F_1 crosses were made in the summer of 2006 and the seed was sent to the USDA-ARS Cotton Winter Nursery in Mexico for selfing to the F_2 generation. These will be placed in replicated yield tests to determine the suitability of the germplasms to be further tested.

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References

Day, J.L. and L. Thompson. 2007. 2006 cotton variety trials. p. xxx-xxx. *In* R. Kemerait et al. (ed.) 2006 Georgia Cotton and Extension Reports. UGA/CPES Research – Extension Publication No. x, University of Georgia, Athens, GA

Table 1. Results of 2006 Advanced (F6) Trial 1.

2006 AT 1 Tifton							**2006 AT 1 Plains**						
ENTRY	**Lint Yield**	**Lint %**	**UHM in.**	**mic**	**UI %**	**Str g/tex**	**ENTRY**	**Lint Yield**	**Lint %**	**UHM in.**	**mic**	**UI %**	**Str g/tex**
GA 2004143	**1698**	0.45	1.12	5.25	82.6	31.8	GA 2004122	**2219**	0.46	1.25	5.05	84.5	28.2
GA 2004089	**1694**	0.43	1.17	5.10	83.5	31.2	GA 2004142	**2159**	0.46	1.25	5.20	84.1	30.7
GA 2004137	**1685**	0.43	1.15	5.25	83.5	32.4	GA 2004155	**2106**	0.47	1.20	5.05	83.3	29.0
GA 2004174	**1568**	0.45	1.16	5.60	83.7	31.8	GA 2004174	1998	0.47	1.23	4.95	84.4	30.8
DeltaPEARL	**1555**	0.41	1.18	5.45	83.8	30.7	GA 2004143	1976	0.47	1.24	5.00	84.7	29.9
GA 2004175	1500	0.45	1.14	5.40	82.5	29.8	GA 2004089	1968	0.45	1.26	4.60	85.4	30.2
GA 2004155	1470	0.45	1.09	5.65	82.0	31.2	GA 2004022	1958	0.43	1.21	5.00	84.6	28.8
GA 2004122	1441	0.44	1.15	5.45	83.0	29.8	GA 2004108	1914	0.45	1.25	4.65	84.0	30.4
GA 2004010	1437	0.44	1.12	5.45	83.6	31.8	DeltaPEARL	1893	0.42	1.22	5.05	84.0	30.1
GA 2004142	1399	0.45	1.26	5.55	81.5	30.9	GA 2004088	1885	0.43	1.26	4.65	85.9	29.5
GA 2004030	1396	0.41	1.15	5.15	84.5	30.5	GA 2004079	1874	0.43	1.25	4.40	83.5	28.7
GA 2004108	1381	0.43	1.20	5.20	83.6	33.3	GA 2004168	1869	0.45	1.29	4.80	85.2	29.8
GA 2004054	1362	0.39	1.17	4.60	82.2	31.1	GA 2004160	1868	0.43	1.27	4.90	84.8	29.9
GA 2004022	1350	0.43	1.15	5.25	84.9	31.8	GA 2004055	1825	0.43	1.23	4.90	84.9	32.6
GA 2004160	1336	0.42	1.13	5.60	82.4	32.2	GA 2004137	1810	0.45	1.21	4.85	84.4	29.4
GA 2004079	1312	0.40	1.18	5.10	83.6	31.8	GA 2004010	1781	0.44	1.17	5.00	84.6	29.1
GA 2004168	1288	0.43	1.18	5.45	82.7	30.6	GA 2004175	1756	0.46	1.24	5.00	84.0	28.8
GA 2004131	1281	0.43	1.12	5.35	83.6	29.8	GA 2004016	1726	0.44	1.19	4.75	84.7	28.4
GA 2004020	1268	0.43	1.12	5.40	83.6	31.9	GA 2004030	1720	0.42	1.22	4.80	84.6	28.4
GA 2004088	1222	0.40	1.15	5.10	82.6	30.8	GA 2004054	1715	0.40	1.26	4.65	84.2	30.6
GA 2004055	1222	0.41	1.19	5.15	84.6	33.6	GA 2004040	1693	0.44	1.21	4.75	85.9	31.1
GA 2004016	1218	0.44	1.11	5.30	83.0	30.8	GA 2004020	1646	0.44	1.19	4.90	85.4	31.6
FM 958	1204	0.41	1.15	5.00	83.2	33.6	FM 958	1523	0.43	1.18	4.85	83.7	31.6
GA 2004040	1132	0.42	1.13	5.10	83.8	30.9							
$LSD_{0.10}$	**173**	**0.01**	**0.05**	**0.16**	**ns**	**1.1**	**$LSD_{0.10}$**	**127**	**0.01**	**0.03**	**0.22**	**ns**	**1.3**

The bold type indicates the lint yields that are not significantly different from the top. DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 2. Results of 2006 Advanced (F6) Trial 2.

2006 AT 2 Tifton							2006 AT 2 Plains						
ENTRY	Lint Yield	Lint %	UHM in.	mic	UI %	Str g/tex	ENTRY	Lint Yield	Lint %	UHM in.	mic	UI %	Str g/tex
GA 2004206	**1811**	0.44	1.16	5.50	83.85	30.60	GA 2004358	**1970**	0.44	1.24	4.75	85.20	30.45
GA 2004230	**1811**	0.42	1.23	4.80	83.25	30.90	GA 2004313	**1964**	0.42	1.20	5.00	83.85	29.25
GA 2004358	**1811**	0.44	1.16	5.30	83.75	32.50	GA 2004181	**1957**	0.45	1.26	5.20	84.40	29.05
GA 2004236	**1811**	0.46	1.17	4.90	83.70	29.35	GA 2004331	**1954**	0.44	1.23	5.20	85.50	31.00
GA 2004331	**1811**	0.44	1.14	5.85	84.00	32.95	GA 2004230	**1949**	0.43	1.28	4.65	84.90	30.85
GA 2004181	**1811**	0.45	1.16	5.45	83.40	30.85	GA 2004207	**1949**	0.44	1.23	4.75	84.75	29.50
GA 2004353	**1811**	0.43	1.15	5.10	83.65	31.05	GA 2004290	**1887**	0.42	1.18	5.25	84.05	28.55
GA 2004352	1676	0.43	1.17	5.05	82.85	31.30	GA 2004340	**1864**	0.44	1.21	5.30	84.50	30.50
GA 2004201	1675	0.46	1.11	5.75	82.70	33.55	GA 2004201	**1854**	0.46	1.23	4.95	83.95	31.90
GA 2004416	1626	0.43	1.20	5.25	84.35	31.65	GA 2004236	**1844**	0.45	1.24	4.75	84.20	27.80
GA 2004196	1598	0.44	1.17	5.05	84.25	32.00	GA 2004217	**1838**	0.43	1.25	5.10	84.70	30.25
GA 2004192	1594	0.45	1.13	5.65	83.85	32.05	DeltaPEARL	1784	0.41	1.23	4.85	83.75	30.60
GA 2004284	1582	0.41	1.14	5.25	83.60	32.90	GA 2004352	1779	0.43	1.26	5.00	85.80	29.20
DeltaPEARL	1578	0.41	1.17	5.15	82.75	32.20	GA 2004206	1767	0.44	1.24	4.95	83.60	29.65
GA 2004340	1567	0.44	1.15	5.45	83.85	32.80	GA 2004284	1695	0.42	1.17	5.15	84.05	31.50
GA 2004207	1566	0.44	1.10	5.45	83.65	30.85	GA 2004416	1675	0.41	1.25	5.20	84.90	29.15
GA 2004184	1562	0.43	1.18	5.15	84.20	32.00	GA 2004353	1651	0.43	1.19	4.90	83.70	28.55
GA 2004430	1554	0.42	1.18	5.30	83.85	33.95	GA 2004196	1600	0.43	1.24	4.45	84.15	30.10
GA 2004313	1538	0.40	1.15	5.30	83.50	31.75	GA 2004430	1599	0.41	1.25	5.00	84.95	30.45
GA 2004290	1534	0.41	1.11	5.45	82.60	30.60	GA 2004256	1596	0.44	1.23	4.90	85.25	32.90
GA 2004256	1513	0.43	1.15	5.20	83.95	33.60	GA 2004192	1579	0.44	1.19	5.25	84.15	30.75
GA 2004217	1439	0.43	1.18	5.35	83.40	31.20	GA 2004413	1493	0.42	1.24	5.00	84.75	29.55
GA 2004413	1434	0.42	1.15	5.35	83.60	32.65	FM 958	1335	0.42	1.20	4.75	83.90	32.55
FM 958	1405	0.41	1.17	5.20	83.00	32.40							
LSD0.10	**133**	**0.01**	**0.03**	**0.27**	**ns**	**1.22**	**LSD0.10**	**173**	**0.01**	**0.03**	**0.25**	**ns**	**1.05**

The bold type indicates the lint yields that are not significantly different from the top. DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 3. Results of 2006 Preliminary (F5) Trials 1 and 2.

2006 PT1							2006 PT2						
ENTRY	Lint Yield	Lint %	UHM in.	mic	UI %	Str g/tex	ENTRY	Lint Yield	Lint %	UHM in.	mic	UI %	Str g/tex
GA 2006009	**1303**	0.44	1.19	5.0	83.0	30.6	GA 2006031	**1575**	0.43	1.19	5.0	84.0	31.8
GA 2006011	**1275**	0.42	1.17	5.0	81.8	32.3	GA 2006042	**1570**	0.43	1.16	4.9	83.3	31.2
GA 2006006	**1248**	0.40	1.20	4.9	83.6	31.2	GA 2006030	**1566**	0.41	1.18	4.9	84.1	31.7
GA 2006014	**1232**	0.39	1.23	5.0	84.8	29.8	DeltaPEARL	**1519**	0.43	1.19	4.9	82.8	32.2
GA 2006010	**1230**	0.38	1.21	4.2	83.0	30.3	GA 2006038	**1491**	0.42	1.20	5.1	84.8	32.0
GA 2006015	**1220**	0.42	1.22	5.1	85.2	30.6	GA 2006035	**1473**	0.41	1.23	4.7	84.4	31.1
GA 2006016	**1219**	0.41	1.22	4.5	83.9	29.3	GA 2006044	**1457**	0.43	1.21	5.0	84.3	31.8
GA 2006008	**1217**	0.38	1.20	4.6	83.5	31.5	GA 2006039	**1449**	0.42	1.21	4.3	83.1	31.6
DeltaPEARL	**1207**	0.40	1.17	5.3	82.0	31.6	GA 2006033	1435	0.42	1.20	4.7	84.2	31.8
GA 2006005	**1206**	0.40	1.20	5.0	84.0	31.3	GA 2006037	1387	0.42	1.19	4.3	82.6	33.3
GA 2006012	**1191**	0.42	1.18	4.8	84.3	32.9	GA 2006032	1348	0.42	1.23	4.5	84.2	32.0
GA 2006007	1178	0.39	1.19	4.1	82.1	31.3	GA 2006041	1347	0.42	1.23	4.7	85.4	32.0
GA 2006020	1174	0.41	1.23	5.1	85.2	29.4	GA 2006043	1335	0.40	1.20	4.8	84.6	33.0
GA 2006013	1170	0.39	1.16	4.6	82.2	31.5	GA 2006034	1328	0.42	1.22	4.8	84.5	31.1
GA 2006018	1144	0.42	1.20	5.1	85.1	30.6	GA 2006023	1316	0.39	1.15	4.4	83.1	30.3
GA 2006022	1132	0.38	1.17	4.9	84.5	33.8	GA 2006036	1298	0.42	1.22	4.7	84.1	32.1
GA 2006021	1132	0.39	1.19	4.9	83.4	30.4	GA 2006040	1291	0.43	1.22	5.0	84.3	33.8
GA 2006019	1120	0.42	1.22	4.9	84.4	30.0	FM 958	1284	0.41	1.19	4.5	84.2	33.9
FM 958	1118	0.40	1.17	5.1	83.8	34.4	GA 2006026	1267	0.42	1.20	5.2	85.1	29.8
GA 2006003	1084	0.41	1.14	5.4	82.4	35.1	GA 2006027	1258	0.41	1.18	4.9	84.3	31.4
GA 2006017	1056	0.42	1.19	5.2	84.4	28.8	GA 2006025	1096	0.40	1.19	4.9	84.9	29.9
GA 2006002	962	0.39	1.12	5.4	83.1	33.6	GA 2006029	1000	0.40	1.20	4.5	84.8	31.7
GA 2006004	949	0.39	1.20	4.5	83.0	31.8	GA 2006028	-	0.39	1.21	5.0	86.0	33.0
GA 2006001	-	0.43	1.16	5.2	82.9	30.3	GA 2006024	-	0.39	1.21	5.4	84.8	30.6
$LSD_{0.10}$	**122**	**0.01**	**0.03**	**0.34**	**0.80**	**1.07**	**$LSD_{0.10}$**	**136**	**0.01**	**0.02**	**0.26**	**ns**	**1.35**

The bold type indicates the lint yields that are not significantly different from the top. DeltaPEARL and FiberMax FM 966 are check varieties for comparison purposes.

Table 4. Results of 2006 Preliminary (F5) Trials 3 and 4.

2006 PT3							2006 PT4						
ENTRY	**Lint Yield**	**Lint %**	**UHM in.**	**mic**	**UI %**	**Str g/tex**	**ENTRY**	**Lint Yield**	**Lint %**	**UHM in.**	**mic**	**UI %**	**Str g/tex**
GA 2006063	**1728**	0.41	1.21	5.2	83.9	30.2	GA 2006073	**1611**	0.41	1.20	5.2	84.0	32.2
GA 2006053	**1721**	0.42	1.17	5.3	81.8	29.2	GA 2006069	**1588**	0.39	1.15	5.3	83.1	30.1
GA 2006045	**1696**	0.42	1.23	4.8	83.6	30.1	GA 2006086	**1544**	0.40	1.18	5.0	84.5	34.1
GA 2006064	**1667**	0.43	1.19	5.1	84.2	30.4	GA 2006071	1493	0.40	1.12	5.7	82.6	32.2
GA 2006066	**1666**	0.42	1.18	4.9	84.0	31.0	GA 2006079	1492	0.41	1.17	5.0	83.1	31.6
GA 2006052	**1621**	0.41	1.20	4.8	84.5	30.3	GA 2006080	1477	0.39	1.19	5.1	84.7	33.1
GA 2006048	1584	0.44	1.20	5.2	83.1	29.3	GA 2006074	1468	0.38	1.16	5.0	82.2	29.3
GA 2006061	1579	0.43	1.16	5.1	82.6	32.1	GA 2006081	1453	0.39	1.19	4.9	84.1	31.9
GA 2006046	1574	0.42	1.17	4.7	82.4	28.9	DeltaPEARL	1446	0.39	1.19	5.1	84.4	33.4
GA 2006051	1565	0.41	1.20	5.2	84.1	31.9	GA 2006072	1442	0.40	1.14	5.3	83.3	34.0
GA 2006050	1553	0.42	1.19	5.3	84.2	31.8	GA 2006075	1434	0.40	1.19	5.1	83.6	31.1
GA 2006049	1539	0.42	1.20	5.0	82.5	29.6	GA 2006084	1431	0.39	1.15	5.1	83.1	32.8
DeltaPEARL	1538	0.41	1.21	4.7	82.9	31.6	GA 2006085	1429	0.41	1.17	5.3	82.6	34.1
GA 2006058	1529	0.42	1.20	4.9	84.0	30.2	GA 2006070	1422	0.38	1.19	4.9	84.3	32.7
GA 2006065	1514	0.40	1.23	4.6	84.5	31.6	GA 2006088	1416	0.42	1.21	5.0	84.1	34.8
GA 2006056	1502	0.41	1.21	5.3	84.0	31.1	GA 2006078	1408	0.41	1.20	4.9	84.2	32.4
GA 2006059	1493	0.42	1.20	5.1	83.7	30.4	GA 2006082	1402	0.41	1.17	4.8	83.1	32.2
GA 2006055	1462	0.40	1.19	4.6	83.5	31.0	GA 2006083	1382	0.42	1.14	4.8	83.1	33.2
FM 958	1461	0.41	1.18	5.1	84.1	33.7	GA 2006068	1332	0.39	1.19	5.1	82.9	30.9
GA 2006054	1419	0.43	1.17	5.4	83.8	31.1	GA 2006087	1331	0.41	1.14	5.3	84.3	35.0
GA 2006060	1376	0.41	1.17	4.7	83.0	31.6	GA 2006076	1309	0.38	1.18	5.0	84.5	34.8
GA 2006047	1369	0.41	1.27	5.0	85.5	32.9	GA 2006077	1291	0.38	1.15	4.8	83.3	32.8
GA 2006057	-	0.41	1.17	5.2	83.7	31.3	GA 2006067	1215	0.38	1.18	5.4	84.3	32.2
GA 2006062	-	0.43	1.20	4.9	83.6	30.8	FM 958	1174	0.40	1.17	4.8	83.4	34.4
$LSD_{0.10}$	**141**	**0.01**	**0.03**	**0.26**	**0.98**	**1.01**	**$LSD_{0.10}$**	**103**	**0.01**	**0.02**	**0.26**	**0.61**	**1.24**

The bold type indicates the lint yields that are not significantly different from the top.
DeltaPEARL and FiberMax FM 966 are check varieties for comparison purposes.

Table 5. Results of 2006 Preliminary (F5) Trials 5 and 6.

2006 PT5							2006 PT6						
ENTRY	Lint Yield	Lint %	UHM in.	mic	UI %	Str g/tex	ENTRY	Lint Yield	Lint %	UHM in.	mic	UI %	Str g/tex
GA 2006093	**1704**	0.42	1.19	4.9	83.8	32.6	GA 2006127	**1746**	0.44	1.16	5.2	83.7	30.0
GA 2006106	1555	0.42	1.21	4.8	83.1	32.7	GA 2006124	**1664**	0.41	1.19	4.9	84.5	31.5
GA 2006089	1541	0.42	1.16	4.9	83.0	33.8	GA 2006112	1600	0.42	1.26	5.3	85.6	35.1
GA 2006109	1535	0.40	1.20	5.0	84.0	34.5	GA 2006126	1580	0.44	1.14	4.5	84.0	30.3
GA 2006091	1510	0.43	1.18	4.8	82.4	30.1	GA 2006123	1567	0.40	1.19	4.7	84.2	35.3
GA 2006101	1505	0.42	1.20	4.7	83.4	31.1	GA 2006113	1551	0.41	1.18	4.5	83.7	33.0
GA 2006108	1504	0.41	1.18	5.3	83.6	33.6	GA 2006130	1537	0.42	1.18	5.2	84.7	31.4
GA 2006099	1498	0.42	1.19	4.7	83.9	33.7	GA 2006111	1528	0.42	1.19	5.0	83.5	32.1
GA 2006095	1492	0.41	1.23	4.8	84.5	33.7	GA 2006128	1525	0.42	1.23	4.6	85.3	29.6
GA 2006102	1437	0.39	1.20	5.0	83.8	34.7	GA 2006120	1518	0.41	1.22	4.3	85.5	35.0
GA 2006090	1435	0.41	1.15	5.4	83.3	33.3	GA 2006121	1485	0.42	1.20	4.9	84.5	33.6
GA 2006107	1427	0.40	1.16	4.7	83.0	34.7	DeltaPearl	1407	0.43	1.18	4.4	83.4	32.6
GA 2006103	1402	0.41	1.22	4.7	84.9	33.8	GA 2006118	1398	0.41	1.20	5.2	84.7	32.3
GA 2006100	1395	0.40	1.21	4.9	84.5	31.7	GA 2006115	1362	0.40	1.19	4.7	83.8	33.9
DeltaPearl	1391	0.40	1.21	5.3	84.0	33.5	GA 2006132	1356	0.44	1.13	4.7	84.8	32.4
GA 2006094	1352	0.42	1.17	5.5	84.6	32.8	GA 2006129	1347	0.43	1.18	4.5	84.8	31.0
GA 2006110	1338	0.39	1.16	4.8	83.2	35.8	GA 2006117	1298	0.41	1.18	4.3	84.1	31.4
GA 2006098	1329	0.41	1.16	5.1	84.7	34.4	FM 958	1275	0.43	1.22	5.3	85.4	33.7
GA 2006097	1320	0.41	1.20	5.0	84.8	32.1	GA 2006116	1233	0.39	1.17	5.7	84.5	33.4
FM 958	1256	0.41	1.19	4.7	83.7	32.7	GA 2006122	1216	0.40	1.19	5.0	84.8	36.2
GA 2006105	1254	0.40	1.17	5.6	83.7	31.8	GA 2006125	1207	0.42	1.18	5.2	84.3	31.5
GA 2006104	1246	0.40	1.23	4.3	83.4	31.8	GA 2006131	1192	0.43	1.20	4.6	85.1	29.9
GA 2006092	1242	0.41	1.22	5.0	84.1	31.2	GA 2006119	1183	0.41	1.20	5.1	84.9	34.7
GA 2006096	1179	0.38	1.20	4.7	84.8	32.5	GA 2006114	1156	0.40	1.14	4.2	84.3	33.8
$LSD_{0.10}$	**115**	**0.01**	**0.03**	**0.25**	**0.81**	**1.03**	**$LSD_{0.10}$**	**122.2**	**0.011**	**0.021**	**0.26**	**0.72**	**1.62**

The bold type indicates the lint yields that are not significantly different from the top. DeltaPEARL and FiberMax FM 966 are check varieties for comparison purposes.

Table 6. Results of 2006 Preliminary (F5) Trials 7 and 8.

2006 PT7						
ENTRY	**Lint Yield**	**Lint %**	**UHM in.**	**mic**	**UI %**	**Str g/tex**
GA 2006139	**1654**	0.44	1.14	5.5	84.1	32.2
GA 2006152	**1616**	0.42	1.14	5.1	83.9	35.6
GA 2006140	**1573**	0.43	1.19	5.5	84.9	33.0
GA 2006154	**1571**	0.41	1.15	5.2	83.0	33.1
GA 2006137	**1551**	0.41	1.18	5.5	84.4	30.8
GA 2006141	1519	0.43	1.17	5.4	84.3	32.4
GA 2006153	1501	0.44	1.19	5.3	84.2	33.1
DeltaPEARL	1496	0.41	1.19	5.2	83.9	32.0
GA 2006133	1470	0.43	1.15	5.6	84.7	30.8
FM 958	1439	0.42	1.15	5.2	83.5	33.4
GA 2006134	1435	0.43	1.16	5.6	84.4	31.9
GA 2006135	1425	0.42	1.19	5.2	84.7	31.7
GA 2006143	1416	0.41	1.16	5.1	84.1	31.6
GA 2006149	1407	0.40	1.21	5.2	84.9	32.4
GA 2006136	1388	0.43	1.20	5.3	84.6	33.3
GA 2006144	1371	0.43	1.14	5.4	84.2	31.3
GA 2006151	1362	0.42	1.15	5.2	84.5	29.9
GA 2006145	1328	0.42	1.16	5.4	84.2	32.8
GA 2006147	1288	0.42	1.11	5.2	83.6	30.1
GA 2006150	1275	0.43	1.14	5.5	84.2	30.1
GA 2006148	1266	0.40	1.15	5.3	84.7	30.5
GA 2006138	1241	0.41	1.16	5.2	84.4	32.2
GA 2006146	1168	0.41	1.13	5.5	84.6	29.9
GA 2006142	1121	0.40	1.17	5.2	84.9	30.9
$LSD_{0.10}$	**124**	**0.02**	**ns**	**ns**	**ns**	**1.12**

2006 PT8						
ENTRY	**Lint Yield**	**Lint %**	**UHM in.**	**mic**	**UI %**	**Str g/tex**
GA 2006168	**1596**	0.43	1.16	5.1	84.4	33.8
GA 2006164	**1592**	0.42	1.21	5.2	83.6	35.1
GA 2006158	**1492**	0.42	1.24	4.9	84.7	33.3
GA 2006155	**1481**	0.42	1.16	5.0	84.4	32.9
GA 2006170	**1479**	0.43	1.21	5.0	84.0	34.5
GA 2006159	**1471**	0.42	1.16	5.3	84.1	32.3
GA 2006167	**1470**	0.42	1.20	5.2	83.9	32.2
GA 2006173	**1431**	0.45	1.15	4.7	84.4	32.6
GA 2006163	**1428**	0.42	1.17	5.1	84.3	32.6
GA 2006161	**1425**	0.42	1.15	5.0	83.7	32.5
GA 2006162	**1416**	0.42	1.20	4.7	84.5	32.0
GA 2006157	1358	0.41	1.21	5.1	84.0	32.8
GA 2006171	1306	0.42	1.23	4.6	84.8	35.0
GA 2006160	1284	0.42	1.15	5.4	84.1	32.2
FM 958	1274	0.42	1.16	5.3	83.8	34.4
GA 2006169	1268	0.42	1.14	4.9	83.0	33.0
GA 2006175	1261	0.40	1.24	4.4	84.7	32.8
GA 2006156	1258	0.42	1.15	5.4	83.4	32.7
GA 2006172	1250	0.42	1.15	5.0	83.4	31.5
DeltaPEARL	1239	0.41	1.18	5.2	83.5	31.0
GA 2006165	1190	0.43	1.16	5.5	84.0	33.2
GA 2006176	1142	0.41	1.23	5.0	85.6	32.5
GA 2006174	1127	0.42	1.22	4.5	84.5	31.8
GA 2006166	1066	0.42	1.18	5.1	84.4	32.5
$LSD_{0.10}$	**182**	**ns**	**0.03**	**0.34**	**ns**	**1.46**

The bold type indicates the lint yields that are not significantly different from the top.
DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

2006 COTTON VARIETY TRIALS

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Introduction

The 2006 University of Georgia Cotton Variety Trials (OVT) were conducted at five locations across Georgia, spanning the cotton belt from southwest to northeast Georgia. Irrigated trials were conducted on-farm in Decatur county and at University research stations and/or education centers in Midville, Plains, and Tifton. Dryland trials were conducted on University research stations and/or education centers in Athens, Midville, Plains, and Tifton. Performance data in these tables, combined with data from previous years should assist growers in variety selection, one of the most important if not most important decisions in an economically viable cotton production plan. Data collected from the University of Georgia Variety Testing Cotton Program can be found at the Statewide Variety Testing Website: www.commodities.caes.uga.edu/swvt. Also, the data is published in the UGA Agricultural Experiment Station Research Report Number 709, January 2007.

Materials and Methods

The University of Georgia conducts Official Cotton Variety and Strain trials across Georgia to provide growers and county agents with performance data to help in selecting varieties. Data from the OVT also helps the private seed companies assess the fit of their products in Georgia. The University of Georgia cotton OVT is conducted by J. LaDon Day, Program Coordinator Cotton OVT, Griffin, GA. along with Mr. Larry Thompson, Research Professional I, Tifton, GA. The OVT is split into variety and strain trials with placement of varieties or strains into the particular trial chosen by its owner. Trials are separated by maturity. Irrigated OVT trials are conducted at Bainbridge, Midville, Plains, and Tifton, while dryland OVTs are conducted at Athens, Midville, Plains, and Tifton, thus varieties placed into the OVT are included in eight trials per year, giving a fair size data set with which to evaluate variety performance. The strains trials are irrigated and conducted at Midville, Plains, and Tifton. Trials consist of 4-replicate, randomized complete block designs. An accepted, common, management system is employed at each location for agronomic and pest management, but transgenic cultivars are not produced according to their intended pest management system(s). A random quality sample was taken on the picker during harvest and ginned to measure lint fraction on all plots including the irrigated late maturing trial at Tifton, but a portion of the seed cotton from the later maturity plots was bagged and sent to the Micro Gin at Tifton for processing. All fiber samples were submitted to Starlab, Knoxville, TN for HVI analyses. All trials were harvested with a state-of-the-art harvest system composed of a International IH 1822 picker fitted with weigh baskets and suspended from load sells.

This system allows one person to harvest yield trials where the established bag-and-weigh approach required eight people or more. The electronic weigh system allowed for timely harvest of yield trials. Data from all trials and combined analyses over locations and years are reported as soon as fiber data are available from the test lab in Adobe pdf and Excel formats on the UGA CottonTeam Website maintained at http://www.griffin.uga.edu/caes/cotton/varities/. Also, the data is available at the Statewide Variety Testing Website: www.commodities.caes.uga.edu/swvt.

Results and Discussion

2006 row crop season in Georgia can best be described as dry and hot. The first week of April was cool. Spotty rainfall during April and May resulted in drought conditions over much of the state. Early and mid May was cool but late May and early June were hot and dry. By mid June less than half of the crops were rated as good. Much of the non-irrigated crops were severely damaged by drought unless they caught a timely rain. Hot late June and July conditions and short water supply made it difficult for irrigation systems to keep up. Late July and August rains were often too late to improve the crops.

During 2006, Cotton producers planted 1.4 million acres of cotton. This number of acres planted was an increase of 15% over 2005. Throughout the growing season the Georgia cotton farmer was on the brink of disaster due to the hot dry weather, many acres of the crop were disked in during July. Even with acres being destroyed, 160,000 more acres(13% more) were harvested than during 2005. Yield per acre was down eight percent less than 2005 but coupled with increased acres harvested, production increased 4.2% during 2006. The overall rebound that the 2006 cotton crop made can not be fully explained but was a welcome relief.

Among varieties in the Dryland Earlier Maturity Trials, ten varieties stand out as varieties with high yield and relative yield stability in the dryland trials (Table 1). There were 12 other varieties that performed above average(Table 1). When summarized over two years, DP 454 BG/RR, PHY370WR, and DP 445BG/RR were top yielders (Table 2).

Among the best performing earlier maturing varieties produced under irrigation, DP 454 BG/RR, FM960BR, ST4427B2RF, and PHY370WR were the highest averaged over locations (Table 3). Eighteen other varieties performed above average(Table 3). DP 454 BG/RR and DP455BG/RR were the highest in yield when averaged over two years and locations in the Irrigated Early Maturity Trials conducted at Bainbridge, Midville, Plains, and Tifton; however, 11 other varieties yielded above average(Table 4).

Later maturity trials produced without irrigation also revealed the consistent performance of DP454BG/RR, DP555BR/RR, GA2003118, DP515BG/RR, DP488BG/RR, and DP493. (Table 5). Averaged over locations and years, DP454BG/RR was the front runner But also yielding above average were varieties from Monsanto and Georgia(Table 6).

Under irrigation, DP555 BG/RR led the standard later maturing trials averaged over locations (Table 7), while 11 other varieties were above average in lint yield. Averaged over years and locations, DP555BG/RR was the best performer (Table 8) with another six varieties yielding above average, Stoneville's 5599BR (Table 8), a variety released in 2003, continues to show promise to help growers with root knot nematodes as it possesses some resistance to root knot.
The Earlier Maturity and Later Maturity Strains Trials portend improved varieties for crop seasons 2007 and beyond (Tables 9). Varieties from Bayer Cropscience FiberMax, Georgia, and Syngenta were the higher yielding performer among standard earlier maturing entries in the strains trial. In the Later Maturity group three lines from Georgia were at the top, but lines from Bayer Cropscience FiberMax yielded above average.

Presented in Table 10 is the Tifton, Georgia, 2006 Later Maturity cotton variety performance, irrigated, data comparing small gin seed/lint with samples processed through the Micro-gin(MG) on the Tifton Campus. The seed cotton from the Later Maturity experiment was sub-sampled, ginned and sent to Star Lab in Knoxville, Tn., for HVI analysis. The remaining seed cotton was sent to the Micro-gin, Tifton Campus for processing and also sent to Star Lab for HVI analysis.

In summary, several new varieties described herein portend potentially higher yields and improved fiber packages available to Georgia growers.

Table 1. Yield Summary for Dryland Earlier Maturity Cotton Varieties, 2006

Entry	Lint Yield[a] Athens		Midville		Plains		Tifton		4-Loc. Average		Lint	Unif. Index	Length	Strength	Mic.
	---------- lb/acre ----------										%	%	in	g/tex	units
DP 454 BG/RR	**1347**	1	**762**	1	**1625**	2	1540	9	**1318**	1	45.9	82.7	1.05	29.2	4.5
PHY370WR	**1263**	3	**605**	8	**1619**	3T	**1599**	4	**1272**	2	43.7	83.0	1.06	30.1	4.6
PHY480WR	**1251**	5	**610**	7	1599	4	1481	13	**1235**	3	41.5	83.7	1.12	30.7	4.8
GA2003156	**1314**	2	494	24	1409	28	**1633**	3	**1212**	4	43.9	82.9	1.12	33.0	5.0
PHY470WR	**1246**	6	560	12	1484	18	1482	12	**1193**	5	42.3	83.5	1.08	29.5	4.6
PHY310R	**1229**	8T	**624**	4	1541	9	1358	24	**1188**	6	43.7	82.5	1.05	30.2	4.8
DP 445 BG/RR	1138	17	**589**	10	1401	29T	**1594**	6T	**1180**	7T	42.8	83.2	1.11	29.2	4.5
DP 455 BG/RR	**1229**	8T	507	20	1584	6	1398	21	**1180**	7T	43.2	81.9	1.08	30.7	4.3
DP 143 B2RF	**1213**	9	577	11	1258	45	**1668**	2	**1179**	8	40.8	82.1	1.17	28.9	4.3
PHY425RF	**1192**	10	**615**	6	1496	16	1390	22	**1173**	9	43.0	83.2	1.10	30.5	4.9
PHY485WRF	1069	24	439	32	**1804**	1	1372	23	1171	11	43.1	83.1	1.11	30.7	4.8
DP 117 B2RF	1129	18	508	19	1489	17	1542	8	1167	11	42.5	82.7	1.12	31.8	4.6
ST 5242BR	**1257**	4	428	34	1435	24	1494	10	1153	12	43.2	83.1	1.08	28.3	4.4
GA2002209	1092	21	**599**	9	1361	35	**1553**	7	1151	13	43.8	82.9	1.11	31.0	5.0
FM966LL	1149	13	381	40	1267	44	**1797**	1	1148	14T	42.2	83.2	1.11	34.9	4.6
GA2002212	1085	23	468	27	1549	8	1492	11	1148	14T	44.2	82.6	1.12	32.5	5.0
FM960B2R	1155	12	324	46	**1619**	3T	1403	20	1125	15	41.6	82.1	1.11	32.5	4.7
DP 432 RR	908	41	412	36	1507	13	**1594**	6T	1105	16	41.2	83.0	1.08	28.9	4.5
FM9063B2F	1140	15	433	33	1389	31	1426	17	1097	17	41.5	83.1	1.17	31.6	4.3
DX25105N	1126	19	521	15	1413	26	1314	26	1094	18	43.1	82.9	1.12	29.6	4.8
DP 110 RF	1147	14	517	16	1432	25	1260	32	1089	19	41.8	83.3	1.13	34.1	4.7
ST 4575BR	1039	30	541	13	1587	5	1179	39T	1087	20	42.3	82.1	1.05	28.7	4.8
DynaGro 060642B2/RF	1068	25	449	30	1531	10	1279	30	1082	21	40.1	82.3	1.07	26.6	3.8
GA2002167	910	40	514	17	1300	42	**1598**	5	1080	22	43.4	82.4	1.09	31.4	4.7
FM960BR	1051	27	286	47	1499	15	1480	14	1079	23	42.1	82.6	1.09	32.2	4.7
FM965LLB2	929	38	485	26T	1460	20	1432	16	1076	24	40.5	82.7	1.12	33.3	4.5
ST4427B2RF	1139	16	394	38	1378	33	1357	25	1067	25	41.8	82.7	1.09	30.1	4.6
DPLX06W650F	**1232**	7	503	21	1231	47	1296	28	1066	26	42.6	82.6	1.10	29.7	4.6
FM9060F	**1168**	11	329	44	1324	38	1435	15	1064	27	42.9	82.6	1.16	29.0	4.3
DP 121 RF	950	35	501	22	1562	7	1222	36	1059	28T	43.2	82.9	1.09	30.3	4.9
DP 393	984	33	**739**	2	1310	39	1201	38	1059	28T	41.9	82.9	1.08	30.2	4.8
DP 147 RF	1105	20T	391	39	1306	41	1423	19	1056	29	42.0	82.7	1.16	30.1	4.4
ST 4554B2RF	1049	28	509	18	1350	36	1301	27	1052	30	41.9	82.4	1.09	30.2	4.7
DynaGro 2520B2/RF	1087	22	454	29	1459	21	1179	39T	1045	31	40.8	82.5	1.11	27.7	4.4
FM9068F	1105	20T	368	41	1281	43	1424	18	1044	32	41.5	83.1	1.15	31.4	4.5
DP 444 BG/RR	1003	32	**616**	5	1254	46	1295	29	1042	33	42.9	82.6	1.06	28.8	4.2
ST 4357B2RF	1060	26	539	14	1383	32	1166	41	1037	34	40.9	83.0	1.11	27.9	4.4
CG3520B2RF	962	34	**681**	3	1392	30	1067	45	1026	35	41.4	82.5	1.09	26.3	4.3
ST 4664RF	1027	31	491	25	1411	27	1155	42	1021	36	41.7	82.8	1.08	29.3	4.7
BW-8391B2F	881	43	442	31	1463	19	1269	31	1014	37T	39.5	82.9	1.13	29.1	4.2

Yield Summary for Dryland Earlier Maturity Cotton Varieties, 2006 (Continued)

Entry	Lint Yield[a] Athens		Midville		Plains		Tifton		4-Loc. Average		Lint	Unif. Index	Length	Strength	Mic.
	---------- lb/acre ----------										%	%	in	g/tex	units

FINE MAPPING FOR FIBER LENGTH ON CHROMOSOME 1 IN COTTON

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Introduction

Cotton is an important cash crop in the world. A long-term challenge facing a cotton breeder is the simultaneous improvement of yield and fiber quality to meet the demands of the cotton producer as well as the textile industry. In the recent years, improvement of cotton fiber quality has been extremely important because of changes in spinning technology. Cotton fiber quality is defined by physical properties. One of the most important aspects of fiber quality is fiber length. Fiber length was the initial property used to assess cotton quality and its suitability for certain end uses. Longer fiber length is desirable for the production of fine yarns and low twist yarns.

The development of DNA markers linked to the fiber quality QTLs would allow cotton breeders to trace this very important trait in early plant-growing stages or early segregating generations. The use of these DNA markers increases the prospect for streamlining the cotton breeding programs to improve fiber quality while maintaining fiber yield. In an earlier study, 24 BC_3F_2 families were developed from a cross by *Gossypium hirsutum* cv. Tamcot 2111 and *G. barbadense* cv. Pima S6 with three backcrosses to Tamcot 2111. Twenty eight non-overlapping QTLs for fiber length were identified in these families. The fiber length QTL on chromosome 1 was detected in three different families which explained 12-24% of phenotypic variance (PV) (Chee et al, 2005). These results suggest that this fiber length QTL can be expressed stably and have less interaction effect with other loci, making it a valuable target for genetic analysis and also for further application in cotton quality breeding.

Materials and Methods

In an earlier study, 28 non-overlapping QTLs for fiber length were identified in BC_3F_2 families developed from a cross by *G. hirsutum* cv. Tamcot 2111 and *G. barbadense* cv. Pima S6. The fiber length QTL on chromosome 1 near RFLP marker A1686a was detected in three different families. In this study, three BC_3F_2 plants, R01-40, R03-02, and R05-17, with a Pima S-6 introgression in the target region had significantly longer fiber and relatively few non-target background introgressions, were selected to develop three BC_3F_3 populations to fine map the target fiber length QTL.

Thirty eight SSR markers from chromosome 1 that were based on the cotton genetic linkage maps of Rong et al. (2004), Nguyen et al. (2004), and Han et al. (2005) along with 16 STS markers were selected to genotype three BC_3F_3 families. Mapping and statistical analysis were performed based on three sets of data from three separate populations and one combined population (combined Pop). Linkage maps were constructed using the MAPMAKER/Exp Version 3.0b Software. QTLs were identified by composite interval mapping (CIM) using Windows QTL Cartographer 2.5.

Results and Discussion

Composite interval mapping for fiber length on chromosome 1 was carried out based on three separate populations and a combined population from two environments. Figure1.A shows the log-likelihood (LOD) score plot in the introgression segment. The maximum LOD score was observed between BNL2921 and JESPR56 in all populations. In the combined population, this QTL had a LOD score of 3.7 in the BC_3F_4 and 4.5 in the BC_3F_5, which explained an R^2 of 12.14% in the BC_3F_4 and 14.48% in the BC_3F_5. The allele from long fiber length parent *G. barbadense* can increase fiber length by 0.0179-0.0211 inch.

To more finely map this QTL location, the phenotypic means for different recombinants were compared to recurrent parent Tamcot 2111. Five of the six recombinants which carried any Pima S-6 introgression segments between BNL1350-JESPR56 had significantly longer fiber lengths than that of recurrent parent Tamcot 2111; the sixth recombinant, R03-02-14, was also longer but not significantly longer. One of the recombinants, R05-17-67, only contained PimaS-6/Tamcott 2111 heterozygous segment between BNL2921-JESPR56, but the mean of fiber length was still significantly longer than the recurrent parent Tamcot 2111, thus indicating that this QTL was most likely located in a 1.5 cM interval flanked by BNL2921-JESPR56. This finding was also supported by the phenotype of the recombinant R-5-17-54, with an introgression between BNL1350-NAU422, which was not significantly different from the control Tamcot 2111.

In our original advanced backcross QTL study, a QTL on chromosome 1 associated with fiber length was detected in three BC_3F_2 families by ANOVA analysis. Here we used three populations derived from three pre-NIILs (Near Isogenic Introgression Line) for the target region to confirm the positive phenotypic effect of the *G. barbadense* allele at this QTL. Our experiments verified that this region is strongly associated with fiber length. Composite interval mapping and comparing different recombinants with stable phenotype confirmed the chromosome position of this QTL was located at a 1.5 cM interval flanked by SSR markers BNL2921 and JESPR56.

References

Chee P, Draye X, Jiang CX, Decanini L, Delmonte T, Bredhauer R, Smith CW, Paterson AH (2005) Molecular dissection of interspecific variation between *Gossypium hirsutum* and *Gossypium barbadense* (cotton) by a backcross-self approach: III. Fiber length. Theor Appl Genet 111:772-781

Han ZG, Guo WZ, Song XL, Zhang TZ (2004) EST-derived microsatellites from diploid A-genome *Gossypium arboreum* and their genetic mapping in AD allotetraploid cotton. Mol Gen Genet 272:308-327

Nguyen TB, Giband M, Brottier P, Risterucci AM, Lacape JM. (2004) Wide coverage of the tetraploid cotton genome using newly developed microsatellite markers. Theor Appl Genet 109:167-175

Rong JK, Abbey C, Bowers JE, Brubaker CL, Chang C, Chee PW, Delmonte TA, Ding X, Garza JJ, Marler BS, Park C, Pierce GJ, Rainey KM, Rastogi VK, Schulze SR, Tronlinde NL, Wendel JF, Wilkins TA, Wing RA, Wright RJ, Zhao X, Zhu L and Paterson AH (2004) A 3347-locus genetic recombination map of sequence-tagged sites reveals features of genome organization, transmission and evolution of cotton (*Gossypium*). Genetics 166:389-417.

Table1. Phenotype values for fiber length (inch) of parents, original BC_3F_2 individuals and their BC_3F_4/BC_3F_5 family.

Populations/ parents	Population Size	BC_3F_4 Family (2004)				BC_3F_5 family (2005)			
		Max	Min	Mean	Skew	Max	Min	Mean	Skew
R-01	24	1.22	1.06	1.16	-0.56	1.26	1.02	1.16	-0.53
R-03	53	1.19	1.06	1.13	-0.14	1.19	1.06	1.11	0.29
R-05	63	1.21	1.05	1.15	-0.91	1.22	1.07	1.15	-0.26
Combined Pop	140	1.22	1.05	1.14	-0.42	1.26	1.02	1.14	0.04
Pima S-6		1.30				1.33			
Tamcot 2111		1.1				1.12			

* See Chee et al. 2005

Table 2. QTL mapping for fiber length by composite interval mapping

Populations	**Year**	**LOD**	**Additive**	**Dominance**	**R^2**
R01	2004	1.57	-0.0246	0.0001	24.97
	2005	3.11	-0.04098	0.0102	43.06
	Combined year (04/05)	2.75	-0.0332	0.0035	39.27
R03	2004	2.09	-0.0206	0.0059	18.42
	2005	2.04	-0.0208	0.0040	18.07
	Combined year (04/05)	2.75	-0.0210	0.0013	23.53
R05	2004	2.02	-0.0152	0.0029	13.54
	2005	2.24	-0.016	0.0058	14.88
	Combined year (04/05)	2.5	-0.0152	0.0072	16.53
Combined Pop	2004	3.7	-0.0179	0.0023	12.14
	2005	4.5	-0.0211	0.0016	14.48
	Combined year (04/05)	4.2	-0.0181	0.0001	13.30

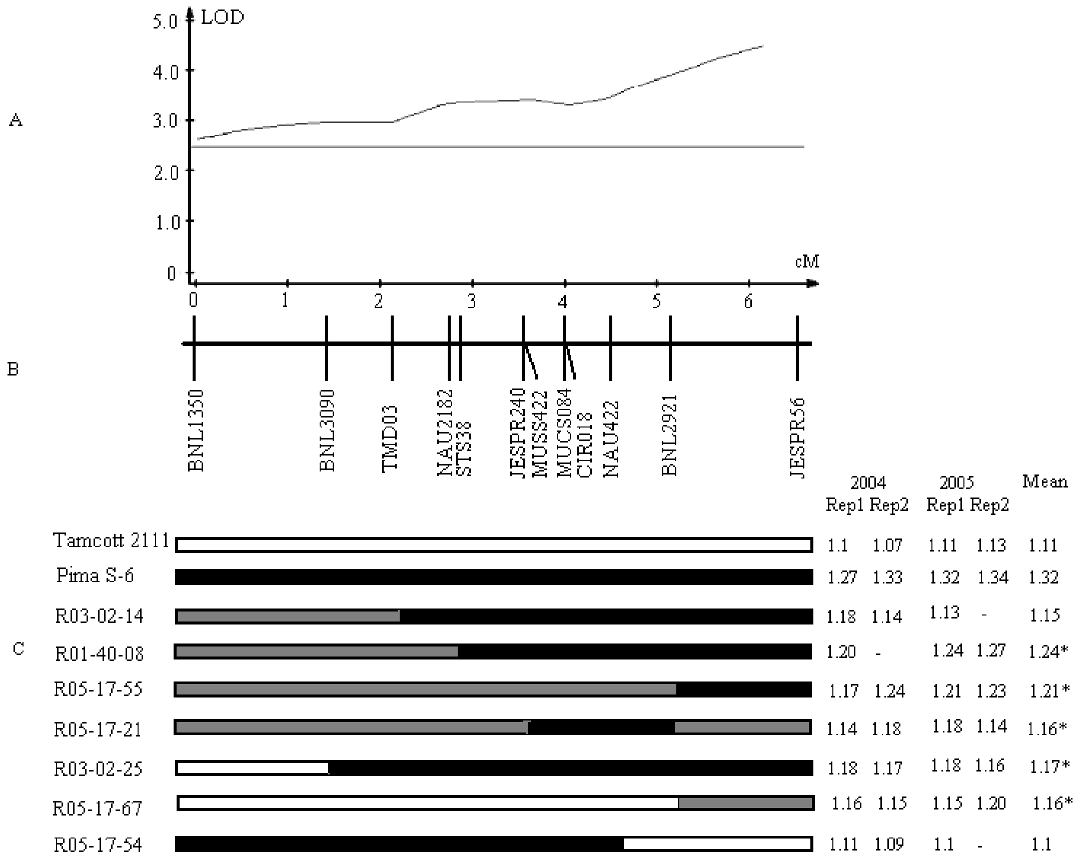

Fig 1 A: Composite interval mapping of fiber length QTL from the combined population in 2005; B: Localized linkage map on chromosome 1; C: Graphical genotypes of recombinant lines and their fiber length (inches). The black, grey, and open boxes indicate homozygous Pima S-6 genotypes, heterozygous genotype and homozygous Tamcot 2111 genotypes. * indicates significant fiber length differences between recombinants and Tamcot 2111.

GREEN FLUORESCENT PROTEIN AS A VISUAL SELECTION MARKER FOR COTTON TRANSFORMATION

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Introduction

Transgenic cotton plants have been produced by vacuum infiltration, particle bombardment, and *Agrobacterium*-mediated transformation. Most transgenic plants have co-introduced antibiotic or herbicide resistant genes which serve no useful purpose after the transgenic plants are produced. The presence of antibiotic and herbicide resistance marker genes in transgenic plants has raised public concern about ecological and food safety perspective of these genes (Puchta 2003). Generating a transformation system without antibiotic resistant and herbicide resistant genes would certainly contribute to public acceptance of transgenic cotton. The green fluorescent protein (GFP) gene has become a very effective marker gene for use in plant genetic transformation. Recent reports on GFP showed that apart from being used as a visual reporter gene instead of β-Glucuronidase (GUS) (Jordan 2000), it could also be used as a visual selection marker gene instead of chemical based antibiotic selection marker genes. Because of it, for the first time in plant transformation, researchers have at their disposal a universal, in vivo, and real-time transgenic visible marker (Stewart 2001). The GFP visual selection efficiency is much higher than antibiotic selection and can greatly reduce the time involved in transgenic plant production. GFP visual selection made transformation possible without antibiotic resistant marker genes without reducing transformation efficiency since there is no harmful effect on plants with the GFP gene. Establishment of GFP gene visual selection transformation system in cotton will provide a new transformation protocol in cotton.

Here we report a time efficient bombardment transformation of cotton using GFP visual selection that is free of selection via antibiotics and the GFP gene expression in different parts of cotton transgenic plant.

Materials and Methods

The seeds of cotton cultivar Coker 312 were kindly provided by Dr. K. Rajasekaran, USDA/ARS, New Orleans, LA. Plant embryogenic callus induction follows the method of Sakhanokho et al. (2004). Plasmid construct p524EGFP.1 expressing visual selection marker gene EGFP from a double 35S cauliflower mosaic virus (35–35S CaMV) promoter with an alfalfa mosaic virus (AMV) enhancer sequence was kindly provided by Dr J. W. Grosser, University of Florida (Fleming et al., 2000). Plasmids were coated onto 1.0-µm gold particles (Bio-Rad) using a modified procedure of Sanford et al. (1991). 10 mg gold particles were first washed with 500 µl sterile distilled water and then resuspend in 200 µl sterile distilled water, a 5–µl aliquot of DNA (at 1 µg/µl) was added to particle suspension, a 35 µl aliquot of a solution consisting of a 5:2 ratio of 2.5M $CaCl_2$ and 0.1M spermidine was added and the tube was immediately finger-vortexed. The tube was incubated in room temperature for 20 min followed by a brief centrifugation, the supernatant was then discarded, and the DNA coated particles were washed with 500 µl 100% ethanol, finger-vortexed, centrifuged, and resuspended in 200 µl 100% ethanol after removal of the supernatant. 10 µl of the suspension were loaded onto a macrocarrier for bombardment. Embryogenic calluses were bombarded with PDS-1000He Particle Delivery System (Bio-Rad) using 1,100 psi rupture disk, 28 in. of Hg vacuum, a gap distance of 0.32 cm and a target distance of 6 cm. Each target callus plate was bombarded two times. Three days following bombardment, the calluses were selected on the basis of florescence (Fig. 1) and transferred to fresh CIM medium. GFP gene expression (visual selection) was detected in callus/somatic embryos illuminated blue light using a Zeiss SV11 stereo microscope equipped for epi-fluorescence with a GFP filter system that allowed an excitation wavelength of 480 ± 30nm and viewing with a barrier filter cutoff wavelength of 515 nm. Images were recorded with a Zeiss AxioCam digital camera coupled to the microscope. The software used to capture and compile the image was Zeiss AxioVision 3.0.6 software and Paintshop 7.0. Fluorescing calluses were separated from non-fluorescing calluses five days later and transfer to EDM medium, selection cycle is five days until homogenously fluorescing calluses/embryos were obtained. The selection experiment was conducted three times; ten dishes were bombarded for each experiment. The results were summarized as the mean number of plants recovered per plate. Plantlet rooting and acclimatization follow the method of Sakhanokho et al. (2004).

Ten separately selected GFP positive plants were subjected to PCR analysis. Genomic DNA was isolated according to the method of Csaikl (1998). PCR primers was designed according to GFP gene sequence: 5′-AAG GGC GAG GAG CTG TTC AC-3′ and 5′-TTC TGC TGG TAG TGG TCG GC-3′. The PCR products were separated on a 0.8% agarose gel with the image recorded.

Transgenic plants grown in green house were subjected to GFP gene expression evaluation with nontransgenic Coker 312 plants as negative control. Different parts of the plant, including roots, stems, leaves, flower buds, and shoot meristems of both plants were sampled and subjected to GFP gene expression evaluation. Expression of GFP gene was measured by Axio software that came with the Zeiss SV11 stereo fluorescent microscope.

Results

Calluses with high embryogenic potential showed light yellow color and red color under a microscope with white light and green fluorescent light respectively. Calluses that expressed transient bright-green fluorescence dots of GFP gene were observed under fluorescent microscope 3 days after bombardment. Stable GFP expressions were observed 7 days after bombardment. Three different developmental pathways were observed on these fluorescent cells, some of the cells will divide and become homologous GFP transgenic callus, some will develop but can not match the division of non-transformed cells and be embedded by fast growing non-transformed cells, the third kind will gradually lose fluorescence and go back to normal non-transformed embryogenic cells. Early visual selection of GFP positive cells could help the transformed cells of the second and third groups to develop into transgenic cell mass with little disturbance by no-transformed surrounding cells. The first selection was performed 3 days after bombardment by transferring calluses with green GFP dots to fresh medium. Selection for stably transformed cells began 5 days after first selection when there is a considerable increase in the mass of the transformed callus. At this stage, it is relatively easy to excise green-fluorescing cells from the larger callus mass and transfer these onto fresh medium. Growth of the fluorescing calluses/embryos was rapid. Each round of selection produced a larger, more homogeneous mass of rapidly growing, fluorescing cells. Calluses that exhibited homogeneous green fluorescence were obtained after approximately 20 days of repeated selection. The homogeneous fluorescing calluses were continually transferred to EIM for somatic embryo formation. A transformation efficiency of 13 GFP positive cell clones per petri-dish of bombarded embryogenic callus was obtained (Table 1).

Somatic embryos regenerated from the larger masses of fluorescing calluses in EIM medium within 25 days. The time used for transgenic callus selection and fluorescing embryo regeneration is same as the process in normal tissue culture somatic embryo regeneration because there is no side effect of the antibiotic selector found in the selection and regeneration medium. The germinated embryos rooted in root induction medium in 20-30 days; young plants were potted to soil in the growth chamber. It takes about 3 months for transformed cell to develop young plants that are suitable for potting from beginning of callus bombardment. In general, it takes about 6-8 months for regeneration of transgenic young plant.

A GFP gene PCR amplification was performed to confirm integration of the *GFP* gene in those plants that were regenerated from calluses transformed with the p254EGFP construct and selected by GFP fluorescing. All ten lines that showed green fluorescence were positive for GFP PCR amplification with the non-transformed lines showing no amplification.

Greenhouse grown, GFP transgenic, and non-transformed control plants were compared for GFP expression. Light images showed that organs from both transgenic and negative control plant were healthy and showed similar greenish color. Green fluorescent images showed that all organs from transgenic plants that were identified by PCR analysis emitted strong green fluorescence; organs from the negative control plant showed red fluorescence, no green fluorescence was observed in negative controls. Detailed measurement showed that all organs from transgenic plants showed a dramatic and significant increase in the level of green fluorescence. Compared with our average green fluorescence value of 6.8 in non-transformed negative control plants, the transgenic plant showed value as high as 171, a 25X increase. GFP expression in different organs is variable, strong expression was observed in fast growing, meristematic tissues (root tip and shoot tip) (Figure 1).

Discussion

Our results showed that GFP visual selection based antibiotic-free transformation system is possible in cotton genetic transformation. The cells that expressed transient and stable GFP were sufficiently bright and it is easy to isolate the transformed green fluorescing cells from the red non-transgenic fluorescing callus. Compared to stable transformation frequency (4%) by β-glucoronidase (GUS) histochemical detection, GFP visual gene selection could produce stable transformation frequency as high as 29%. A mean number of 13 transformed cell lines per plate were obtained;_the brightness of fluorescence was maintained at full intensity during the subculture, growth, and development of somatic embryos from the cultures.

High embryogenic callus exhibited red fluorescence; we don't know from where the fluorescence comes, but the red fluorescence in mature plants is certainly from chlorophyll auto-fluorescence. During the embryo developmental stage, transgenic and non-transgenic embryos showed yellow-green fluorescent and red fluorescent separately, the yellow-green fluorescence came from interaction between green fluorescence from GFP and red fluorescence from chlorophyll. In mature plantlets, transgenics showed yellow fluorescence in stem and leaf parts and green fluorescence in root parts, this confirmed that the yellow\yellow-green color is from chlorophyll and GFP interaction because there is no chlorophyll in root. The same phenomenon showed in mature plant organs; green fluorescence observed in meristematic organs: roots and shoots; yellow\yellow-green images showed in more mature organs like stems and leaves. The use of an appropriate yellow or orange filter to block the emitted red fluorescence showed the transformed plants expressing green fluorescence (Zhu et al. 2004).

In conclusion, an efficient antibiotic free transformation system is established in cotton, this system is based on high embryogenic callus bombardment transformation and GFP visual selection.

References

Csaikl U.M., Bastian H., Brettschneider R., Gauch S., Meir A., Schauerte M., Scholz F., Sperisen C., Vornam B. and Ziegenhagen B. (1998) Comparative analysis of different DNA extraction protocols: A fast, universal maxi-preparation of high quality plant DNA for genetic evaluation and phylogenetic studies. Plant Mol Biol Rep 16:69-86

Fleming G.H., Olivares-Fuster O., Fatta Del-Bosco S., and Grosser J.W. (2000) An alternative method for the genetic transformation of sweet orange. In Vitro Cell. Dev. Biol.-Plant. 36:450-455

Jordan M.C. (2000) Green fluorescent protein as a visual marker for wheat transformation. Plant Cell Rep 19:1069-1075

Murashige T. and Skoog F. (1962) A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol Plant 15:473–497

Puchta H. (2003) Marker-free transgenic plants. Plant Cell, Tissue and Organ Culture. 74:123-134.

Sakhanokho H.F., Ozias-Akins P., May O.L. and Chee P.W. (2004) Induction of somatic embryogenesis and plant regeneration in select Georgia and Pee Dee cotton (*Gossypium hirsutum* L.) lines. Crop Science 44:2199-2205

Stewart Jr. C.N. (2001) The utility of green fluorescent protein in transgenic plants. Plant Cell Rep 20:376-382

Wilkins T.A., Mishra R., and Trolinder N.L. (2004) *Agrobacterium*-mediated transformation and regeneration of cotton. Food, Agriculture & Environment 2(1): 179-187

Zhu Y.J., Agbayani R., and Moore P.H. (2004) Green fluorescent protein as a visual selection marker for papaya (*Carica papaya* L.) transformation. Plant Cell Rep 22: 660-667

Table 1. Transgenic cotton obtained from GFP visual selection

Experiment number	Mean of transient GFP expression dot (two days)	Mean of stable GFP expression dot (seven days)	Mean of GFP and PCR positive lines (callus or somatic embryo)
I	847.7 ± 67.3963	265.0 ± 45.9086	11.0 ± 2.6077
II	1003.2 ± 125.3211	285.5 ± 37.8669	13.3 ± 2.5033
III	1312.3 ± 311.0618	367.3 ± 37.8876	14.5 ± 1.8708

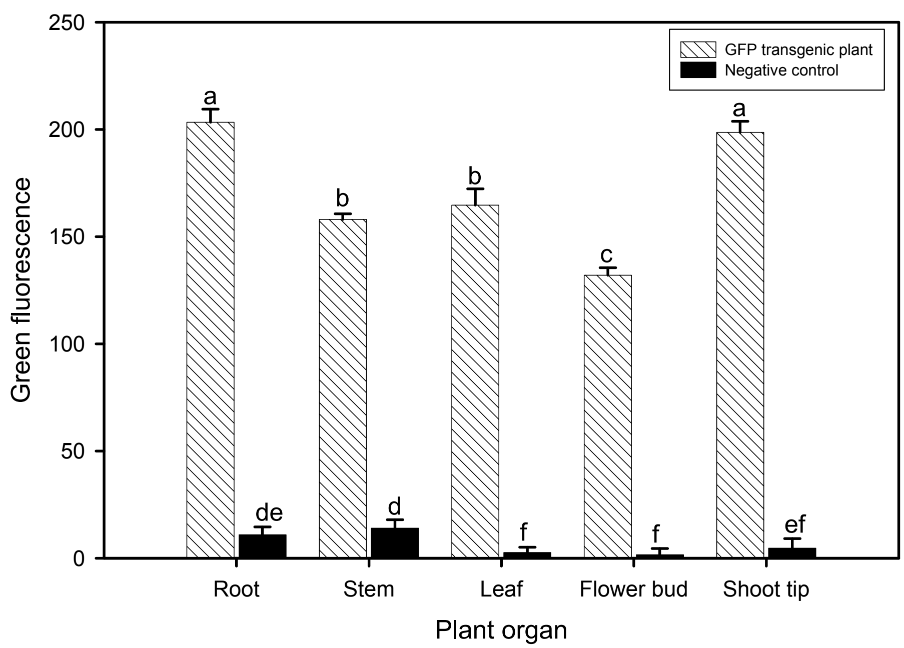

Figure 1. GFP expression in different organs of transgenic plant. GFP expression is significantly high in transgenic plants in all organ compared to expression in negative control plants

CONTROLLING GLYPHOSATE-RESISTANT PALMER AMARANTH IN LIBERTY LINK COTTON

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Introduction

With the 2005 confirmation of glyphosate-resistant Palmer amaranth in Georgia, new management strategies must be implemented to prevent this weed from causing significant economic hardships on Georgia cotton producers. One possible management program includes the use of Liberty Link Cotton cultivars. With this genetically modified crop being commercially available, cotton producers have a tool (Ignite 280) that may be used as an over-the-top postemergence (POST) application capable of controlling small Palmer amaranth.

Materials and Methods

A study was conducted in Macon Co., Georgia in 2006 to evaluate Liberty Link weed control systems for the management of glyphosate-resistant Palmer amaranth. The site had a loamy sand with 2% organic matter and pH of 6.3. Liberty Link 988 BRR cotton was hill dropped on May 1st, 2006 with 2 seeds per 8 inch of row on 36 inch row spacing. Plots were 4 rows by 25 ft long and were prepared with conventional tillage practices. Treatments were organized into a randomized complete block design with four replications. All treatments included a layby application of MSMA (2.7 pt/A) + Direx (2 pt/A) + NIS (0.25% v/v) with individual treatment information being shown in Table 1. PRE applications were made on the day of planting, while POST 1, POST 2, and POST 3 applications were made on May 28th, June 1st, and June 29th to 3- to 4-, 4- to 5-, and 11-lf cotton, respectively. Layby applications were made to 14-lf cotton on July 13th. At the time of application, Palmer amaranth was not emerged, 2.5, 5, up to 10, and up to 20 inches for the PRE, POST 1, POST 2, POST 3, and layby applications, respectively.

Results and Discussion

Ignite 280 at 29 oz/A applied sequentially to 3- to 4-lf and 11-lf cotton followed by (fb) the layby controlled 2 inch Palmer amaranth 74% late in the season with seed cotton yield of 681 lbs/A (Table 1). Delaying the 3- to 4-lf application of Ignite by 3 days allowed the Palmer amaranth to increase in size to 5 inches resulting in 0% control and cotton that was unable to be harvested.

The addition of Prowl H_2O PRE to the Ignite POST program beginning with 3- to 4-lf cotton, increased Palmer amaranth control to 89% and seed cotton yield to 1256 lbs/A (Table 1). Similar results were observed for control (88%) and seed cotton yield (1283 lbs/A) when the second application of Ignite was replaced with the addition of Dual Magnum to the initial Ignite application applied to 3- to 4-lf cotton.

Prowl H_2O PRE fb Ignite POST at 23 or 29 oz/A applied to 2 inch Palmer amaranth fb the layby provided 75 to 77% control with seed cotton yield of 904 to 913 lbs/A (Table 1). Prowl H_2O PRE fb Ignite at 23 oz/A plus Staple LX at 1.7 oz/A POST and the layby provided 76% control with seed cotton yield of 915 lbs/A. The addition of Staple LX did not improve control which may be a result of this Palmer amaranth population not being susceptible to ALS-herbicides.

The addition of Reflex at 1 pt/A or Cotoran at 2.5 pt/A to Prowl H_2O PRE fb Ignite POST and the layby increased Palmer amaranth control to 94% and seed cotton yield to at least 1196 lbs/A (Table 1). There was no benefit observed to Palmer amaranth control or seed cotton yield with the addition of Staple LX or Dual Magnum to these programs.

Conclusions

Our results suggest that Liberty Link weed management systems can be effective in controlling glyphosate-resistant Palmer amaranth, however, success of these programs hinge on the timely application of Ignite to Palmer amaranth that is 2 inches or less in height. A successful program must include a yellow herbicide plus an additional at-plant residual herbicide (i.e. Reflex, Cotoran, or Direx) PRE fb by two applications of Ignite POST or Ignite plus Dual Magnum POST fb an effective layby such as MSMA plus Direx, Valor, Layby Pro, or Suprend. Staple can also be added to the POST Ignite application in sites that do not contain ALS-resistance.

Table 1. Palmer amaranth control and seed cotton yield with Liberty Link weed management systems.

	Herbicide treatment[a]				Palmer control[bc]	Seed cotton yield
	PRE	POST 1	POST 2	POST 3		
		3 to 4-leaf cotton	4 to 5-leaf cotton	11-leaf cotton	%	lbs/A
1		Ignite 280 (29 oz)		Ignite 280 (29 oz)	74 d	681 b
2			Ignite 280 (29 oz)	Ignite 280 (29 oz)	0 e	0 c
3	Prowl H_2O	Ignite 280 (23 oz)		Ignite 280 (23 oz)	89 bc	1256 a
4	Prowl H_2O	Ignite 280 (23 oz) Dual Magnum			88 c	1283 a
5	Prowl H_2O	Ignite 280 (23 oz)			77 d	904 b
6	Prowl H_2O	Ignite 280 (29 oz)			75 d	913 b
7	Prowl H_2O	Ignite 280 (23 oz) Staple LX			76 d	915 b
8	Prowl H_2O Reflex	Ignite 280 (23 oz)			95 abc	1196 a
9	Prowl H_2O Reflex	Ignite 280 (23 oz) Staple LX			98 ab	1267 a
10	Prowl H_2O Reflex	Ignite 280 (23 oz) Dual Magnum			98 ab	1269 a
11	Prowl H_2O Cotoran	Ignite 280 (23 oz)			99 a	1231 a
12	Prowl H_2O Cotoran	Ignite 280 (23 oz) Staple LX			98 ab	1314 a
13	Prowl H_2O Cotoran	Ignite 280 (23 oz) Dual Magnum			94 abc	1303 a

[a] Cotoran = 2.5 pt/A, Dual Magnum = 1 pt/A, Ignite 280 = 23 or 29 fl oz/A, Prowl H_2O = 2 pt/A, Reflex = 1 pt/A, Staple LX = 1.7 fl oz/A. Treatments included a layby application of MSMA (2.7 pt/A) + Direx (2 pt/A) + NIS (0.25% v/v).
[b] Visual ratings 30 days before harvest on a 0 to 100 scale where 0 = no weed control and 100 = weed death.
[c] Values within a column with a common letter are similar based on statistical analysis by Fisher's protected LSD.

PHYSIOLOGICAL RESPONSE OF GLYPHOSATE RESISTANT PALMER AMARANTH.

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Introduction

Palmer amaranth is among the three most troublesome weeds in Georgia cotton, peanut (*Arachis hypogaea* L.), and soybean [*Glycine max* (L.) Merr.] (Webster 2005). It is presently the most common *Amaranthus* species in Georgia agronomic crops, which is likely in response to its competitiveness and aggressive growth habit and prolific seed production.

Since commercialization of glyphosate-resistant cotton in 1997, some Georgia growers have produced this cotton in a monoculture system and have relied exclusively on glyphosate applied multiple times each season to manage Palmer amaranth. Glyphosate resistant Palmer amaranth has been confirmed in four counties in Georgia. Research is being conducted to develop better management strategies and to understand the mechanisms of glyphosate-resistant Palmer amaranth spread. The objectives of this research were as compare physiological parameters (growth, photosynthetic assimilation rates) of glyphosate-resistant compared to the glyphosate-susceptible biotype.

Materials and Methods

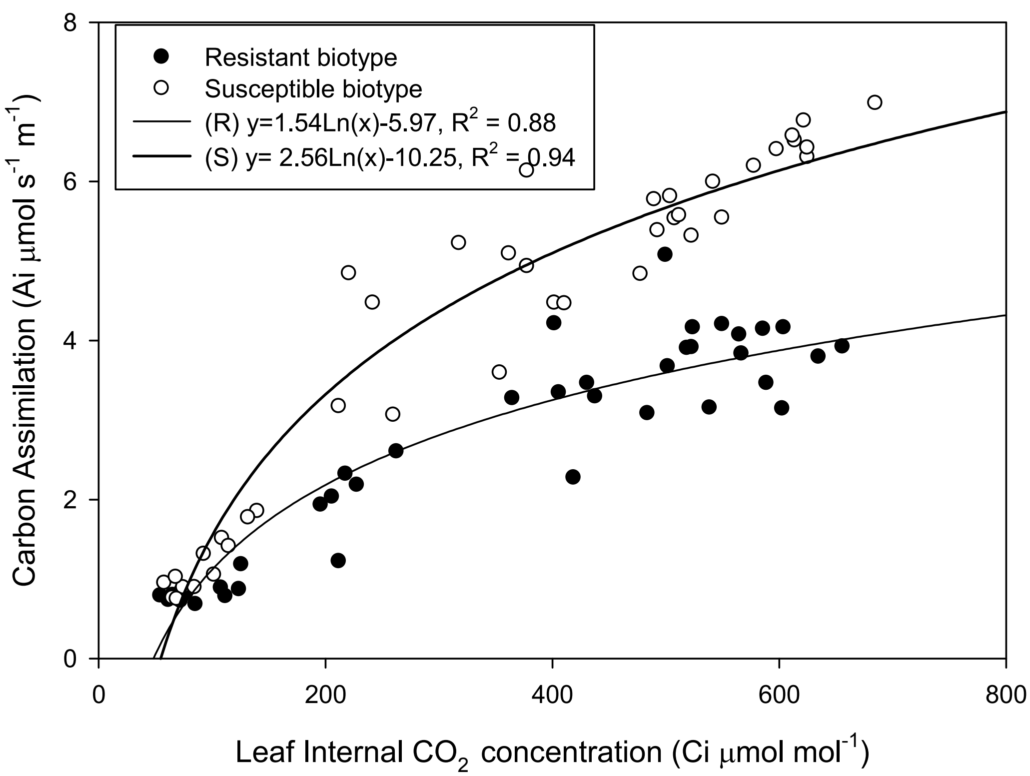
Mature seeds from a single female Palmer amaranth plant surviving three glyphosate (0.84 kg ha^{-1}) applications were collected at one of the previously described Macon County, Georgia sites in the fall of 2004. The seeds (F1 generation) were hand-cleaned and stored in a refrigerator at 1 C until use. Seeds from a known glyphosate-susceptible population of Palmer amaranth were collected from the University of Georgia Ponder Farm Research Station in Worth County and stored in a similar manner.

Plant height, branch structure, photosynthetic rate, and chlorophyll meter measurements were taken from glyphosate-resistant Palmer amaranth exposed to glyphosate (GR_{50} = 4.7 kg ai/ha). Gas exchange measurements using LI-COR LI-6400 to compare the relative gas exchange efficiencies of resistant and susceptible Palmer amaranth at seven PAR levels were fit to logarithmic curves. A randomized complete block design was used for each study with three replicates. Studies were repeated in time.

Results and Discussion

Chlorophyll content taken by a SPAD meter and photosystem I activity showed no discernible relationship to glyphosate rate. In glyphosate-resistant Palmer amaranth there were no significant differences in branching observed except at the two highest rates, which were lethal. Greenhouse studies showed similar results with glyphosate-resistant Palmer amaranth, and a comparison between R- and S- biotypes measurements taken weekly until 42 days after emergence revealed growth rates of both biotypes to fit linear regressions with correlation coefficients of 0.99 and 0.97, respectively, and a 10.88% greater slope for the S-biotype. Gas exchange measurements to compare the relative gas exchange efficiencies of resistant and susceptible Palmer amaranth at seven PAR levels were fit to logarithmic curves (Figure 1). The S-biotype assimilated carbon at a statistically significant higher rate than the R-biotype. These studies indicate that the glyphosate-resistant Palmer amaranth may not be as physiologically competitive as the suceptible biotype.

Photosynthetic Carbon Assimilation



Webster, T. M. 2005. Weed Survey-Southern States: Broadleaf Crops Subsection. Proc. South. Weed Sci. Soc. 58:291-304.

INFLUENCE OF CONSERVATION TILLAGE PRACTICES ON HAZARD FOR THRIPS INFESTATIONS IN COTTON

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Introduction

Conservation tillage practices for field crops like cotton have increased greatly. Reduced tillage changes the cropping environment and can influence risks for different pest infestations in a positive, negative, or neutral manner as compared to conventional tillage (All 1989). More than a decade ago we noted that thrips (mostly tobacco thrips, *Frankiniella fusca* (Hinds)) infestations in seedling cotton were reduced in conservation tillage systems (All et al. 1994) as compared to conventional tillage, and this observation has been verified in many experiments with cotton. Wheat and crimson clover are two cover crops that may influence hazard for thrips infestations in conservation tillage cotton. These cover crops are killed with herbicides prior to planting cotton (burndown) and timing of burndown application may influence whether resident thrips populations have suitable harborage before cotton seedlings germinate. Unfortunately, conservation tillage does not eliminate economic damage on cotton at the same level as systemic insecticides such as Temik™ (aldicarb), which controls thrips for 45 days or more. Cotton is planted in rows at a 0.15 to 0.3 m “hill” spacing, and the rate of Temik™ required for thrips control in conventional tillage cotton can be reduced if the granules are applied by precision placement in cotton hills as compared to the conventional application method of dribbling granules along the seed furrow (Lohmeyer and All 2003). Recently insecticide seed treatments such as Cruiser™ (thiomethoxam) have shown promise for thrips control in cotton. The objectives of the study were to evaluate the effect of cover crop, burndown timing, and insecticide treatment individually and in combination on hazard for economic damage by thrips in conservation tillage cotton.

Materials and Methods

Two field tests were conducted during 2006 at the University of Georgia (UGA) Plant Sciences Farm near Athens and at the UGA Southeastern Branch Research and Education Center (SEB) in Burke County. Fields approximately 1.5 Ha in size were separated into 12 blocks, four blocks each were planted with wheat or clover or left fallow in November 2005. In May 2006 each block of wheat and clover was separated into equal sized, randomized plots for application of one of the following glyphosate (broadcast application @ 0.83 kg a.i./Ha) burndown regimes: 30 days, 15 days, or 5 days before planting cotton. The fallow blocks were plowed at least three times beginning 15 days before planting so that a smooth seed bed was present for conventional tillage treatments. Four row plots of insecticide treatment (and a non-chemical check) were randomized in each burndown plot. The insecticide treatments were Cruiser™ treated seed at (0.34 mg a.i./seed), in-furrow application of Temik™ (0.6 kg a.i./Ha), and precision placement of Temik™ (0.1 kg a.i./Ha). The cotton variety used in the test was DP543BIIRR which was tolerant to glyphosate, and the herbicide was used as needed for weed control during the season following thrips sampling. Other standard agronomic practices for cotton at the locations were applied at appropriate times. The thrips were sampled on the cotton seedlings at 7, 14, and 30 days after planting by immersing 10 randomly selected seedlings in a specimen cup containing alcohol. Thrips were counted and identified using a dissecting microscope. Data analysis utilized SAS (Statistical Analysis System) procedures for ANOVA at $P<0.05$ considering experiment design with mean separation using Tukey's Studentized Range Test.

Results and Discussion

Table 1 shows data from sampling dates at 7 (seedlings had small cotyledon leaves), 14 (plants had large cotyledon leaves), and 30 (plants had large cotyledon leaves and a small vegetative branch leaf) days after planting at Athens and Midville. The Midville field was subject to very dry conditions during the season, whereas Athens cotton had adequate moisture. The data demonstrates that thrips populations were significantly greater on cotton in conservation tillage (overall) as compared to conventional tillage. Adult populations were over 98% tobacco thrips at both locations. Adult counts predominated in the 7-day sample, but immatures were more numerous in the other sample dates. The cover crops in conservation tillage of wheat and crimson clover had statistically similar populations during the sampling periods at both locations (Table 2). Significantly higher numbers of thrips were present on cotton 7 and 14 days after planting in conservation tillage with crimson clover cover at Athens (Table 3). Significantly higher thrips numbers in the 30 day crimson clover burndown timing treatments occurred at the Midville location. At Athens, most of the insecticide treatments produced significant reduction in thrips numbers during the 30 days of sampling (Table 4). The higher rate of Temik™ (0.6 kg a.i./Ha) applied in-furrow and Cruiser™ treated seed produced better control as compared to the lower rate of Temik™ (0.1 kg a.i./Ha) that was precision-applied in seed hills. However, an additive effect of conservation tillage and Temik™ precision placement was indicated in the wheat cover crop plots in all 3 burndown timing regimes at both locations.

References

All, J. N. 1989. Importance of designating prevention and suppression control strategies for insect pest management programs in conservation tillage. pp. 1-5, In: I. O. Teare, E. Brown, and C. A. Trimble (eds.), Conservation Farming, Integrated Pest Management. Proc. Southern Conservation Tillage Conf. Univ. Fla. Press, Sp. Bull. 89-91. 86 pp.

All, J. N., P. M. Roberts, G. Langdale, and W. K. Vencill. 1994. Interaction of cover crop, tillage and insecticide on thrips populations in seedling cotton. Proc. 1993 Beltwide Cotton Conference 3: 1066-1067.

Lohmeyer, K. H., J. N. All, P. M. Roberts, and P. Bush. 2003. Precision application of aldicarb to enhance efficiency of thrips (Thysanoptera: Thripidae) management in cotton. J. Econ Entomol. 96: 748-754.

Acknowledgements

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Table 1. Effect of tillage practice on thrips populations on seedling cotton in two locations.

Tillage Practice	Location and Days after Planting					
	Athens			Midville		
	7	14	30	7	14	30
	# Thrips / Plant					
Conservation	1.8 a	0.9 a	0.5 a	0.9 a	2.8 a	4.1 a
Conventional	3.9 b	3.6 b	1.0 b	5.7 b	7.6 b	15.3 b

Means within the same columns with the same letter are not significantly different, Tukey (P<0.05).

Table 2. Effect of cover crop in conservation tillage treatments vs conventional tillage on thrips populations in two locations.

Cover Crop	Location and Days after Planting					
	Athens			Midville		
	7	14	30	7	14	30
	# Thrips / Plant					
Wheat	0.7 a	2.7 a	0.6 a	0.7 a	2.7 a	4.2 a
Clover	1.1 a	2.9 a	0.5 a	1.1 a	2.9 a	4.0 a
Conv. Till	5.7 b	7.6 b	0.9 a	5.7 b	7.6 b	15.3 b

Means within the same columns with the same letter are not significantly different, Tukey (P<0.05).

Table 3. Effect of burndown (glyphosate) timing on total thrips populations at two locations.

Burndown Timing and Cover Crop	Location and Days after Planting							
	Athens				Midville			
	7	14	30	Total	7	14	30	Total
	# Thrips / Plant							
Conservation Till								
Clover – 30 days	3.4 a	3.8 a	0.8 a	8.0	1.4 b	3.3 b	6.7 a	11.4
Clover – 15 days	1.5 ab	1.4 ab	0.5 a	3.4	0.4 b	2.2 b	2.4 b	5.0
Clover – 5 days	0.0 b	0.8 b	0.3 a	1.1	1.3 b	3.1 b	2.8 b	7.2
Wheat – 30 days	0.9 b	1.0 ab	0.8 a	2.7	0.7 b	3.7 b	5.4 a	9.8
Wheat – 15 days	1.2 ab	0.6 b	0.6 a	2.4	0.3 b	2.4 b	2.8 b	5.5
Wheat – 5 days	0.3 b	0.3 b	0.3 a	0.9	1.1 b	2.1 b	4.4 ab	7.6
Conventional Till	3.9 a	3.6 a	1.0 a	8.5	5.7 a	7.6 a	15.3 c	28.6

Means within the same columns with the same letter are not significantly different, Tukey ($P<0.05$).

Table 4. Effect of insecticide treatments on total thrips populations in two locations.

Burndown Timing and Cover Crop	Athens				Midville			
	Temik™ In-furrow	Temik™ PP	Cruiser™	Check	Temik™ In-furrow	Temik™ PP	Cruiser™	Check
	Total # Thrips / Plant During 30 Days							
Conservation Till								
Clover – 30 days	0.6 a	3.0 ab	1.3 a	8.2 b	3.1 a	5.8 ab	3.1 a	7.8 b
Clover – 15 days	0.4 a	1.8 ab	0.7 a	4.7 b	2.4 a	2.5 a	1.4 a	4.1 a
Clover – 5 days	0.4 a	1.3 a	0.3 a	2.1 a	3.5 a	4.5 ab	2.4 a	7.5 ab
Wheat – 30 days	0.4 a	0.7 a	0.8 a	2.8 b	1.4 a	3.6 a	2.1 a	4.2 a
Wheat – 15 days	0.6 a	0.8 a	0.8a	2.5 b	1.9 a	3.2 ab	0.9 a	4.3 b
Wheat – 5 days	0.2 a	0.4 a	0.5 a	0.8 a	3.4 a	6.4 ab	2.3 a	7.6 b
Conventional Till	0.6 a	2.4 ab	0.9 a	8.5 b	6.5 a	17.3 b	7.6 a	21.9 b

Means across rows at each location with the same letter are not significantly different, Tukey ($P<0.05$).

PERFORMANCE OF INSECTICIDES WITH DIFFERENT PHYSIOLOGICAL TARGETING OF BOLLWORM IN NONBT COTTON

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Introduction

Insecticides remain important pest management tools for profitable production of both transgenic *Bt* (*Bacillus thuringiensis*) and non *Bt* cotton. Currently there are several insecticides that are available for cotton pest managers which have different physiological targeting mechanisms for insects. Interchanging insecticides with different modes of action in spray programs during the season could help prevent resistance. This research was done at the Southeastern Branch Research and Education Center near Midville where we have conducted insecticide screening trials for 30 years. The data with organophosphate (chlorpyrifos, Lorsban^{TM}), carbamate (thiodicarb, Larvin^{TM}) and the pyrethroid (lambda cyhalothrin, Karate^{TM}) insecticides is additive to our comparative database of the performance of these chemical types during that period. These standards were compared to newer insecticides rynaxypur (Coragen, Altacer, (proposed trade names)), spinosad (Tracer^{TM}), indoxacarb (Steward^{TM}), and novaluron (Diamond^{TM}), all of which have different modes of toxicity. The primary target site of action of organophosphates and carbamates is inhibition of acetylcholine esterase in neural synapses and for pyrethroids it is modulation of sodium channels on neural membranes. Indoxacarb also disturbs sodium channels, but not like pyrethroids, and cross resistance between the two insecticide classes does not occur. Spinosad affects insect nerves by selective inhibition of nicotinic acetylcholine receptors at neural junctions. Novaluron (Diamond^{TM}) is a chitin (an essential constituent of insect cuticle) biosythesis inhibitor (All and Treacy 2006). The Heliothine population (bollworm and budworm) at Midville usually has more than 50% bollworm during the season and insecticide evaluations at this location are more reflective of cotton infestations in eastern Georgia and the Carolinas.

Methods

The cotton was DP494R and four row plots (with one buffer row separating each plot) were established that were 40 feet long with 38 inch row width, 15 foot alleys arranged in a randomized complete block design replicated four times. Plots were sprayed with a high cycle sprayer equipped with a four row boom using three TX 4 spray nozzles/row. The sprayer traveled at 3 mph and applied 10 gallons per acre finished spray volume. Sprays were initiated when 8% squares showed damage in the field on July 7 and work continued on July 11, 19, 25, August 1 and 9. Adult bollworm and budworm populations were monitored weekly using pheromone traps (Figure 1). Fruiting structures in plots were monitored for damage by selecting five plants in the two middle rows of each plot and examining all fruiting structures in the upper half of the plant for damage and larvae. The two middle rows of each plot were harvested with a cotton picker on November 20.

Results and Discussion

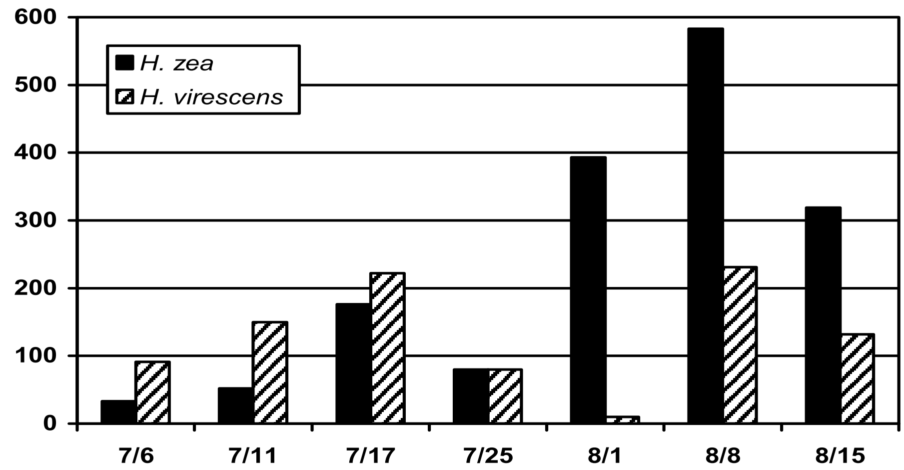
With the exception of Lorsban™ and the Diamond™ + Bidrin™ treatments all of the insecticides produced control of infestations during most of the season (Table 1). Only Tracer™ and rynaxypur kept infestations below 5% throughout the season. Larvin™ and Karate™ performed well during the season and efficacy was generally similar to performance over many years at the Midville Station. Diamond™, a slow acting chitin synthesis inhibitor, performed moderately well during the season especially when combined with Karate™. Highest yields in the test were associated with Karate™ (Karate™ alone and the combo treatments with Diamond™). Rynaxypur, Steward™, Tracer™ and Larvin™ treatments all had higher yield than the untreated check.

References

All, J. N. and M. F. Treacy, eds. 2006. Use and Management of Insecticides, Acaricides, and Transgenic Crops. APS Press. St. Paul, MN. 148 pp.

Table 1. Cotton insecticide screening trial, Midville, GA

		Percent Fruit Damage By Date					Yield Lbs/A
Treatment	Rate (#a.i./A)	7/11	7/17	7/25	8/1	8/8	10/20
Check		12.4 a	11.1 a	41.4 a	55.2 a	16.7 a	2557 c
Diamond™	0.058	0.8 b	4.7 abc	6.8 b	7.8 bc	3.2 b	3550 abc
Diamond™+Bidrin™	0.058 + 0.3	2.1 b	7.4 abc	12.2 b	16.0 bc	3.8 b	3722 ab
Diamond™+Karate™	0.039 + 0.025	2.7 b	2.0 bc	3.5 b	7.0 c	0.7 b	4044 a
Diamond™+Karate™	0.058 + 0.025	2.9 b	0.7 c	11.7 b	3.8 c	0.0 b	4340 a
Karate™	0.025	2.6 b	1.5 bc	8.8 b	4.7 c	3.6 b	4134 a
Larvin™	0.53	5.0 ab	4.4 abc	7.1 b	8.8 bc	4.9 ab	3868 ab
Lorsban™	1.0	2.0 b	8.1 ab	20.5 ab	25.2 b	11.6 ab	2892 bc
Rynaxypyr	0.088	4.4 ab	0.8 c	0.7 b	0.6 c	0.0 b	3859 ab
Steward™	0.088	2.8 b	0.6 c	10.5 b	6.9 c	0.8 b	3760 ab
Tracer™	0.062	2.1 b	0.6 c	1.4 b	2.0 c	1.5 b	3799 ab



2006 pheromone trap captures of male moths of *Helicoverpa zea* and *Heliothis virescens* at the Southeastern Branch research and Education Center near Midville GA.

WIDESTRIKE™ PLANT INCORPORATED PROTECTANT TRAIT EFFICACY ON HELIOTHINE SPECIES

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Introduction

WideStrike™ *Insect Protection* gene technology is a *Bt* pyramided trait (Cry 1F and Cry 1Ac) incorporated into certain cotton varieties produced by Phytogen Seed Company LLC and is known to have good efficacy against budworm and bollworm. Widestrike™ cotton has been evaluated since 2003 at the Southeastern Branch Research and Education Center (SEB) near Midville and the present study conducted in 2006 was a continued assessment of WideStike™ field performance at that location.

Methods

Treatment plots were planted with a 4-row John Deere® vacuum planter in 40-foot long x 38-inch wide rows arranged in a randomized complete block experimental design with 15-foot alleys separating blocks, replicated four times. Temik® 15G @ 3.5 lbs/acre was applied in the seed furrow of all cotton at planting for early season thrips control, but no additional insecticide applications were made during the season. Normal agronomic practices of fertilization, weed control, and irrigation used for cotton at the SEB were used in the tests. The two center rows of each plot were harvested with a mechanical spindle picker and weighed for assessment of yield.

Surveys of insect infestation and plant injury were done weekly or at other specified intervals during the season after cotton fruiting had begun. Plant terminals and two each of squares, flowers, and bolls on 20 plants selected at random in the center two rows of each plot were examined for injury and the presence of larvae. Hartstack-style traps were located near the test fields, one each baited with sex pheromone of *H. zea* and *Heliothis virescens* (Fabricius). Moth captures were monitored weekly during the season. Data analysis utilized SAS (Statistical Analysis System) for ANOVA at $P<0.05$ with mean separation using LSD for percent damage.

Results and Discussion

Breeding lines expressing the WideStrike™ plant incorporated protectant trait were PHY 485 WRF, PHY 480 WR, PHY 470 WR, PHY 370 WR, and two lines that did not have the two *Bt* transgenes were PHY 425 RF and PHY 310 R. No foliar insecticides were used in this test during the season. Table 1 shows overall infestation of fruiting structures during the season and yield of the different cotton lines. For comparison to non*Bt* cotton sprayed with various insecticides during the season, refer to Table 1 of the report titled "Performance of Insecticides with Different Physiological Targeting of Bollworm In Non*Bt* Cotton" published in this bulletin. The pheromone trap captures of male bollworm and budworm moths published in the above paper would also apply to the Widestrike™ field. The two cotton fields were located adjacent to each other (the nonBt cotton in the adjacent field was DP 494R). The data shows that all the breeding lines expressing the Widestrike™ *Bt* toxins controlled infestations as well as most of the insecticide treatments in the adjacent field.

Tables 2, 3, and 4 show infestation data on different developmental stages (squares, flowering squares, and bolls, respectively) of cotton fruiting structures, and the data indicates that most damage in Widestrike™ lines occurred with squares. Infestation of flowering squares and bolls was low throughout the season and was substantially less than the two non*Bt* lines on 7/25, 8/1, and 8/8. Terminal damage was generally reduced in the Widestrike™ lines compared to the two non*Bt* cotton types, but on 7/25 and 8/1, considerable % terminal injury occurred in Widestrike™. Overall, the results confirm previous research demonstrating that Widestrike™ cotton produces good season-long control of heliothine infestations.

Table 1. Heliothine infestation of Widestrike™ cotton fruiting structures, Midville, GA

	% Fruiting Structures Damaged by Date[1]						Yield
	7/11	7/17	7/25	8/1	8/8	8/15	Lbs[2]
PHY 485 WRF[3]	0.4 c	1.5 c	3.3 b	3.3 b	5.8 bc	2.3 a	4228 ab
PHY 480 WR	0.0 c	1.0 c	1.5 b	4.0 b	3.3 c	0.6 a	4254 a
PHY 470 WR	0.4 c	2.7 c	3.5 b	5.2 b	1.5 c	0.0 a	3743 ab
PHY 370 WR	0.6 bc	2.5 c	1.7 b	4.0 b	2.1 c	1.3 a	3691 b
PHY 425 RF	6.3 a	14.8 a	19.6 a	40.2 a	13.8 b	1.9 a	2973 c
PHY 310 R	2.5 b	7.9 b	23.5 a	42.1 a	25.2 a	1.9 a	3145 c

[1] Means followed by the same letter in a row are not significantly different, LSD ($P < 0.05$).

[2] Lbs per acre seed cotton.

[3] PHY 485 WRF, PHY 480 WR, PHY 470 WR, and PHY 370 WR had Widestrike™ (Cry 1F and Cry 1Ac), PHY 425 RF and PHY 310 R had no Widestrike™ Cry transgenes.

Table 2. Heliothine infestation of Widestrike™ cotton squares, Midville, GA

	% Squares Damaged by Date[1]						
	7/11	7/17	7/25	8/1	8/8	8/15	Avg.
PHY 485 WRF	0.6 c	2.5 cd	8.1 bc	7.5 b	7.5 bc	3.1 a	5.0
PHY 480 WR	0.0 c	1.9 c	3.1 c	8.8 b	2.5 bc	0.6 a	2.8
PHY 470 WR	1.3 c	7.5 bc	7.5 bc	8.8 b	1.3 c	0.0 a	4.4
PHY 370 WR	1.3 c	1.9 d	4.4 c	8.1 b	1.9 c	1.3 a	3.1
PHY 425 RF	15.6 a	35.7 a	25.0 ab	55.0 a	13.1 b	3.1 a	24.6
PHY 310 R	6.3 b	13.8 b	28.8 a	50.6 a	25.0 a	2.5 a	21.1

[1] Means followed by the same letter in a row are not significantly different, LSD (P < 0.05).

Table 3. Heliothine infestation of Widestrike™ cotton flowers, Midville, GA

	% Flowers Damaged by Date[1]						
	7/11	7/17	7/25	8/1	8/8	8/15	Avg.
PHY 485 WRF	0.6 a	0.6 a	1.9 b	1.9 b	5.6 ab	0.6 a	1.9
PHY 480 WR	0.0 a	1.3 a	1.3 b	1.9 b	3.1 b	1.3 a	1.5
PHY 470 WR	0.0 a	0.6 a	2.5 b	3.8 b	1.9 b	0.0 a	1.5
PHY 370 WR	0.6 a	2.5 a	0.0 b	2.5 b	1.9 b	1.3 a	1.5
PHY 425 RF	1.9 a	6.3 a	15.0 a	23.8 a	12.5 a	0.6 a	10.0
PHY 310 R	0.0 a	6.3 a	19.4 a	25.7 a	7.5 ab	1.9 a	10.1

[1] Means followed by the same letter in a row are not significantly different, LSD (P < 0.05).

Table 4. Heliothine infestation of Widestrike™ cotton bolls, Midville, GA

	% Bolls Damaged by Date[1]						
	7/11	7/17	7/25	8/1	8/8	8/15	Avg.
PHY 485 WRF	0.0 a	1.3 a	0.0 b	0.6 b	4.4 b	3.1 a	1.6
PHY 480 WR	0.0 a	0.0 a	0.0 b	1.3 b	4.4 b	0.0 a	0.9
PHY 470 WR	0.0 a	0.0 a	0.6 b	3.1 b	1.3 b	0.0 a	0.8
PHY 370 WR	0.0 a	3.1 a	0.6 b	1.3 b	2.5 b	1.3 a	1.5
PHY 425 RF	1.3 a	2.5 a	18.8 a	41.9 a	15.6 b	1.9 a	13.6
PHY 310 R	1.3 a	3.8 a	22.5 a	50.0 a	43.1 a	1.3 a	20.3

[1] Means followed by the same letter in a row are not significantly different, LSD (P < 0.05).

Table 5. Heliothine infestation of Widestrike™ cotton terminals, Midville, GA

	% Terminals Damaged by Date						
	7/11	7/17	7/25	8/1	8/8	8/15	Avg.
PHY 485 WRF	0.0 a	3.8 b	11.3 a	10.0 b	11.3 b	0.0 b	6.0
PHY 480 WR	0.0 a	2.5 b	12.5 a	8.8 b	5.0 b	2.5 ab	5.2
PHY 470 WR	2.5 a	6.3 b	10.0 a	21.3 ab	6.3 b	5.0 ab	8.5
PHY 370 WR	1.3 a	2.5 b	17.5 a	6.3 b	3.8 b	2.5 ab	5.6
PHY 425 RF	1.3 a	21.3 a	17.5 a	41.3 a	20.0 b	3.8 ab	17.5
PHY 310 R	2.5 a	17.5 a	23.8 a	42.5 a	41.3 a	6.3 a	22.3

[1] Means followed by the same letter in a row are not significantly different, LSD (P < 0.05).

COTTON APHID INSECTICIDE CONTROL CONSIDERATIONS

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Introduction

Cotton aphid is an annual insect pest which builds to high numbers in most Georgia cotton fields. A naturally occurring fungus, *Neozygites fresenii*, annually infects aphid populations and causes populations to crash in late June or early July. Aphids feed on plant sap, removing moisture and nutrients and are often considered a stress inducing pests.

Aphid populations were unusually long lived during 2006. The naturally occurring fungus was observed in southernmost Georgia during late June but was much slower to spread than in recent years. Perhaps the slow development of the fungus was related to low relative humidity experienced during the hot and dry conditions of June and early July. The prolonged aphid infestations have renewed interest in aphid management. Reported in this paper are results of an aphid insecticide efficacy trial conducted during 2006 and a summary of available yield data for trials which included aphid treated and untreated plots from 1998-2005.

Methods

A field trial was established on the Coastal Plain Experiment Station in Tift county Georgia to evaluate the efficacy of recommended insecticides for aphid control. Plots were 6 feet wide and 40 feet in length and arranged in a randomized complete block design with four replications. Insecticide treatments (Table 1) were applied on July 3, 2006 with a CO2 backpack sprayer calibrated to deliver 16 gpa. Aphid populations were evaluated 2, 4, 7, and 14 days after treatment (DAT) by selecting the 3rd expanded leaf below the terminal from ten randomly selected plants in each plot. The leaves were returned to the laboratory and the aphids were counted on the left half of each leaf. Data were subjected to an analysis of variance and treatment means were separated using LSD (P=0.05).

Yield and aphid population data were summarized from 23 trials conducted during 1998-2005 which included aphid treated and untreated plots. Treated plots were sprayed 1-4 times with various aphid insecticides all of which provided good control of aphids. Trial means were used as replicates and a t-test was used to compare means. The 23 trials were also segregated into categories of low to moderate aphid infestations (< 75/leaf) and high infestations (> 75/leaf) and t-test were performed on each.

Results

Aphid populations were high and long lived in this trial; populations did not crash due to the naturally occurring fungus until after July 17 (14 DAT). This allowed us to examine residual control of the various insecticides. All recommended aphid insecticides significantly reduced aphid populations at 2, 4, and 7 days after treatment compared with the untreated (Table 1). Aphid populations were significantly greater in the Carbine treatment at 2 DAT compared with other insecticides due its slower mode of action. At 4 DAT, Assail and Centric provided the greatest reduction in aphid populations and were statistically similar with Bidrin and Carbine. At 7 DAT Assail and Carbine provided the greatest reduction in aphid populations. At 14 DAT Assail, Centric, and Carbine significantly reduced aphid populations compared with the untreated. Populations were building in the Bidrin and Trimax plots at 14 DAT and were not significantly different than the untreated. In summary all treatments provided acceptable control of aphids up to 7 DAT. Assail, Centric, and Carbine tended to provide longer residual control of aphids compared with Trimax and Bidrin.

Table 1. Aphid populations 2, 4, 7, and 14 days after treatment following application of recommended aphid insecticides on July 3, 2006, Coastal Plain Experiment Station, Tift county GA 2006.

		Aphids per ½ Leaf (3rd expanded leaf below terminal)			
Treatment	Rate per Acre	2 DAT	4 DAT	7 DAT	14 DAT
Untreated	-	202 a	154 a	145 a	154 a
Assail 70 WP	0.6 ozs	29 c	34 c	37 c	39 c
Bidrin 8E	6 ozs	29 c	44 bc	60 bc	112 ab
Centric 40 WG	1.25 ozs	45 c	35 c	53 bc	66 bc
Trimax Pro	1.5 ozs	43 c	74 b	83 b	116 ab
Carbine 50 WG	1.4 ozs	73 b	50 bc	43 c	70 bc

Means followed by the same letter do not significantly differ (P=0.05).

As demonstrated in the 2006 aphid efficacy trial, insecticides are commercially available which will provide good control of aphids. However, questions still remain as to when and if insecticide treatment is economically justified. Since 1998, 23 field trials have been conducted in Georgia examining the impact of cotton aphid on yield. Mean yields were similar (prob t=0.38) in untreated plots compared with aphid treated plots, 1090 lbs and 1094 lbs lint/acre respectively. Of the 23 trials, aphid populations were low to moderate (< 75/leaf) in nine locations. In low to moderate aphid environments yields were not significantly different (prob t=0.20) but tended to be lower where insecticides were used; untreated 1120 lbs lint/are and treated 1071 lbs lint/acre. Fourteen trials were conducted in high aphid environments (> 75/leaf) and yields were significantly increased (prob t=0.01) in treated compared with untreated plots. Untreated yields were 1094 lbs lint/acre compared with 1131 lbs lint/acre in treated plots.

Cotton appears to have the ability to endure and maintain yield potential under low to moderate aphid infestations as yields were not significantly improved in treated plots. A small but statistically significant, 37 lbs lint/acre, increase in yield was observed in environments where aphids exceeded 75 per leaf in untreated plots. Additional research is needed to determine when and if control of aphids is economically warranted.

MONITORING CORN EARWORM SUSCEPTIBILITY TO PYRETHROIDS USING ADULT VIAL TESTS

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Introduction

Corn earworm (CEW) is a pest of cotton and many other cultivated crops grown in Georgia and the southeast. Corn earworms reproduce on many wild host plants and have a short generation time, about four weeks, allowing CEW populations to build up large populations relatively quickly. Corn earworms also have the capacity to disperse and move long distances in a short time period. Single gene Bt cotton provides good control of CEW but supplemental treatment with insecticide may be needed in some situations. Pyrethroid insecticides are typically viewed as the standard for control of CEW in cotton.

During recent years, susceptibility of CEW to pyrethroid insecticides has declined in some areas of the US. Reduced field control of CEW with pyrethroids in sweet corn grown in the Midwest has been measured. Elevated LD50s (the lethal dose to kill 50 percent of a population) of some CEW collections have been observed in LA and TX during recent years. During 2005, less than optimal control of CEW in some parts of southwest Georgia was observed when two or more applications of pyrethroids were applied to Bt cotton. Subsequent collections and testing of surviving CEW populations from problem fields during 2005 indicated elevated LD50s or increased tolerance to the pyrethroid cypermethrin compared with previous years (Ottens et.al. 2006).

Due to concerns relative to the susceptibility of CEW to pyrethroids, monitoring efforts on the susceptibility of CEW to pyrethroids were expanded in southwest Georgia.

Methods

Pheromone traps baited with a CEW lure were established in four southwest Georgia counties to capture moths for pyrethroid susceptibility monitoring purposes;

1. **Coastal Plain Experiment Station in Tift county**
2. **Stripling Irrigation Research park in Mitchell county**
3. **grower cooperator fields in Seminole county**
4. **grower cooperator fields in Macon county**

Traps were monitored periodically and when adequate CEW captures were attained, moths (captured the previous night) were assayed using the Adult Vial Test (AVT) procedure. AVTs were performed using 20 ml scintillation vials coated with an acetone solution of technical grade cypermethrin with dosages of 5 or 10 µg/vial and an acetone treated check. Vials were obtained from two sources, Russ Ottens at the University of Georgia and Greg Payne at West Georgia College. Individual moths were placed in treated and untreated vials and survival was checked after 24 hours. Only moths which were able to fly in a normal manner were considered alive. Percent mortality in the treated vials was corrected for mortality in the untreated. If survivorship in the untreated vials was below 80 percent, the test was discarded.

Results

Initial CEW moth captures occurred during late March and early April, but adequate numbers of moths were not collected for conducting AVTs until late April. Moth captures were high in traps during June and July but declined significantly in August and September.

Figure 1 illustrates percent survival of CEW at 5 and 10 µg/vial by date. A total of 742 moths were tested at the 5 µg/vial dose and 666 moths at the 10 µg/vial dose. Mean survival for all dates at the 5 µg/vial dose was 12.4 percent compared with 6.8 percent at the 10 µg/vial dose. Increased survivorship in treated vials suggests increased tolerance or reduced susceptibility in the field. During the last 10 days of July, survival tended to increase, especially at the 5 µg/vial dose. It is important to note that survivorship only exceeded 30 percent at the 5 µg/vial dose on four dates, late April, early May, and twice in late July. During 2005, survival at the 5 µg/vial dose was 31 and 44 percent near known problem fields.

Mean survivorship at the 5 µg/vial dose is illustrated in Figure 2 for succeeding periods of four and two weeks. Mean survival was 20 percent during April and the first half of May. Moths tested during this time were likely moths from pupae which had overwintered. From mid-May to mid-July, survivorship was 8-10 percent. Populations tested during this time were from the first field generation. These data suggest that tolerance from the previous year is being diluted during May and June (i.e. little pyrethroid use during this time and thus no selection of tolerant individuals). However during the last two weeks of July survivorship increased to 19 percent. Pyrethroid use was more common during mid and late July and the increase in survivorship is likely a result of selecting more tolerant individuals. Survivorship tended to decline during August and September, perhaps due to a reduction in pyrethroid use as populations for most insect pests were unusually low.

Results from AVTs conducted during 2006 did not indicate any major problems with CEW tolerance or resistance to pyrethroid insecticides. However, these data do suggests that some level of tolerance exists in CEW populations and that selection for those tolerant individuals is occurring. County agents, consultants, growers, and the industry as a whole should monitor performance of pyrethroids closely. Pyrethroids continue to be the treatment of choice for control of CEW, but should be used at high rates.

Figure 1. Percent survival by date of corn earworm moths 24 hours after exposure to cypermethrin in Adult Vial Tests conducted in Tift, Mitchell, Seminole, and Macon counties, Georgia, 2005.

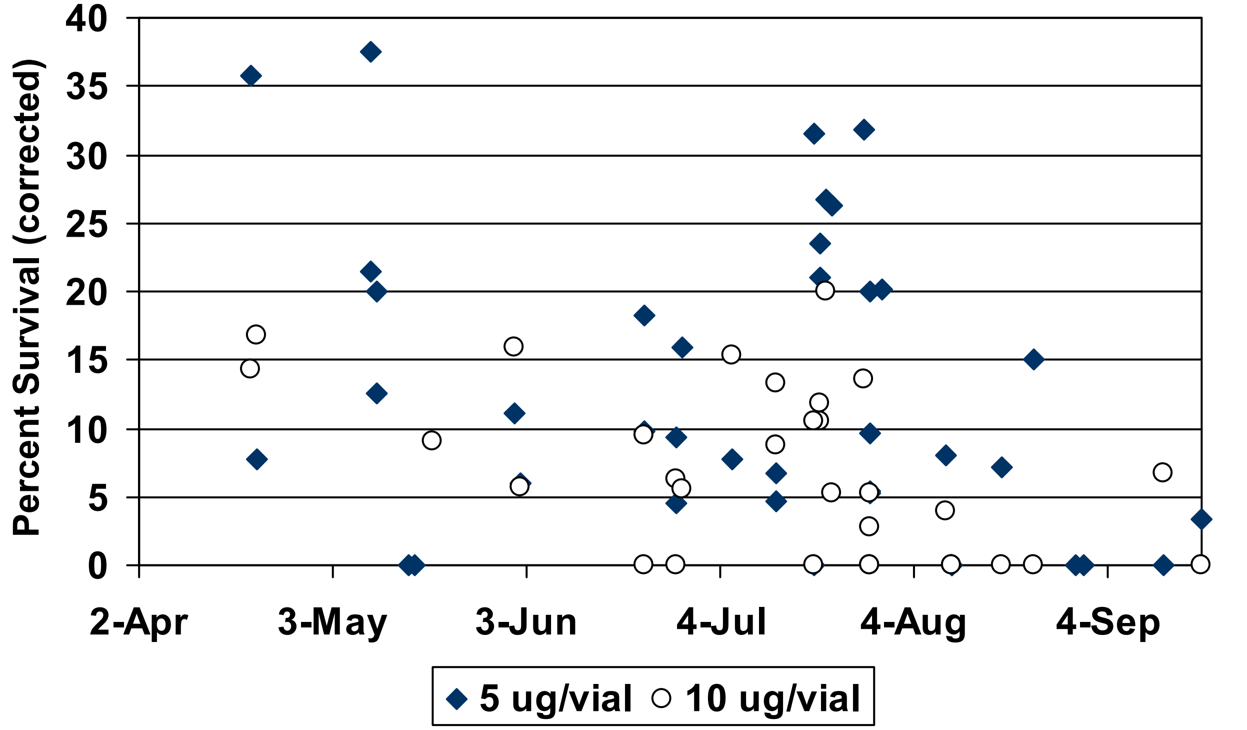
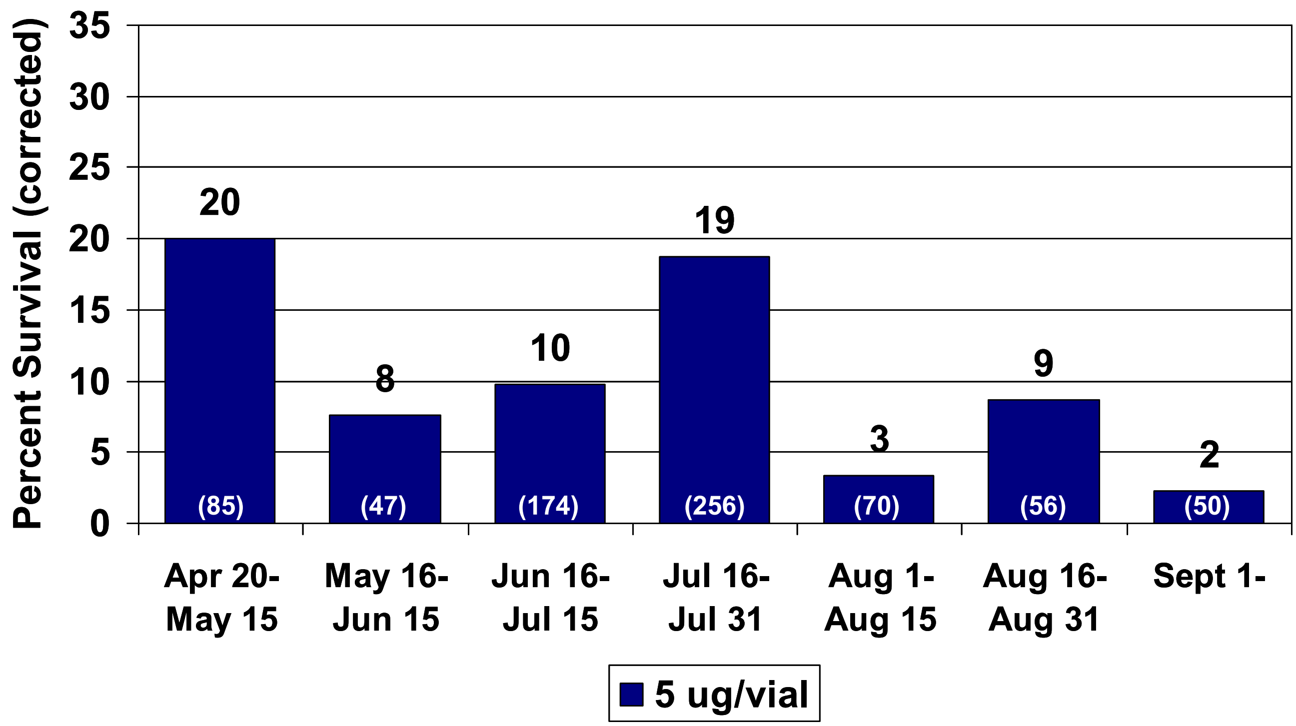


Figure 2. Percent survival 24 hours after exposure and number of corn earworm moths tested (x) in Adult Vial Test using 5 µg/vial of cypermethrin, Tift, Mitchell, Seminole, and Macon counties, Georgia, 2005.



NITROGEN EFFECTS ON BIOLOGICAL CONTROL IN COTTON

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Introduction

The availability of Bt-transgenic cotton varieties and other pesticide-incorporated plants (PIPs) has been a great boon for growers in managing their caterpillar pests. However, other pests have emerged in the wake of widespread adoption of insecticidal-transgenic cotton. Stink bugs have become a serious problem with the reduced use of broad-spectrum insecticides. Further, there are caterpillar pests that remain problematic in cotton, even on Bt-transgenic varieties (particularly armyworms, but also including bollworms). There is a continued need to fit biological control into management systems to help growers reduce pest management costs and to enhance sustainability of cotton production systems. However, the factors limiting effectiveness of natural enemies in cotton are still unclear. In this project we are examining one of those factors – nitrogen levels – to assess if and how it affects the activity of natural enemies in the field and laboratory.

It has become apparent that the plant plays a critical role in the efficacy of numerous biological control agents in agriculture (e.g., Boethel and Eikenbary 1986, Hare 2002, Turlings et al. 2002). An extensive body of literature asserts the importance of the plant as a source of critical signals for a number of natural enemies; however, the role of the plant's nutritional status in the effectiveness of natural enemies is poorly understood, with only a few studies having been conducted to date. For example, increased foliar nitrogen in collards was directly related to the proportion of female offspring produced by the parasitoid *Diadegma insulare* (Fox et al. 1990). Similarly, high levels of phosphorus in soybeans contributed to consistently higher populations of big-eyed bug nymphs (*Geocoris* spp.) (Funderburk et al. 1994). Fertilizer application to *Spartina* islets in salt marshes resulted in increased abundance of herbivore species, and significantly enhanced spider activity against certain groups of herbivores (Denno et al. 2003). Thus, the nutritional status of the plant may exert effects on biological control, although the mechanisms for these effects are not known.

The bollworms (tobacco budworm, *Heliothis virescens*, and corn earworm, *Helicoverpa zea*) are important pests of cotton in the southeastern US. These two species are capable of causing extensive damage to cotton, in addition to other crops in the region. Biological control has long been an important aspect of managing these pests, as it became apparent, shortly after the advent of widespread use of synthetic insecticides, that disruption of natural enemies could produce serious pest outbreaks. Transgenic crops provide good to excellent control where they are planted, but biological control can provide an additional long-term, sustainable tool for managing these and other insect pests. Among the key native parasitoids of bollworms are the braconid parasitoids *Cardiochiles nigriceps* Viereck, *Microplitis croceipes* (Cresson), and *Cotesia marginiventris* (Cresson). *M. croceipes* can parasitize moths from the two noctuid genera *Heliothis* and *Helicoverpa*, ranging over a substantial number of host plant taxa where representatives of these two genera occur. In comparison with *C. nigriceps*, which attacks tobacco budworms almost exclusively, it is a relatively less specialized larval endoparasitoid. *Cotesia marginiventris*, in contrast, attacks a wide range of caterpillar pests, including tobacco budworms, corn earworms, soybean loopers, beet armyworms, southern armyworms, and others.

All three of these parasitoid species have been shown to respond strongly to plant- and host-related cues to locate and accept hosts in laboratory studies (e.g., Kasas et al. 1992, McCall et al. 1993, De Moraes et al. 1999). Although these cues have been demonstrated in the laboratory, their importance in the field under the varying conditions prevalent in agricultural systems has not been elucidated. Further, there is recent evidence to suggest that the nutritional status of plants can have important implications for the foraging success of parasitoids and predators, at least in the laboratory (e.g., Dicke and Sabelis, 1988; Dicke et al., 1990; Turlings et al., 1990, 1993). Thus, understanding the role of the plant's nutritional status in the effectiveness of biological control can have very important consequences for anticipating effectiveness of biological control agents in the field, and possibly devising or modifying practices to improve biological control by modifying plant health.

The objectives of this project are to elucidate the role of plant nitrogen levels in the function of natural enemies of several cotton pests in the laboratory and field.

Methods

Greenhouse Studies

Cotton plants were grown in a potting soil/peat moss blend with hydroponic solutions that were modifications of the Hoagland Solution (Hoagland and Arnon 1950) and permitted us to manipulate the nitrogen concentrations in the solutions. These plants were used for several studies of the responses of beet armyworms to various nitrogen levels in plants (not reported here and the responses of the parasitoid *Cotesia marginiventris* to beet armyworms on the plants.

Parasitoid responses to plants. To test whether parasitoids preferred plants with low or high nitrogen fertilization, we set up a choice experiment with whole plants in cages. Test cages were (LxWxH =100x60x60 cm) made of PVC pipes covered with fine mesh outside and were placed in the greenhouse (24 $\pm$ 4°C; L:D 14:10). Two nitrogen treatments were examined in the choice test: 42 ppm nitrogen in the watering solution and 196 ppm nitrogen in the watering solution. These solutions yielded plants that were somewhat yellowed and stressed (42 ppm) and plants that were dark green and visually healthy (196 ppm), and differed significantly in leaf nitrates as determined by petiole analysis (163.40 ppm N for the 42 ppm treatment, and 14,416.60 ppm N for the 196 ppm treatment). Four cotton plants (2 for each treatment) were arranged so that the two from the respective treatments were touching each other, and the plants of the two treatments were physically separated from one another at opposite ends of the cage. Plants of different treatments were ca. 50 cm apart to permit the parasitoids the opportunity to make a choice between the two treatments, and to limit caterpillar movement between treatments. Forty 2-d-old beet armyworm larvae were introduced to each plant in the cage and allowed to feed for 24 h before the introduction of 8 female *Cotesia marginiventris*. The parasitoid females were 3-4 days old, and had had prior ovipositional experience. They were not exposed to hosts for 24 h preceding their release into the cages. A cotton ball soaked with a 10% honey:water solution was provided as parasitoid food in cage. All surviving beet armyworm larvae were recovered 24 later and returned to the laboratory, where they were placed on artificial diet and held to monitor for parasitism. The experiment was replicated 8 times, and preference was evaluated as the percentage of caterpillars successfully parasitized in the treatments..

Field Studies
Cotton seed (variety FiberMax 989, a non-Bt variety) was planted on 15 May 2006 in field plots with four levels of nitrogen: (1) no nitrogen added; (2) 40 lbs/A (1 application of 40lbs/A); (3) 80 lbs/A (two applications of 40lbs/A); and (4) 120 lbs/A (three applications of 40lbs/A). The first application was on 9 June, the second on 19 June, and the third on 29 June. Each treatment was replicated 5 times in a randomized complete block design. Each plot was 12 rows wide and 50 feet long.

We examined the plots weekly using drop cloths to sample two rows of cotton in each plot (a total of 10 row feet were sampled per plot) to quantify populations of parasites and predators. In addition, caterpillars were collected from samples and returned to the laboratory to evaluate parasitism rates among the various plant nitrogen treatments.

Assessment of predation and parasitism. In addition to collecting naturally-occurring caterpillar pests, we also placed beet armyworm larvae on plants to evaluate predation and parasitism. Laboratory produced beet armyworm eggs and caterpillars were placed in the field to evaluate the influence of N on predation and parasitism rate. About 50 neonate caterpillars were confined to small cages made of 12-ounce styrofoam soft drink cups covered with nylon stocking material. Each cage enclosed one leaf in the middle of the cotton plants. The cages were removed 24 h later and caterpillars on leaves were counted. Caterpillars were subsequently exposed to feral natural enemies for 48 h. Then all remaining caterpillars were counted again and placed on artificial diet in groups of 5 to 10 caterpillars per diet cup. Parasitism rate was calculated as number of parasitoid cocoons divided by total caterpillars recovered. Four replicates were placed in each plot. Emerged parasitoids were identified to species for feral and sentinel caterpillars collected, and levels of parasitism will be analyzed, by parasitoid species, among the nitrogen (and moisture, if possible) treatments. Caterpillars were placed on plants in two trials. The first was placed in the field on 9 August and completed on 12 August. The second was placed on 22 August and completed on 25 August

Egg predation was evaluated by placing one egg mass with ca. 40 beet armyworm eggs attached to paper tissue on one leaf in the middle of cotton plant on 2 August. Eggs were frozen for 2 days before experimentation, so that they were not able to emerge as caterpillar but the color and shape of eggs remained. The eggs were checked twice daily (once in the morning, ca. 9 am, and once in the afternoon, ca. 4 pm) and remaining eggs counted over a 2-d period (through 4 August). The plants were located in the middle of the plots. Four replicate egg masses were placed in each plot.

Assessment of plant nitrogen. Two petioles from each of 10 randomly chosen cotton plants in each plot were pooled together in each plot in September, 2006, to assess leaf nitrate levels. Samples were oven-dried at 65°C for 2 d then sent to the Soil, Plant, and Water Laboratory of the University of Georgia for N analysis. This plant tissue nitrate-N analysis utilizes H_2O_2-H_2SO_4 mixture for digestion of plant material in the absence of heavy metals which were previously used in the plant and soil analysis (McGill and Figureiredo, 1993). At the end of the growing season, 5 plants from each of the 2 middle rows of each plot were randomly selected to evaluate plant height number of nodes (cotyledon node 0). Yields were taken from the two middle rows of each plot using a 2-row John Deere cotton picker on 13 October.

Data Analyses

The greenhouse experiments were analyzed using a paired t-test, assuming heterogeneity of variances, and using a null hypothesis of equal parasitism in both treatments (SAS Institute 1999).

Field data were analyzed using analysis of variance (PROC GLM of SAS; SAS Institute 1999), followed by a means separation using the Waller-Duncan Bayesian *k* ratio (with k = 100) when significant differences were indicated by the ANOVA. Abundance data from the shake samples were analyzed with repeated measures ANOVA.

Results and Discussion

The greenhouse trials indicated that *Cotesia marginiventris* does not have a preference, given the two nitrogen options in the cage setting. Approximately the same percentage of beet armyworm larvae was successfully parasitized in both treatments (39.3 $\pm$ 20.28% parasitism at 42 ppm N, and 42.6 $\pm$ 9.94% parasitism at 196 ppm N), although the variability in parasitism rates was higher in the lower nitrogen treatment. These data suggest that this parasitoid may not be significantly affected by nitrogen levels in the plant, which would be a positive feature in a biological control agent.

The various nitrogen treatments in the field exerted significant effects on the plants, with the highest nitrate readings, greatest plant height, and greatest number of nodes on plants in the highest nitrogen treatments (Table 1). However, there were no significant differences in plant height or number of nodes among any of the treatments receiving nitrogen. Nor was yield was significantly affected by nitrogen treatment (Table 1). These results indicate that the nitrogen treatments did have significant effects on the plants, which, in turn, could affect the pest and beneficial species associated with them, but that these differences did not translate into statistically-significant yield effects.

Overall, pest numbers were low throughout the season, and there were very few significant differences among treatments (Table 2). Caterpillar pests were present in low numbers, and were not sufficiently abundant to permit statistical evaluation (see Table 4 for totals). Cotton aphids appeared relatively early, built up quickly, then rapidly declined (Table 2, Fig. 1). Aphid abundance was significantly affected by nitrogen treatment, with the highest aphid numbers occurring in the 40 and 120 lbs/acre treatments. Similar to caterpillars, relatively few bug pests were observed in 2006 in the plots. The dominant bug species present were the fleahoppers – the cotton fleahopper, *Pseudatomoscelis seriatus*, and garden fleahopper, *Halticus bractatus*, but there were no significant differences among treatments for abundance of any of the bug pests.

Among natural enemies observed in samples, only the big-eyed bug *Geocoris punctipes* differed significantly in abundance among nitrogen treatments (Table 3). The predator was consistently least abundant in the 0 nitrogen treatment, while abundance varied in the other treatments (Fig. 2). The low predator population in the 0-nitrogen treatment may be in response to relative prey abundance, or may be a direct response to the plant, as *Geocoris* species are omnivores that also respond to plants. Unlike 2005, spider abundance was unaffected by nitrogen level (Table 3).

The results of the sentinel beet armyworm larval trials also failed to yield any statistically-significant differences in numbers of caterpillars collected or parasitized among nitrogen treatments. Very few of the larvae placed at each location were recovered (Table 5), with no differences among treatments. Parasitism rates were somewhat low, and did not vary significantly among treatments (Table 5), but it must be noted that the larvae were only exposed for 48 hours. Longer exposure might have resulted in higher parasitism rates, but also would have resulted in higher loss of caterpillars. Loss of larvae may have been due to predation, dislodgement, or movement, so it is difficult to interpret larval loss as predation without more detailed studies. However, the egg mass study provides greater insight into predation because the egg masses remain where they are placed, and the removal or consumption via chewing or sucking is recognizable. Sentinel eggs were predated at a significantly higher rate in the 0-nitrogen treatment than in the highest nitrogen treatment, with predation in the other nitrogen treatments generally falling numerically in between the two extremes (Table 6). This result indicates that predators were probably quite active in removing beet armyworms in all of the treatments (although some of the loss is also certainly due to dislodgement from the plants), but that the predation is greatest with the least nitrogen. This may reflect differences in plant structure, since cotton plants in the 0-nitrogen treatment were smaller and less complex than those in other treatments, and may have facilitated searching by predators. Predator abundance would not account for the difference in predation rates, because there was only one species that exhibited a significant effect of nitrogen treatment (*G. punctipes*), and it was most abundant in the higher nitrogen treatments (Fig. 2). The causes of this difference in predation among treatments are unclear at present.

Literature

Boethel, D. J., and R. D. Eikenbary (eds.). 1986. “Interactions of Host Plant Resistance and Parasitoids and Predators of Insects”. Halstead Press, New York.

De Moraes, C.M., Cortesero, A.M., Stapel, J. O., and Lewis, W.J. 1999. Intrinsic and extrinsic competitive interactions between two larval parasitoids of *Heliothis virescens*. *Ecological Entomology*, 24: 402-410.

Denno, R.F., Gratton, C., Döbel, H., and Finke, D.L. 2003. Predation risk affects relative strength of top-down and bottom-up impacts on insect herbivores. *Ecology* 84:1032-1044.

Dicke, M., and Sabelis, M. W. 1988. How plants obtain predatory mites as bodyguards. *Neth. J. Zool*. 38:148-165.

Dicke, M., and Takabayashi, J. 1991. Specificity of induced indirect defence of plants against herbivores. *Redia*, 74 (3) Appendix: 105-113.

Fox, L. R., Letourneau, D. K., Eisenbach, J., and van Nouhuys, S. 1990. Parasitism rates and sex ratios of a parasitic wasp: Effects of herbivore and plant quality. *Oecologia* 83, 414-419.

Funderburk, J.E., F.M. Rhoads, and Teare, I.D. 1994. Modifying soil nutrient level affects soybean insect predators. *Agron. J*. 86, 581-585.

Hare, J. D. 2002. Plant genetic variation in tritrophic interactions. *In* “Multitrophic Level Interactions” (T. Tscharntke and B.A. Hawkins, Eds.), pp. 8-43. Cambridge Univ. Press, Cambridge UK.

Hoagland, D.R., and Arnon, D.I. 1950. The water-culture method for growing plants without soil. Calif. Agric. Exp. Sta. Circ. 347.

Hodges, T.A. 2002. Foraging behavior of a larval endoparasitoid and the role of plant damage and herbivore-associated cues: Influence of learning. M.S. Thesis, Georgia Southern Univ., Statesboro, GA.

Kasas, J.P., Elzen, G.W., and Ramaswamy, S.B. 1992. Flight responses in a wind tunnel of the parasitoid *Microplitis croceipes* to three spring and three summer host plants of Heliothis spp. *Entomol. Exp. Appl*. 63: 207-212.

McCall, P.J., Turlings, T.C.J., Lewis, W.J., and Tumlinson, J.H. 1993. Role of plant volatiles in host location by the specialist parasitoid *Microplitis croceipes* Cresson (Braconidae: Hymenoptera). *J. Insect Behav*. 6: 625-639.

Michel, B.E. 1983. Evaluation of the water potentials of solutions of polyethylene glycol 8000 both in the absence and presence of other solutes. *Plant Physiol*. 72: 66-70.

SAS Institute. 1999. SAS/STAT User’s guide, version 8.02, TS level 2MO. SAS Institute Inc., Cary, NC.

Turlings, T. C. J., Gouinguené, S., Degen, T., and Fritzsche-Hoballah, M. E. 2002. The chemical ecology of plant-caterpillar-parasitoid interactions. *In* “Multitrophic Level Interactions” (T. Tscharntke and B. A. Hawkins, Eds.), pp. 148-173. Cambridge Univ. Press, Cambridge UK.

Turlings, T. C. J., Scheepmaker, J. W. A., Vet, L. E. M., Tumlinson, J. H., and Lewis, W. J. 1990. How contact foraging experiences affect preferences for host-related odors in the larval parasitoid *Cotesia marginiventris* (Cresson) (Hymenoptera: Braconidae). J*. Chem. Ecol.* 16, 1577-1589.
Turlings, T. C. J., Wäckers, F. L., Vet, L. E. M., Lewis, W. J., and Tumlinson, J. H. 1993. Learning of host-finding cues by hymenopterous parasitoids. *In* "Insect Learning" (D. R. Papaj and A. C. Lewis, Eds.), pp. 51-78. Chapman & Hall, New York.

Table 1. Cotton plant growth characters and seed cotton yield in response to varying N fertilization levels (Lang Farm, Tifton, GA, 2006). Petiole samples collected in September. Height and node number were evaluated at the end of the season.

Nitrogen treatment (lbs/A)	Petiole NO_3-N Mean±SEM (ppm)	Plant height Mean±SEM (m)	Node No. *Mean±SEM*	Yield (lbs seed cotton/a)
0	151.25 ± 20.83	0.96 ± 0.0045 a	22.1 ± 0.06 a	2447.09 ± 89.35
40	219.80 ± 33.60	1.14 ± 0.0033 b	24.8 ± 0.06 b	2776.13 ± 57.47
80	427.22 ± 47.52	1.16 ± 0.0052 b	24.7 ± 0.06 b	2691.91 ± 41.78
120	446.49 ± 55.96	1.15 ± 0.0052 b	24.3 ± 0.07 b	2771.74 ± 59.13

Source	**DF**	**F**	***P***	**DF**	**F**	***P***	**DF**	**F**	***P***	**DF**	**F**	**P**
Block	5	1.01	0.44	5	30.8	< .0001	5	10.36	< 0.0001	5	3.70	0.02
Treatment	3	0.58	0.64	3	11.9	< .0001	3	10.59	< 0.0001	3	1.62	0.23

Means followed by different low case letters within a column indicated significant difference. Data were analyzed with ANOVA. Means were separated with paired Bonferroni's *t*-test if overall null hypothesis was rejected ($p<0.05$).

Table 2. ANOVA results of insect pests in cotton field (Lang Farm, Tifton, GA 2006)

		***Heliothis* spp.**		**Loopers[1]**		***Lygus lineolaris***		**Fleahoppers[2]**		**Stink bugs[3]**		***Aphis gossypii***	
Source	**DF**	**F**	***P***	**F**	***P***	**F**	***P***	**F**	***P***	**F**	***P***	**F**	***P***
Block	5	1.78	0.12	2.63	0.03	0.39	0.86	1.58	0.17	0.80	0.55	1.89	0.10
Date	9	10.80	<0.0001	1.47	0.16	8.15	<0.0001	10.60	<0.0001	1.70	0.09	73.53	<0.0001
Treatment	3	0.50	0.68	1.19	0.31	2.04	0.11	0.73	0.54	1.98	0.12	3.09	0.03
Date*Treatment	27	0.73	0.83	0.85	0.68	1.97	0.0045	0.86	0.67	1.32	0.14	1.31	0.15

[1] soybean looper *P. includens* and cabbage looper *T. ni*; [2]cotton fleahopper *P. seriatus* and garden fleahopper *H. bractatus*; [3]southern green stinkbug *N. viridula*, green stinkbug *A. hilare*, and brown stinkbug *E. servus*). Treatment: no fertilizer throughout the growing season (T1); 1 application of 40 lbs/a during the season (T2); 2 applications during the season (T3); 3 applications during the season (T4). Data were analyzed with repeated measure ANOVA.

Table 3. ANOVA results of beneficial arthropods in cotton field (Lang Farm, Tifton, GA 2006)

2005		**Ants**		**Spiders**		***Geocoris* spp.**		**Ladybeetles**[1]		***Orius* spp.**		**Lacewi**	
Source	**DF**	**F**	***P***	**F**	***P***	**F**	***P***	**F**	***P***	**F**	***P***	**F**	
Block	5	0.36	0.87	3	0.01	1.20	0.31	4.55	0.0006	3.74	0.003	3.43	0
Date	9	13.16	<0.0001	11.22	<0.0001	31.75	<0.0001	88.66	<0.0001	53.97	<0.0001	12.09	<0
Treatment	3	0.90	0.44	1.76	0.16	7.33	0.0001	0.84	0.48	0.16	0.93	2.23	
Date*Treatment	27	0.50	0.98	1.14	0.30	1.30	0.16	0.69	0.87	0.37	1.00	1.86	0

[1] 7-spotted lady beetles, *C. septempunctana*; Asian lady beetle *H. axyridis*; convergent lady beetle *H. convergens*; scymnus lady beetle *Scymnus* spp.;[2] green lacewing *Chrysoperla* spp. and *Chrysopa* spp.; brown lacewing *Hemerobius* spp. and *Micromus* spp. Treatment: no fertilizer throughout the growing season (T1); 1 application of 40 lbs/a during the season (T2); 2 applications during the season (T3); 3 applications during the season (T4). Data were analyzed with repeated measure ANOVA.

Table 4. Seasonal parasitism of caterpillars collected during weekly drop cloth sampling (Lang Farm, Tifton, GA, 2006)

Nitrogen treatment (lbs/A)	***Heliothis* spp. (%)**	**Loopers (%)**	**Others (%)**	**No. of caterpillars collected**	**Total (%)**
0	0.00	0.00	0.00	42	36.36
40	4.55	30.77	12.50	67	16.67
80	0.00	5.56	12.12	69	30.65
120	0.00	27.27	13.04	56	20.93
				Mean	25.44

Table 5. Loss and parasitism of BAW caterpillars placed in the field (mean±SEM) on 9 and 22 August and left uncovered for two days prior to collection.

Nitrogen treatment (lbs/A)	2006	
	Recovery rate	Parasitism rate
0	6.61±0.60	7.69±1.90
40	10.89±1.74	24.76±5.52
80	17.23±1.29	18.25±2.69
120	12.18±1.04	28.39±3.24
	χ^2=2.71 DF=3 *P*=0.45	χ^2=2.11 DF=3 *P*=0.55

T1: no fertilizer throughout the growing season; T2; 1 application of 45 kg/ha during the season; T3: 2 applications during the season; T4: 3 applications during the season. Data were analyzed with non-parametric Kruskal-wallis test.

Table 6. Percent of BAW eggs predated (mean %±SEM) in the field (Lang Farm, Tifton, GA 2006)

Nitrogen treatment (lbs/A)	Sampling time after placement			
	6 h	24 h	30 h	48 h
0	37.53±1.64 b	83.28±1.43 b	90.66±1.10 b	92.52±0.94 b
40	55.20±1.82 b	66.15±1.73 b	72.93±1.54 a	81.38±1.45 ab
80	43.23±1.91 b	70.18±1.82 b	75.02±1.68 a	90.48±1.10 b
120	16.71±1.11 a	36.90±1.76 a	52.00±1.86 a	61.64±1.78 a
	χ^2=10.03 DF=3 *P*=0.0183	χ^2=14.00 DF=3 *P*=0.0029	χ^2=12.25 DF=3 *P*=0.0066	χ^2=12.48 DF=3 *P*=0.0059

Sampling time: hours after setting up of experiment. Data were analyzed with non-parametric Kruskal-wallis tests.

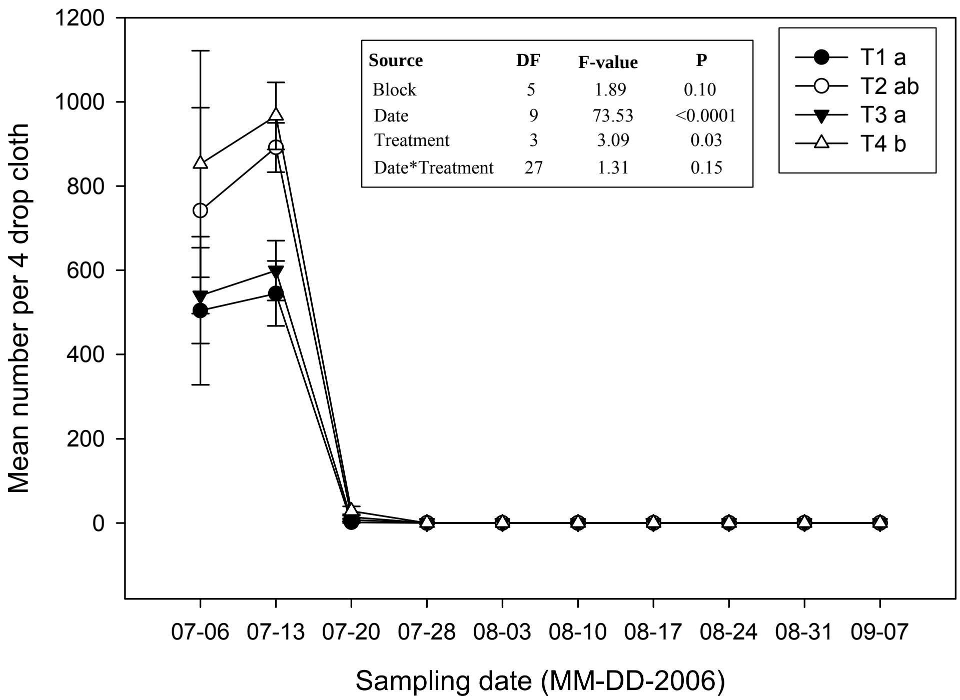

Fig 1. Seasonal dynamics of aphids in the cotton field, 2006. T1: no fertilizer throughout the growing season; T2; 1 application of 40 lbs/a during the season; T3: 2 applications during the season; T4: 3 applications during the season. Data were analyzed with repeated measures ANOVA.

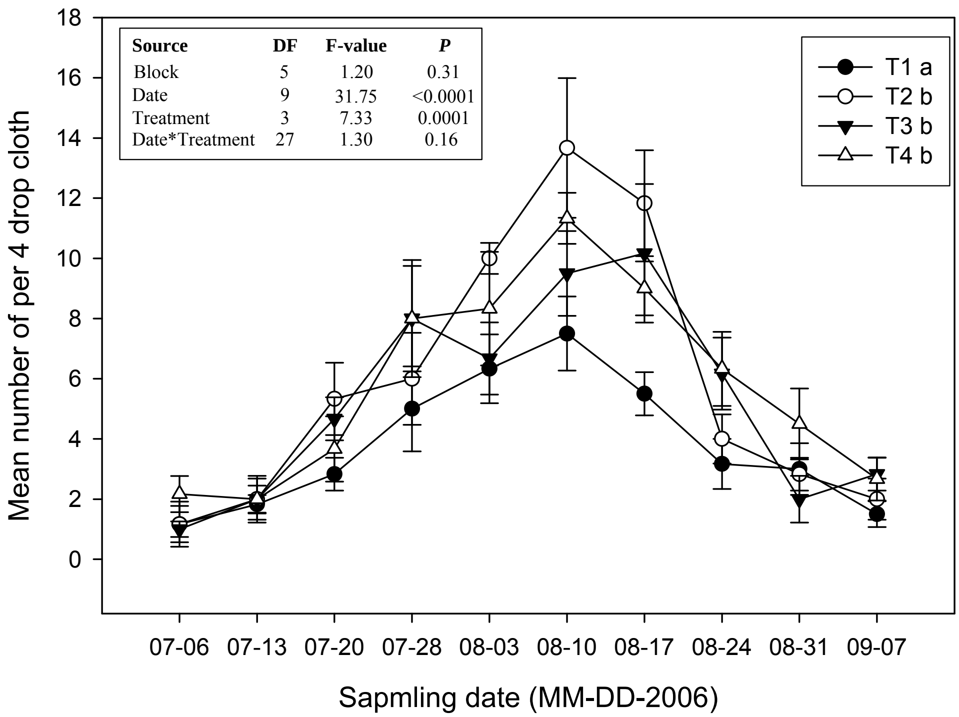

Fig 2. Seasonal dynamics of *Geocoris* spp. in the cotton field, 2006. T1: no fertilizer throughout the growing season; T2; 1 application of 40 lbs/a during the season; T3: 2 applications during the season; T4: 3 applications during the season. Data were analyzed with repeated measures ANOVA.

INSECTICIDE RESISTANCE MONITORING IN LEPIDOPTERAN COTTON PESTS

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Introduction

Insecticides remain the tool of choice for control of lepidopteran pests that exceed economic thresholds in many Georgia row crops, though great strides have been made during the past two decades in reducing chemical use. Insecticides, particularly pyrethroids, continue to play a key role in management of lepidopteran pests due to their general effectiveness to Lepidopteran and other pests, and their low costs. Newer insecticides have become available, but the specificity of many of them tends to impose limits on their general utility, and they are significantly more expensive to use. Further, pyrethroids provide some level of activity against stink bugs, and have historically been effective against corn earworms in Bollgard cotton. It is, therefore, important that we understand the susceptibility of target pests to the older insecticides, especially pyrethroids, so that we can continue to use them effectively and make appropriate management decisions to prolong the life of effective insecticides.

In recent years, there have been increasingly frequent reports of pyrethroid failures targeting tobacco budworm (TBW) in cotton and tobacco. In 2004, we documented significantly greater pyrethroid tolerance in populations of the TBW from Colquitt, Terrell, and Tift Counties than was observed in our historical dataset. We observed the same problem with TBW on a larger scale in 2005. And in 2005, we found elevated levels of pyrethroid tolerance in corn earworm (CEW) populations, and several pyrethroid failures were reported. In 2006, we continued our monitoring efforts for both TBW and CEW in Georgia.

Materials and Methods

In 2006, larvae of the tobacco budworm, *Heliothis virescens*, were bioassayed for resistance to the pyrethroid insecticides cypermethrin and cyhalothrin. Cultures were established from eggs and/or larvae collected in tobacco in various Georgia counties. Collections were made in Appling (TBW and CEW), Jeff Davis County (TBW and CEW), Miller County (CEW), Mitchell County (CEW), Terrell County (CEW), Tift County (CEW), Union County (CEW), and Ware County (TBW and CEW). Field-collected larvae were reared to adulthood. These parent moths were confined in 1 gal plastic containers with cheesecloth lids serving as oviposition sites. When the eggs hatched, neonate larvae were placed on pinto bean meal synthetic diet in 30 ml plastic cups. F_1 larvae were used for bioassays, with the exception of the Tift County cultures, where F_2 larvae were also used. Both TBW and CEW populations were reduced in 2006 relative to previous years, with TBW being particularly difficult to find. Only Appling and Jeff Davis counties yielded enough TBW to get suitable test results. All life stages of the insects were held in an incubator at 27 $\pm$ 2^{o}C, ca 60% RH and a 14:10 hr light: dark cycle.

Evaluation of larval susceptibility of *H. virescens* basically followed the protocol outlined in the ESA Standard Test Method for detection of resistance in *Heliothis* spp. (Anon. 1970). Larvae were treated with 89.9% technical grade cyhalothrin, or 92.4% technical grade cypermethrin. Stock solutions in acetone were prepared and serially diluted to obtain the desired concentrations. Microgram equivalents were calculated, adjusting for the percent active ingredient in the technical materials. One microliter of solution was applied to the dorsal thoracic region of each larva using a Microliter no. 705 (Hamilton Company, Reno, NV) hand-held applicator. Three to five replications were used in each bioassay with ten third instar, 30-40 mg larvae per dosage and an acetone check.

Observations were made 72 hr post-treatment and a larva was considered dead if it made no movement when prodded with a pencil point. Larvae were considered moribund if they moved when prodded, yet appeared black and as small or smaller than their size at treatment. These were considered alive when determining LD (lethal dosage) values, but considered dead when calculating ED (effective dosage) values. In many instances, larvae treated with pyrethroids linger on several days beyond observation time as moribund larvae that eventually die. For this reason we present ED values as well as LD values for a more complete picture of dosage-response. Data were analyzed using Daum's (1970) probit analysis computer program, and 95% confidence intervals were calculated.

To evaluate corn earworm adults, we set up pheromone traps in 6 Georgia counties (Burke, Decatur, Jeff Davis, Montgomery, Sumter, and Tift) and monitored them throughout the season. In practice, moth responses to the traps were low, despite season-long trapping, and did not provide enough moths to permit us to obtain definitive results.

Results and Discussion

The ED_{50} values for the 2006 TBW larval bioassays are presented in Table 1. All values for cyhalothrin were higher in the Tift County test population than the average of bioassays performed on Tift Co. TBW larvae since 1985. The historical change in the ED_{50} values for the TBW in Georgia are shown in Figure 1.

For cypermethrin, all ED_{50} values for the CEW and TBW, except the Tift Co. F_2 CEW larvae and Ware County CEW larvae and Jeff Davis County TBW larvae, were higher than those of Tift Co. in 2005; however, all were elevated in comparison with the Tift Co. long term average (including 2005) of 0.36 µg/g larval wt. for CEW and 2.44 µg/g larval wt. for TBW since testing began in 1983 (Table 1).

The CEW population most tolerant to pyrethroids was the Terrell County population (Table 1), which is notably where field failures occurred in 2006. Unexpectedly, however, the second highest level of tolerance occurred in the Union County population of extreme northern Georgia. This is unexpected because that region has had very little historical use of pyrethroids, so the pressure to develop resistance is very low. Nevertheless, the tolerance level was quite high, suggesting that the insects were migrants from other areas where pyrethroid pressure is higher. The lowest tolerance was observed in the Ware County CEW, which was comparable to that of the Tift County F_2 larvae. The historical change in the ED_{50} values for the CEW in Georgia are shown in Figure 2.

Elevated pyrethroid tolerance appears to be widespread in Georgia, with increased tolerance now documented in southwestern, south central, and east central counties (Table 1). The presence of very elevated tolerance in extreme northern Georgia, where pyrethroid use is very limited, indicates that tolerant moths are probably migrating into the area from other regions where pyrethroid use is much higher.

Widespread pyrethroid resistance in larval tobacco budworms in Georgia should be viewed with great concern. The 2005 results were the most widespread incidence of pyrethroid tolerance in tobacco budworm of any year to date, and the data from only two albeit widespread counties in 2006 suggest that pyrethroid resistance remains widespread and very high in TBW. These results mean that in the first generation of tobacco budworms attacking tobacco, resistance to pyrethroids is already elevated, and the likelihood of failure with these insecticides is great. Further, the potential for selecting even greater resistance levels in subsequent generations of TBW is quite high if pyrethroids are applied to the early-season generations of this pest. As such, it is critical to avoid pyrethroids use for control of TBW in tobacco. If pyrethroids are used, they will need to be used at the highest labeled rate to have any notable effect. However, the probability of failure with the high rate is quite high, and this pyrethroid usage will only create an even more resistant tobacco budworm for the remainder of the growing season. Future monitoring of pyrethroid resistance in tobacco budworms in Georgia is essential.

Although the resistance ratios were not excessive for the corn earworms tested, it is apparent that the tolerance is indeed elevated, and is elevated at multiple locations including at least one location with very little history of pyrethroid use (Union County). This contrasts with the experience in South Carolina in 1999, when elevated pyrethroid tolerance in the corn earworm also was observed, but only in a single county and a single year. The magnitude of pyrethroid resistance in Georgia corn earworms is still somewhat low, but the occurrence of this phenomenon in multiple spatially disparate counties over two years indicates that growers must be increasingly cautious in their use of pyrethroids. Growers must be certain to use the higher labeled rates when treating corn earworm populations to eliminate heterozygous individuals, and reduce the frequency of resistant alleles in the population. In addition, the increased use of alternative modes of action is critical for prolonging the usable life of pyrethroids against heliothine pests. The elevated pyrethroid tolerance in observed in Georgia corn earworms has thus far not behaved as the South Carolina tolerance, which disappeared the season following detection, and this should be cause for concern. In addition, the Union County population suggests that pyrethroid resistance in the CEW is a highly mobile attribute, so the risk of spread is very great. It is critical that growers prepare for increased problems with pyrethroids so that we can prolong the useful life of these important compounds, and continue to manage corn earworms.

Acknowledgments

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References

Anonymous. 1970. Second conference on test methods for resistance in insects of agricultural importance. Bull. Entomol. Soc. Am. 16:147-153.

Daum, R. J. 1970. A revision of two computer programs for probit analysis. Bull. Entomol. Soc. Am. 16:10-15.

Table 1. ED_{50}'s for various insecticides against larval *Helicoverpa zea* (CEW) and *Heliothis virescens* (TBW) at 72 hr post-treatment. 2006.

Chemical	Gen.	No. Reps	ED50(µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2005	Change (+/-) from Tift Co. avg	Slope ± SE
Cyhalothrin - CEW							
Tift Co.	*F1*	4	0.45	0.36 – 0.56	-	+0.38	2.30 ± 0.27
Tift Co.	*F2*	4	0.26	0.20 – 0.35	-	+0.19	1.63 ± 0.24
Cypermethrin - CEW							
Jeff Davis Co.	*F1*	4	1.10	0.75 - 1.46	+0.08	+0.74	1.77 ± 0.34
Miller Co.	*F1*	3	1.39	0.93 - 1.96	+0.37	+1.03	1.61 ± 0.30
Mitchell Co.	*F1*	5	1.04	0.81 – 1.28	+0.02	+0.68	2.52 ± 0.33
Terrell Co.	*F1*	3	2.51	1.20 - 7.35	+1.49	+2.15	0.94 ± 0.25
Tift Co.	*F1*	5	1.25	0.96 - 1.59	+0.23	+0.89	1.80 ± 0.24
Tift Co.	*F2*	4	0.79	0.22 – 1.58	-0.23	+0.43	1.71 ± 0.43
Union Co.	*F1*	4	1.68	1.21 - 2.32	+0.66	+1.32	1.52 ± 0.19
Ware Co.	*F1*	2	0.72	0.55 - 0.89	-0.30	+0.36	4.18 ± 0.86
Cypermethrin - TBW							
Appling Co.	*F1*	4	3.46	2.08 – 11.16	+1.02	+2.59	1.11 ± 0.32
Jeff Davis Co.	*F1*	5	2.15	1.67 – 2.84	-0.29	+1.28	1.98 ± 0.27

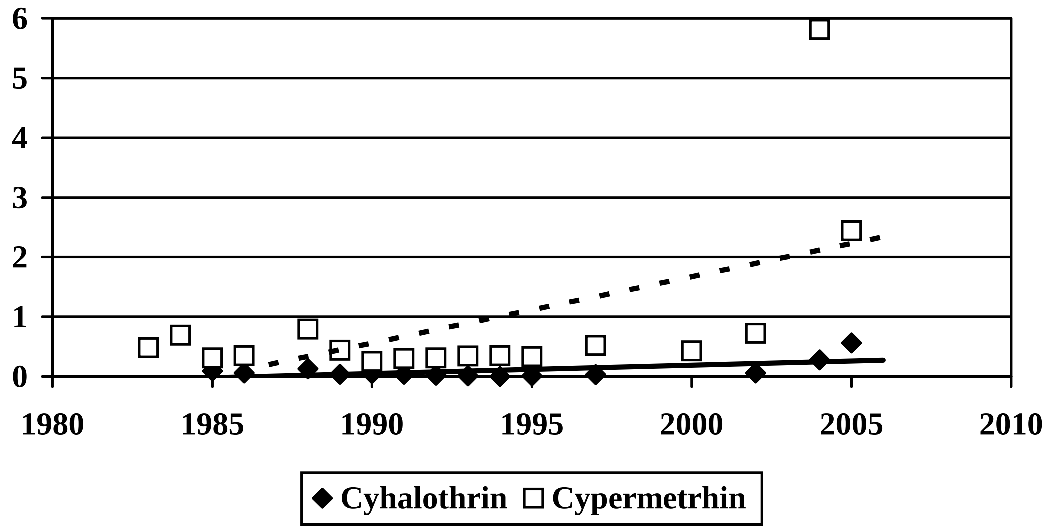

Fig. 1. ED_{50} values in µg/g larval wt for λ-cyhalothrin and cypermethrin against larval tobacco budworms, *Heliothis virescens.*

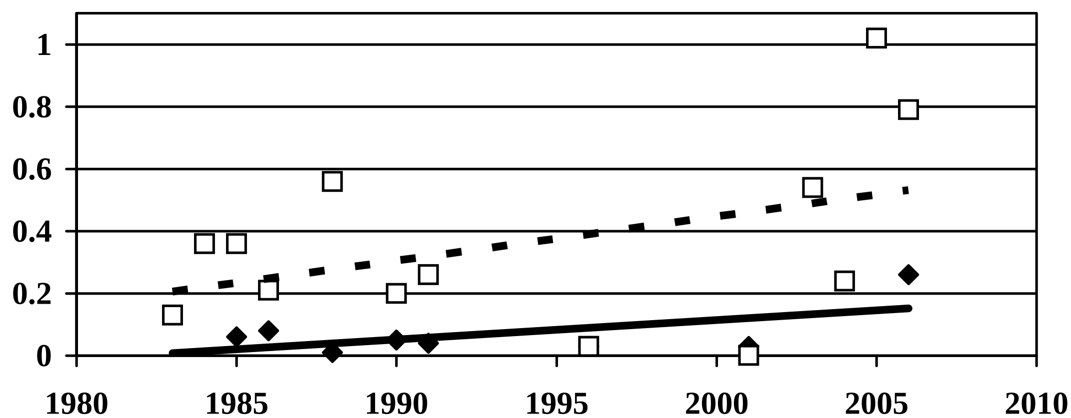

Fig. 2 ED_{50} values in µg/g larval wt for λ-cyhalothrin and cypermethrin against larval bollworms, *Helicoverpa zea.*

FIELD EDGES, BARRIERS AND COTTON FILED PENETRATION BY STINK BUGS

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Introduction

The stink bug complex has become a serious problem for cotton production in the southeastern United States (Greene et al. 2001; Williams 2006).

It has become increasingly apparent from that stink bug colonization of cotton fields exhibits distinctive edge effects. This effect is particularly apparent adjacent to peanut fields, where bug damage is often most intense in the rows nearest the peanut border. This pattern of colonization suggests that stink bug movement into a field may be slowed or disrupted by managing the edge of the cotton field. Management practices might involve the use of border sprays of insecticides or the insertion of barriers to slow movement. This project examined the latter option, using grain sorghum and sorghum sudangrass as planted barriers between the cotton and an adjacent peanut planting. Grain sorghum can attain heights of 4-5 feet, whereas sudangrass attains heights in excess of 10 feet, forming a taller barrier. These were compared to two no-barrier scenarios: bare ground and peanuts.

Materials and Methods

Cotton (variety DPL 543BG2/RR) was planted on 26 May at the Lang-Rigdon Farm of the Coastal Plain Experiment Station in Tift County, Georgia, using a Monosem pneumatic planter equipped to add granular insecticides in the furrow. Peanuts (variety 'Georgia Green') were planted adjacent to all cotton plots on 8 June 2006. Throughout the course of the season, all plots were irrigated for optimal growth. All cotton received 3.5 lbs of Temik at planting with the Monosem planter.

We examined the effects of three different field borders on stink bug populartions and injury in cotton. The borders were all 24 feet wide, were planted immediately adjacent to the cotton plants (and with adjoining peanuts on the other side), and were (1) bare, tilled soil, (2) grain sorghum (var Southland SL280), or (3) sorghum sudangrass (var Dekalb SX17). Each barrier treatment was replicated four times. Sorghum and sudangrass were planted with a Monosem 2-row planter, with a seed spacing of 2 3/8" to 7". Each plot was 94 feet long, and separated by 10 feet of bare ground lengthwise between plots. We sampled stink bugs in the cotton weekly by taking 25 sweep samples in each plot on rows 1, 3, 6, 12, and 18 between 9 and 11 am (EDT). Stink bugs collected in the samples were identified and counted. Samples were taken from 1 August until 19 September. Stink bugs also were sampled in peanuts with a suction sampler (50 suctions per plot, for a sample of 25 linear feet), and in grain sorghum and sorghum sudangrass by visual examinations of 30 plants per plot. The border crops were sampled on the same dates as the cotton samples were taken to determine stink bug presence. In addition, boll injury evaluations were made on sample dates for 20 bolls each on rows 1, 6, and 12 to detect any patterns of feeding injury that might relate to colonization. Bolls were considered injured if internal warting and/or lint staining was present, indicating bug feeding. An end-of-season boll injury count was made in early October, in which we examined 100 bolls on each of rows 3, 7, and 13 in each plot, using the same criteria for injury as were used for samples during the growing season.

Cotton was picked with a 2-row mechanical picker and ginned at the University of Georgia Micro-gin facility to obtain lint yields.

Data (bug numbers, boll injury, yield) were analyzed using PROC GLM of SAS, followed by separation of significantly different means using the Waller-Duncan Bayesian *k* ratio, with *k*=100 (SAS Institute 1999). Adult and nymphal numbers were transformed prior to analysis (square root transformation) due to proportionally heterogeneous variances.

Results and Discussion

Small cotton bolls first began to appear in the plots at the end of July, and presumably this would have been the period when the plants would have been most attractive to stink bugs. Adult stink bugs were collected in low numbers throughout August (Fig. 1a), and overall numbers increased somewhat in September (Fig. 1b). There were no significant differences observed in adult stink bug numbers among barrier crops or rows on any sample date. Thus, there was no clear pattern of colonization that was apparent in adult abundance. This lack of pattern also may reflect sampling errors, as the cotton plants became larger as the season progressed, decreasing the efficiency of the sweep net samples. In addition, adult stink bugs are quite active, and some of the bugs may have escaped sampling, adding another element of variability.

Unlike adults, nymphs are much more sedentary and are more likely to be captured in samples. No nymphs were collected prior to 22 August, but they were consistently collected at relatively low levels thereafter (Fig. 2). Barrier type had no effect on nymphal abundance on any date, but, unlike adult samples, row number did affect nymphal abundance on 29 August and 12 September (F=3.56; P=0.0133, df=2,27; and F=2.61, P=0.0481, df=2,27; respectively), and overall, nymphs were more abundance in rows proximate to the barriers. This suggests a progressive colonization, with reproduction concentrated on the field edge. By 19 September, nymphal abundance had increased further into the field (Fig. 2), indicating that field penetration by reproducing bugs had increased.

The boll injury data collected during the growing season support the model of progressive edge colonization, with gradual increases into the field (Fig. 3). Like nymphal abundance, boll injury was unaffected by barrier type, but was influenced by row number on 16 and 22 August, and 12 September (F=7.86, P=0.0020, df=2,27;

F=9.93; P=0.0006, df=2,27; and F=5.92, P=0.0074, df=2,27; respectively). Injury tended to progressively increase with time, but the general trajectory of the injury in relation to row number remained relatively constant (Fig. 3). This suggests that bugs are steadily colonizing the field edges and penetrating further into the field at a relatively constant rate. The increase in injury as the season progresses also may reflect the development and maturation of nymphs that were the offspring of colonizers.

The end-of-season boll injury assessment failed to indicate any significant effect of row on internal boll injury (Fig. 4). However, it should be noted that variability in injury increased with increasing distance from the field border. Increased variability suggests that the injury further into the field was more irregular than was the case for peripheral rows, adding some measure of support for the in-season injury results

Lint yield was unaffected by either barrier type or row distance from the barrier (Table 1). Assuming that a significant proportion of the yield variability was due to stink bug activity, these results suggest that the bugs were distributed across the field by the season's end.

In summary, barriers of sorghum and sorghum sudangrass separating peanuts from cotton did not significantly alter stink bug dynamics in the cotton in comparison with bare ground. There were significant differences in stink bug abundance in relation to the distance of cotton rows from the field border adjacent to the barrier and peanuts, although this pattern was inconsistent for adults. However, there was a relatively consistent pattern of increased nymphal numbers and increased boll injury during the season as the distance from the border declined. These results indicate that there is apparent colonization of the field from the edges, and that this colonization is fairly persistent when the cotton plants are maturing bolls. Colonization from the edges may create opportunities to use border treatments to effectively manage colonizing bugs, and thereby manage bugs throughout the crop.

Acknowledgment

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References Cited

Greene, J.K., S.G. Turnipseed, M.J. Sullivan, O.L. May. 2001. Treatment thresholds for stink bugs (Hemiptera: Pentatomidae) in cotton. J. Econ. Entomol. 94: 403-409.

Williams, M.R. 2006. Cotton insect losses – 2005. Proc. 2006 Beltwide Cotton Research Conf., pp. 1151-1204.

Table 1. Lint yields in relation to barrier crop and rows distad to barriers. No significant differences were observed in relation to barrier or row number.

No. rows from barrier	Barrier crop		
	Bare soil	Sorghum	Sudangrass
2	1167 ± 177.4	1255 ± 98.5	1047 ± 300.2
3	1111 ± 239.1	1135 ± 254.5	1267 ± 230.1
7	1195 ± 187.3	1147 ± 277.2	1049 ± 157.0
8	1186 ± 279.4	1468 ± 104.3	1243 ± 432.4
13	1272 ± 369.1	1346 ± 401.8	1199 ± 536.1
14	1188 ± 523.1	1134 ± 165.8	1080 ± 295.0

Fig. 1a. Number of adult stink bugs per 25 sweeps (y axis) in relation to border type (bare soil, sorghum, and sorghum sudangrass) and number of rows from barrier (20 bolls sampled per row per date) from 1 to 22 August 2006. No significant differences were observed among barrier treatments or rows on any sample date.

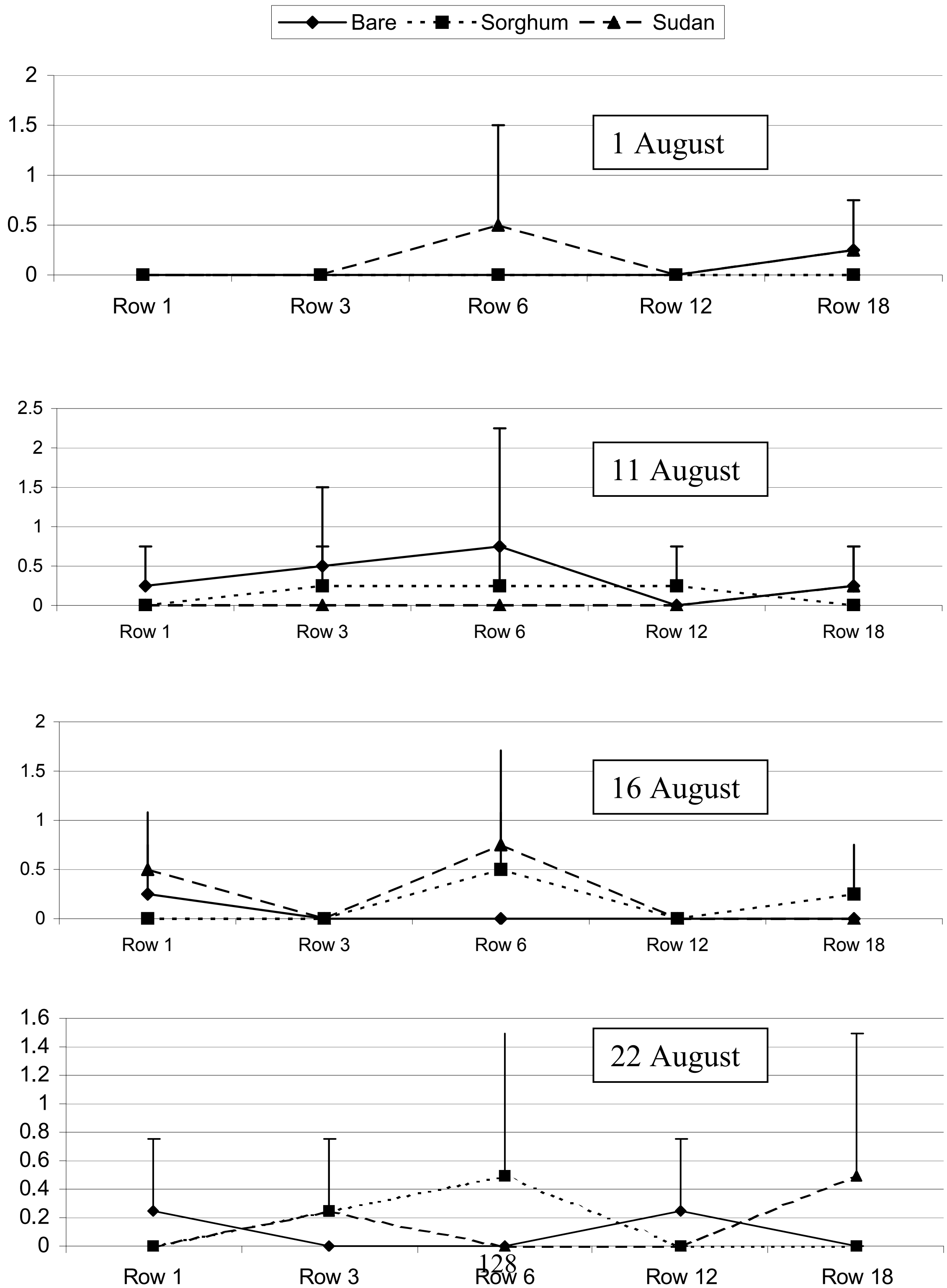


Fig. 1b. Number of adult stink bugs per 25 sweeps (y axis) in relation to border type (bare soil, sorghum, and sorghum sudangrass) and number of rows from barrier (20 bolls sampled per row per date) from 29 August to 19 September 2006. No significant differences were observed among barrier treatments or rows on any sample date.

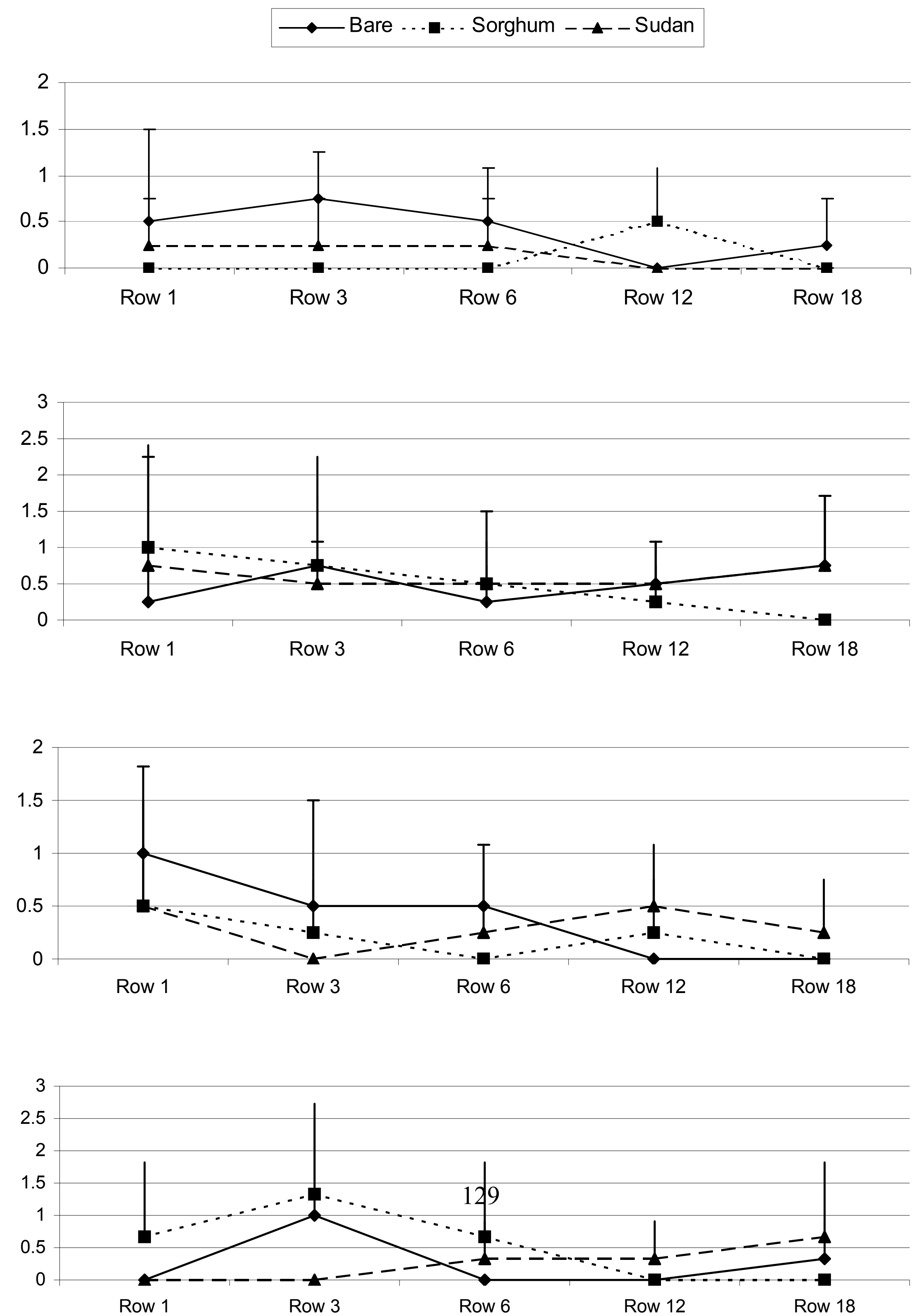
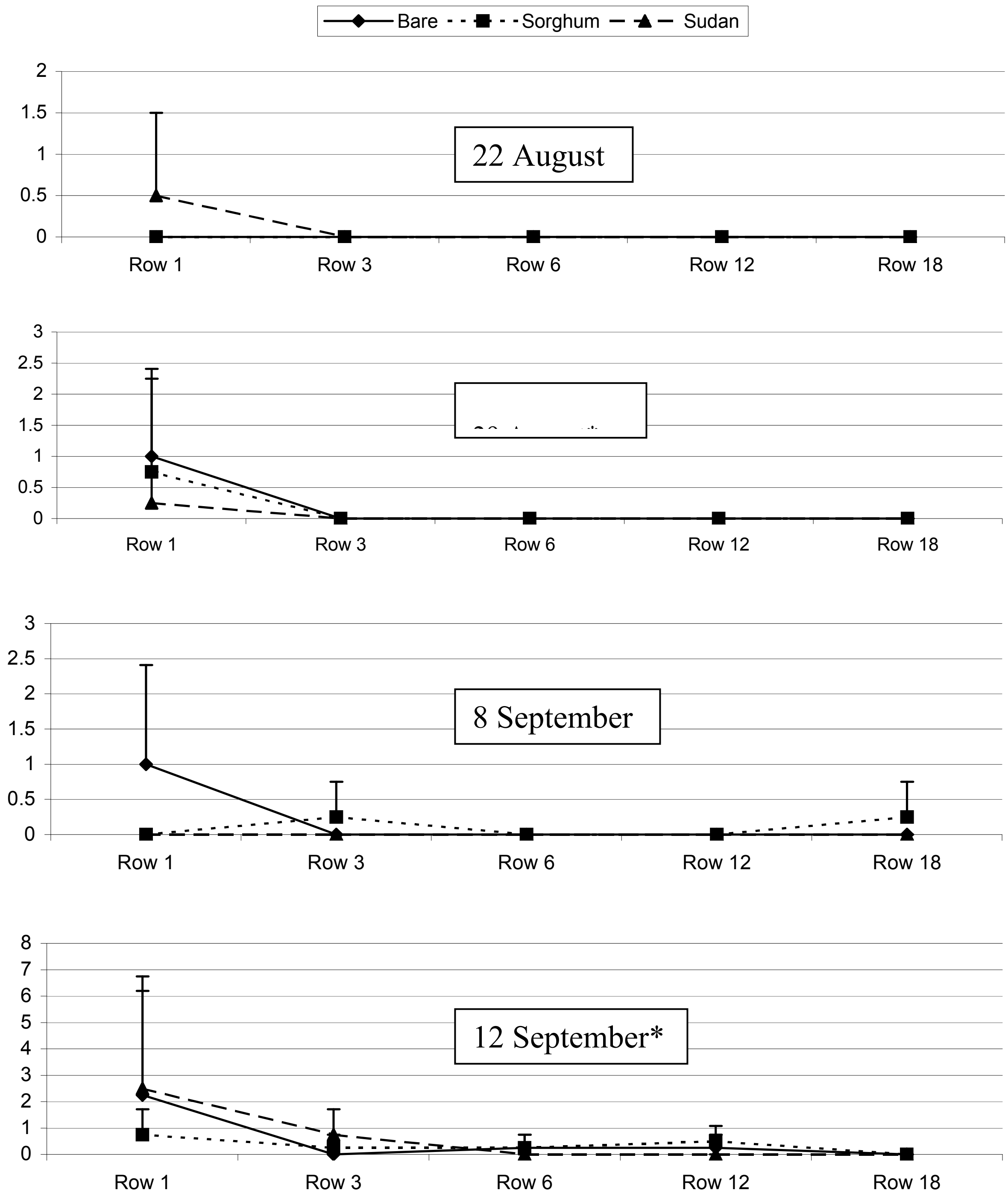
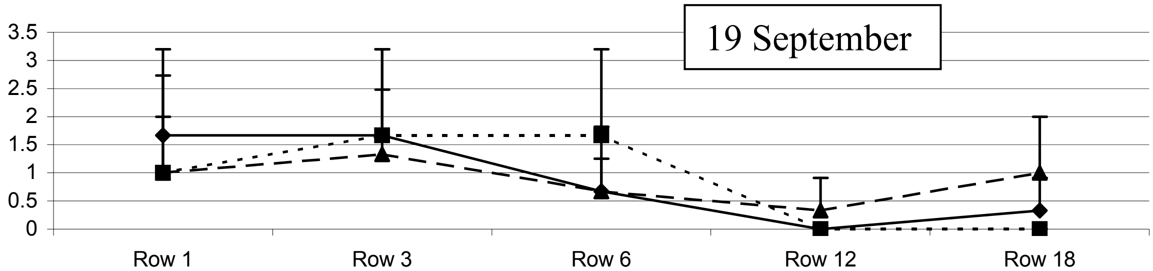


Fig. 2. Number of stink bug nymphs per 25 sweeps (y axis) in relation to border type (bare soil, sorghum, and sorghum sudangrass) and number of rows from barrier (20 bolls sampled per row per date). No significant differences were observed among barrier treatments on any sample date.





19 September
3.5
3
2.5
2
1.5
1
0.5
0
Row 1
Row 3
Row 6
Row 12
Row 18

Fig. 3. Boll injury in relation to field border in Trial 1 (20 bolls sampled per row per date). No significant differences were observed among barrier treatments, so all barrier treatments are pooled here. Significant differences among rows were observed on 16 and 22 August and 12 September.

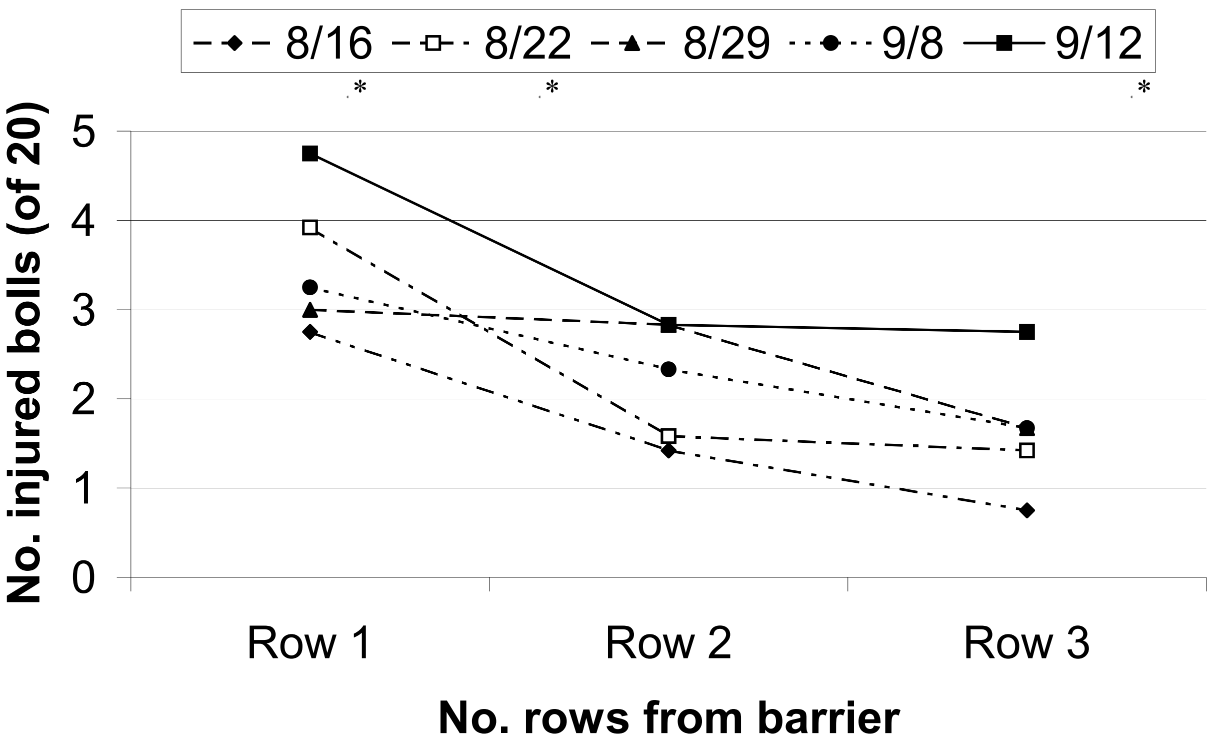
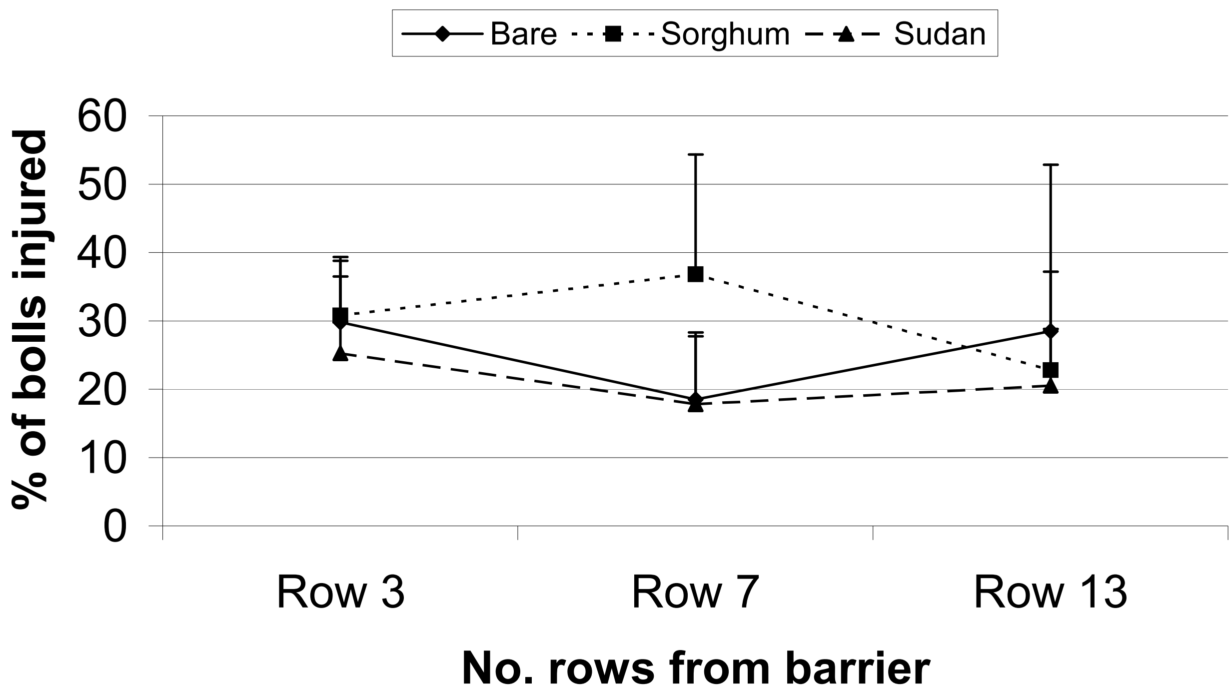


Fig. 4. Boll injury in relation to field barrier type and number of rows distant from barrier (100 bolls sampled per row at end of the season). No significant differences were observed among barrier treatments or rows.



EVALUATION OF A DYNAMIC THRESHOLD FOR MANAGEMENT OF BOLL FEEDING BUGS

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Introduction

Boll feeding bugs have emerged as primary pests of cotton following the successful elimination of the boll weevil as an economic pests and the commercialization of Bt cotton. A complex of bugs exploits the low insecticide use environment and feeds on developing bolls. Stink bugs, primarily the southern green and brown, are the primary boll feeding bugs in this complex. However, tarnished and clouded plant bugs, and leaf-footed bugs may also damage developing bolls. Research has documented losses in both yield and fiber quality to the boll feeding bug complex in Georgia.

Management of stink bugs is accomplished by thorough scouting of medium sized bolls for internal symptoms of feeding. Bolls which have callous growths or warts on the inner surface of the boll wall and/or stained lint are considered damaged. Insecticide treatments are recommended when 20 percent of medium sized bolls (the diameter of a quarter) display internal signs of feeding and stink bugs are observed. Scouts should be observant for bugs when making plant inspections allowing for appropriate insecticide selection if boll damage thresholds are exceeded. Pyrethroid insecticides provide good control of southern green stink bugs but only fair control of brown stink bugs. When brown stink bugs comprise an economic population, organophosphate insecticides are recommended.

The current threshold is static in that the 20 percent internal boll damage level is held constant throughout the season. However, during the growing season the actual number of bolls per plant which are susceptible (less than 25 days of age) to stink bugs varies. The number of bolls per plant which are susceptible to stink bug damage tends to increase in time from the first week of bloom to about the fifth week of bloom and then decreases as plants approach cutout. Intuitively the use of a dynamic or changing threshold which considers the number of susceptible bolls per plant is logical. Potential damage when many bolls per plant are susceptible is much greater than when only a few bolls per plant are susceptible. Thus the objective of these trials was to evaluate a dynamic threshold for management of the boll feeding bug complex.

Methods

Field experiments were established at five locations during 2006 to evaluate the feasibility of a dynamic threshold for management of stink bugs. Three field sites were located in Tift county (RDC Pivot and Lang Farm on the Coastal Plain Experiment Station and at the ABAC Farm), one at the Sunbelt EXPO in Colquitt county, and one at the Southwest GA Research and Education Center near Plains GA in Sumter county. Treatments were arranged in a randomized complete block and replicated four times at each location. Plots varied in size from 6 to 12 rows wide and 40-50 feet in length. Treatments included an untreated check, the current threshold of 20 percent internal boll damage, a dynamic threshold (30 percent internal boll damage during the first and second week of bloom, 10 percent during weeks 3-5 of bloom, and 30 percent after the fifth week of bloom), and an aggressively sprayed (weekly applications). Plots were scouted weekly by examining 10 bolls per plot for internal damage. When thresholds were exceeded in a given treatment, Bidrin at 8 ozs/acre and Baythroid at 3.2 ozs per acre were applied with a self-propelled high clearance sprayer calibrated to deliver 7 gpa with TXVS 8 hollow cone nozzles spaced 18 inches apart. The center two or four rows from each plot were machine harvested and seedcotton samples were submitted to the UGA MicroGin for processing and fiber quality analysis. The mean number of insecticide applications required, lint yield, and net return to management (lint value $0.60/lb and $8.00 per insecticide application) in individual trials were used as replicates and analyzed using an analysis of variance. Treatment means were separated using LSD (P=0.05).

Results

Stink bug populations were generally low at all field sites with the exception of Plains which was planted within a peanut field. The mean number of insecticide applications required in the 20 percent threshold was 0.6 and 1.4 in the dynamic threshold (Table 1). The number of insecticide applications required ranged from 0 to 1 in the 20 percent threshold (two of the five locations never exceeded the 20 percent threshold) and 1 to 2 in the dynamic threshold. The aggressively sprayed plots were sprayed 4 to 7 times depending on location. No significant differences were observed in lint yield; however both threshold treatments and the aggressively sprayed treatment tended to increase yields compared with the untreated. No significant differences were observed in net return to stink bug management above that of the untreated. However, the threshold treatments tended to improve net returns greater than the aggressively sprayed treatment.

Table 1. Number of insecticide applications required, lint yield, and net return to management of boll feeding bugs at five locations, Georgia 2006.

	No. Insecticide Applications	Yield (lbs lint/acre)	Net Return Above Untreated per Acre
Untreated	0.00 a	1302 a	na
20 Percent Threshold	0.60 ab	1345 a	$22.32 a
Dynamic Threshold	1.40 b	1369 a	$29.40 a
Aggressively Sprayed	6.00 c	1385 a	$4.74 a

Means followed by same letter do not significantly differ (P=0.05, LSD)

Boll feeding bug populations were unusually low during 2006; however the data indicates that in the absence of threshold populations, there is no economic advantage to applying insecticides. Thorough stink bug scouting and the use of thresholds is a must to maximize economic returns. Intuitively, consideration should be given to the number of bolls per plant susceptible to stink bugs when making a treatment decision.

EFFECTS OF INSECTICIDAL TREATMENTS ON THRIPS ABUNDANCE, COTTON GROWTH AND YIELD IN SOUTH GEORGIA

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Introduction

Thrips in the genus *Frankliniella* are perennial pests of cotton in Georgia, and can have various substantive impacts on cotton production, ranging from minor cosmetic damage, to delay of crop maturity, or even stand destruction (Watts 1937, Hawkins et al. 1966). Thrips begin feeding on cotton in Georgia immediately after seedling emergence. The plants are at greatest risk early in the season when the seedlings can be quite susceptible to thrips damage on the leaves and growing meristem. In some instances, damage is severe enough to cause abortion of the terminal and loss of apical dominance. Thrips populations vary greatly from year to year, but in severe infestations, they can reduce yields by as much as 50 or 60 percent if not controlled by insecticides applied in-furrow, as seed treatments, or foliar sprays (Johnson et al. 2001). Lambert (1985) states that dealing with the thrips problem in cotton is complex. Universities in many cotton-producing states offer suggestions for thrips control, though their research rarely shows yield increases attributable to these control measures. Increased industry-grower interest in early season pest management has prompted us to evaluate the efficacy of insecticides for thrips management in south Georgia.

Materials and Methods

Cotton (variety DPL 555B/RR) was planted on 24 May 2006 at the Lang-Rigdon Farm of the Coastal Plain Experiment Station in Tift County, Georgia, using a Monosem pneumatic planter equipped to add granular insecticides in the furrow. Plots were 4 rows by 50 ft long, with a 36-inch row spacing and 4 replications per treatment. Eight replications were used for the untreated control because an anticipated treatment was never applied and the additional 4 replications were pooled with the original 4 untreated plots. Throughout the course of the season, all plots were irrigated for optimum growth. The treatments were (1) an untreated control, (2) V-10193 10% WP at 22 grams ai/acre foliar spray, (3) V-10193 10% WP at 45 grams ai/acre foliar spray, (4) V-10193 10% WP at 90 grams ai/acre foliar spray, (5) Orthene 97 pellets at 0.5 lb ai/acre foliar spray, (6) V-10193 10% WP at 100 grams ai/acre in-furrow spray, (7) V-10193 10% WP at 200 grams ai/acre in-furrow spray, (8) V-10193 10% WP at 400 grams ai/acre in-furrow spray, and (9) Temik 15G at 5 lb product/a in-furrow. The in-furrow and foliar treatments were applied with a CO_2-powered backpack sprayer using a single TX6 nozzle calibrated to deliver 4.7 GPA. The Temik treatment was applied with the Monosem planter. For the in-furrow treatments, the planter press wheels were secured to allow the furrows to remain open and the insecticides were applied immediately after planting with the backpack sprayer. Upon completion of the sprays, the furrows were covered with soil using a hoe. The foliar sprays were applied 8 June 2006.

Thrips were sampled 1, 2, 3, and 4 weeks after planting. Each sample consisted of five plants that were picked and swirled in a 1-pint jar containing ca. 300 ml of water, with several drops of liquid dishwashing detergent added as a surfactant. Samples were returned to the laboratory for counting. Each sample was poured through a 120-mesh sieve (Hubbard Scientific Co., Northbrook, IL) and rinsed with tap water. The thrips were then flushed into a 100 x 15 mm plastic petri dish for microscopic examination. Both adults and nymphs were counted, though the numbers were pooled for statistical analysis. Visual ratings were made on 22 June 2006, with each plot assigned a damage rating from 1 to 5, where 1 equaled no visible thrips damage and 5 equaled severe thrips damage. Open flower counts were made on 27 July 2006. Height measurements and node counts were taken on 27 July and 1 Sept. Seed cotton yields were taken by mechanically picking the middle 2 rows of each plot 20 October 2006.

Data (thrips numbers, visual ratings, height measurements, node counts, flower counts, and yield) were analyzed using the general linear models procedure, followed by separation of significantly different means using Duncan's New Multiple Range Test, with $p<0.05$ as the upper limit for significance (SAS Institute 1999).

Results and Discussion

In samples taken 2 and 4 weeks after planting, there were no significant differences in thrips numbers (Tables 1-3). Foliar sprays were not applied until after thrips samples were collected 2 weeks post-planting, thus these treatments should be viewed as equivalent to the untreated control until sample weeks 3 and 4. Significant differences occurred in the week 1 and 3 samples, though some they may have been due to clumped thrips populations. However, there was a significant reduction generally in those treatments applied at planting (Temik, Orthene, and V10193). Foliar applications had not yet been made, so one would not expect a reduction in the foliar-treated plots at this stage of the trial. However, in week 1, plots assigned to the Orthene foliar spray had significantly fewer thrips than the untreated plots even though the actual Orthene application did not occur until one week later (Table 3), suggesting that there was significant noise in the data. Overall, thrips numbers in our experimental plots were generally lower than previous years.

With the visual damage ratings, all treatments had significantly less thrips damage than the untreated control plots (Table 4). The in-furrow treatments, including Temik, had numerical ratings with the least damage. The foliar treatments had higher numerical damage ratings, probably because they were not applied until 8 June, allowing thrips damage to occur during a period of two weeks post-planting (Table 4).

No significant differences were seen among treatments for our height measurements and node samples on either 27 July or 1 September (Table 5). This was also true for open flower samples taken on 27 July, though numerically, plots receiving Temik® or a foliar spray of 45 g ai/acre of V-10193 10% WP had nearly twice as many open flowers as the untreated plots (Table 5).

None of the treated plots differed significantly from untreated plots in seed cotton yield. In some instances, treated plots actually resulted in a lower numerical yield than the untreated plots (Table 6). The highest numerical yield was in plots treated with aldicarb (Temik® 15G) at 5.0 lbs per acre.

Our insecticidal treatments failed to significantly improve yields relative to the untreated plots, even in those instances where thrips abundance was reduced. This may be due to the low thrips numbers in 2006. Even in years with higher thrips populations, the extended growing season in south Georgia may allow the plants to compensate for damage incurred early in the season, effectively masking any potential yield effects.

Acknowledgment

We thank Alton Hudgins and Javier Madrigal-Sanchez for their technical assistance in this research and Valent Corporation for their provision of materials and financial support.

References Cited

Hawkins, B. S., H. A. Peacock, and T. E. Steele. 1966. Thrips injury to upland cotton (*Gossypium hirsutum* L.) Varieties. Crop Sci. 6: 256-8.

Johnson, D.R., J.D. Hopkins, G.M. Lorenz, III and J.D. Reaper, III. 2001. Evaluation of thrips management options in cotton. *In* Proceedings, 2001 Beltwide Cotton Production Conferences, National Cotton Council of America, Memphis, TN, 2: 1086-1088.

Lambert, W. R. 1985. The thrips problem. *In* Proceedings, Beltwide Cotton Production Conference, National Cotton Council of America, Memphis, TN,: 130-131.

SAS Institute. 1999. SAS/STAT User's guide, version 8.02. SAS Institute, Cary, NC.

Watts, J. G. 1937. Reduction of cotton yields by thrips. J. Econ. Entomol. 30: 860-863.

Table 1. Numbers of immature thrips per plant in relation to insecticide treatment (foliar treatments applied on 8 June 2006 [15 DAP], following sampling on that date). Significant differences were observed on 15 June.

Treatment	Application	Sample dates[a]			
		1 June	8 June	15 June	22 June
Untreated	NA	0.13 ± 0.15	1.03 ± 1.35	0.55 ± 0.50 A	0.48 ± 0.45
V10193 22 g ai	Foliar spray	**0.20 ± 0.28**	**1.85 ± 2.64**	0.55 ± 0.38 A	0.25 ± 0.25
V10193 45 g ai	Foliar spray	**0.0 ± 0.00**	**1.10 ± 0.74**	0.0 ± 0.00 B	0.10 ± 0.20
V10193 90 g ai	Foliar spray	**0.0 ± 0.00**	**1.30 ± 0.60**	0.0 ± 0.00 B	0.20 ± 0.23
V10193 100 g ai	In-furrow spray	0.0 ± 0.00	0.20 ± 0.40	0.10 ± 0.20 B	0.45 ± 0.44
V10193 200 g ai	In-furrow spray	0.0 ± 0.00	0.45 ± 0.77	0.20 ± 0.16 AB	0.50 ± 0.60
V10193 400 g ai	In-furrow spray	0.0 ± 0.00	0.70 ± 0.66	0.05 ± 0.10 B	0.15 ± 0.19
Orthene 0.5 lbs./A	Foliar spray	0.0 ± 0.00	1.65 ± 2.37	0.0 ± 0.00 B	0.35 ± 0.30
Temik 5 lb product	In-furrow granule	0.0 ± 0.00	0.35 ± 0.70	0.05 ± 0.10 B	0.05 ± 0.10
	df	8,31	8,31	8,31	8,31
	F	2.00	0.72	3.46	1.03
	P	0.0796	0.6764	0.0058	0.4379

[a]Means in columns followed by the same letters are not significantly different (Waller-Duncan Bayesian *k* ratio, *k* = 100).
Foliar sprays were not applied until 8 June 2006, thus the bold numbers represent thrips samples that were essentially equivalent to the untreated control group.

Table 2. Numbers of adult thrips per plant in relation to insecticide treatment (foliar treatments applied on 8 June 2006 [15 DAP], following sampling on that date).

Treatment	Application	Sample dates[a] 1 June	8 June	15 June	22 June
Untreated	NA	0.55 ± 0.45 AB	0.20 ± 0.19 B	0.13 ± 0.15	0.23 ± 0.23 AB
V10193 22 g ai	Foliar spray	**0.60 ± 0.16 A**	**0.10 ± 0.12 B**	0.05 ± 0.10	0.0 ± 0.00 B
V10193 45 g ai	Foliar spray	**0.50 ± 0.34 AB**	**0.20 ± 0.16 B**	0.10 ± 0.20	0.0 ± 0.00 B
V10193 90 g ai	Foliar spray	**0.40 ± 0.28 AB**	**0.65 ± 0.47 A**	0.05 ± 0.10	0.05 ± 0.10 AB
V10193 100 g ai	In-furrow spray	0.10 ± 0.12 B	0.25 ± 0.19 B	0.05 ± 0.10	0.20 ± 0.16 AB
V10193 200 g ai	In-furrow spray	0.15 ± 0.19 AB	0.20 ± 0.28 B	0.10 ± 0.12	0.25 ± 0.10 A
V10193 400 g ai	In-furrow spray	0.30 ± 0.12 AB	0.10 ± 0.12 B	0.10 ± 0.20	0.0 ± 0.00 B
Orthene 0.5 lbs./A	Foliar spray	0.20 ± 0.16 AB	0.30 ± 0.26 AB	0.05 ± 0.10	0.15 ± 0.19 AB
Temik 5 lb product	In-furrow granule	0.10 ± 0.12 B	0.05 ± 0.10 B	0.05 ± 0.10	0.0 ± 0.00 B
	df	8,31	8,31	8,31	8,31
	F	2.30	2.36	0.30	2.76
	P	0.0462	0.0412	0.9607	0.0199

[a]Means in columns followed by the same letters are not significantly different (Waller-Duncan Bayesian *k* ratio, *k* = 100).
Foliar sprays were not applied until 8 June 2006, thus the bold numbers represent thrips samples that were essentially equivalent to the untreated control group.

Table 3. Numbers of total thrips per plant (adults and immatures) in relation to insecticide treatment (foliar treatments applied on 8 June 2006 [15 DAP], following sampling on that date).

Treatment	Application	Sample dates[a] 1 June	8 June	15 June	22 June
Untreated	NA	0.68 ± 0.41 AB	1.23 ± 1.43	0.68 ± 0.58 A	0.70 ± 0.63
V10193 22 g ai	Foliar spray	**0.80 ± 0.43 A**	**1.95 ± 2.57**	0.60 ± 0.43 AB	0.25 ± 0.25
V10193 45 g ai	Foliar spray	**0.50 ± 0.36 ABC**	**1.30 ± 0.68**	0.10 ± 0.20 B	0.10 ± 0.20
V10193 90 g ai	Foliar spray	**0.40 ± 0.28 ABC**	**1.95 ± 0.79**	0.05 ± 0.10 B	0.25 ± 0.19
V10193 100 g ai	In-furrow spray	0.10 ± 0.12 C	0.45 ± 0.53	0.15 ± 0.19 AB	0.65 ± 0.57
V10193 200 g ai	In-furrow spray	0.15 ± 0.19 C	0.65 ± 1.05	0.30 ± 0.26 AB	0.75 ± 0.57
V10193 400 g ai	In-furrow spray	0.30 ± 0.12 BC	0.80 ± 0.77	0.15 ± 0.19 AB	0.15 ± 0.19
Orthene 0.5 lbs./A	Foliar spray	0.20 ± 0.16 C	1.95 ± 2.34	0.05 ± 0.10 B	0.50 ± 0.42
Temik 5 lb product	In-furrow granule	0.10 ± 0.12 C	0.40 ± 0.80	0.10 ± 0.20 B	0.05 ± 0.10
	df	8,31	8,31	8,31	8,31
	F	3.56	0.84	2.67	1.84
	P	0.0049	0.5719	0.0235	0.1078

[a]Means in columns followed by the same letters are not significantly different (Waller-Duncan Bayesian *k* ratio, *k* = 100).

Means followed by the same letter are not significantly different (P>0.05).

Foliar sprays were not applied until 8 June 2006, thus the bold numbers represent thrips samples that were essentially equivalent to the untreated control group.

Table 4. Visual damage ratings for various thrips control treatments, where 1 equals no visible thrips damage and 5 equals severe thrips damage. Tift Co., GA, 22 June 2006.

Insecticide Treatment		Damage Rating
Untreated		3.9 ± 0.64 A
V-10193 10% WP at 22 grams ai/acre foliar spray		2.6 ± 0.25 B
V-10193 10% WP at 45 grams ai/acre foliar spray		2.0 ± 0.41 CD
V-10193 10% WP at 90 grams ai/acre foliar spray		2.0 ± 0.41 CD
V-10193 10% WP at 100 grams ai/acre in-furrow spray		1.9 ± 0.48 CD
V-10193 10% WP at 200 grams ai/acre in-furrow spray		1.9 ± 0.48 CD
V-10193 10% WP at 400 grams ai/acre in-furrow spray		1.6 ± 0.48 CD
Orthene 97 pellets at 0.5 lb ai/acre foliar spray		2.1 ± 0.25 BC
Temik 15G at 5 lb product/a in-furrow		1.5 ± 0.00 D
df		8,31
	F	16.50
	P	<0.0001

Means followed by the same letter are not significantly different (P>0.05).

Table 5. Average height of 10 consecutive plants, average total nodes per 10 consecutive plants, and average no. open flowers per 10 consecutive plants on cotton with various insecticidal thrips treatments. Tift Co., GA. 2006. None of the means were significantly different

	Avg. height (cm) 27 July	Avg. height (cm) 1 Sept	Avg. total nodes per plant 27 July	Avg. total nodes per plant 1 Sept	Avg. open flowers per plant 27 July
Untreated	57.9 ± 19.65	79.8 ± 18.98	14.3 ± 2.00	22.8 ± 1.93	0.27 ± 0.18
V-10193 10% WP at 22 grams ai/acre foliar spray	50.8 ± 13.47	81.8 ± 15.63	13.6 ± 1.66	22.8 ± 1.75	0.38 ± 0.17
V-10193 10% WP at 45 grams ai/acre foliar spray	64.3 ± 16.45	77.9 ± 16.09	14.4 ± 1.71	21.1 ± 2.15	0.35 ± 0.33
V-10193 10% WP at 90 grams ai/acre foliar spray	61.7 ± 23.60	81.9 ± 20.25	14.1 ± 2.48	22.3 ± 1.76	0.25 ± 0.29
V-10193 10% WP at 100 grams ai/acre in-furrow spray	53.4 ± 22.69	75.9 ± 16.54	13.3 ± 1.95	22.4 ± 1.29	0.25 ± 0.19
V-10193 10% WP at 200 grams ai/acre in-furrow spray	65.4 ± 14.55	86.4 ± 18.78	14.0 ± 1.25	21.8 ± 2.51	0.25 ± 0.13
V-10193 10% WP at 400 grams ai/acre in-furrow spray	58.0 ± 27.59	73.3 ± 17.73	13.4 ± 3.04	20.3 ± 1.37	0.23 ± 0.22
Orthene 97 pellets at 0.5 lb ai/acre foliar spray	66.4 ± 16.47	78.5 ± 19.68	14.9 ± 1.04	21.6 ± 1.58	0.48 ± 0.39
Temik 15G at 5 lb product/a in-furrow	74.6 ± 7.62	88.3 ± 9.54	14.9 ± 1.00	22.1 ± 1.83	0.50 ± 0.34
df	8,31	8,31	8,31	8,31	8,31
F	0.60	0.30	0.40	0.90	0.69
P	0.7690	0.9610	0.9105	0.5310	0.6970

Table 6. Seed cotton yields of insecticide treatments for thrips control. Tift Co., GA, 2006. No significant differences were detected.

Insecticide Treatment		Pounds Seed Cotton/Acre
Untreated		3753 ± 1082.3
V-10193 10% WP at 22 grams ai/acre foliar spray		3659 ± 701.3
V-10193 10% WP at 45 grams ai/acre foliar spray		4185 ± 747.8
V-10193 10% WP at 90 grams ai/acre foliar spray		3568 ± 1416.8
V-10193 10% WP at 100 grams ai/acre in-furrow spray		3576 ± 944.5
V-10193 10% WP at 200 grams ai/acre in-furrow spray		3975 ± 1058.3
V-10193 10% WP at 400 grams ai/acre in-furrow spray		3935 ± 1345.6
Orthene 97 pellets at 0.5 lb ai/acre foliar spray		4007 ± 1086.3
Temik 15G at 5 lb product/a in-furrow		4585 ± 349.4
df		8,27
	F	0.41
	P	0.9022

Efficacy of Seed-treatments for Management of Nematodes on Cotton in Georgia

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Abstract

Results from 26 cotton studies conducted in 2004, 2005, and 2006 are reported here. Field sites were naturally infested with either southern root-knot nematodes (*Meloidogyne incognita*), reniform nematodes (*Rotylenchlus reniformis*), or Columbia lance nematodes (*Hoplolaimus columbus*). Efficacy of new seed treatments AVICTA Complete Pak and AERIS Seed-Applied System were compared to that of aldicarb (Temik 15G), and to commercial seed treated with insecticides thiomethoxam (Cruiser) or Imidacloprid (Gaucho Grande). Fumigant 1,3-dichloropropene (Telone II) was evaluated in 10 trials. Root gall ratings assessed approximately 30 days after planting were typically significantly lower on plants treated with aldicarb than on plants from seed treated with AVICTA Complete Pak, AERIS Seed-Applied System, Cruiser, or Gaucho Grande. It was difficult to statistically differentiate the efficacy of AVICTA Complete Pak from aldicarb (Temik 15G, 5.0 lb/A), Cruiser, or Gaucho Grande based upon final lint yields. In 14 of 25 studies, plots treated with aldicarb, 5.0 lb/A, numerically out-yielded plots where seeds treated with AVICTA Complete Pak were planted. The average yield advantage to aldicarb in these 14 trials was 119.5 lb lint/A; however in only one of the 14 trials was the yield difference between aldicarb and AVICTA Complete Pak significantly different. In 11 of 25 trials, plots that were planted to seeds treated with AVICTA Complete Pak out yielded plots treated with aldicarb (5.0 lb/A) with a yield advantage of 48.1 lb/A lint. Yields were significantly different in one of the 11 trials. Yield advantage to AVICTA Complete Pak over Cruiser or Gaucho Grande was 54.5 lb/A, though yield differences were statistically significant in only 1 of 25 trials. Where fumigation with 1,3-dichloropropene produced a significant increase in yield over use of

seed treatment AVICTA Complete Pak (four of 10 trials), the increase in lint per acre varied from 224 lb to 615 lb.

Introduction

Parasitic nematodes are one of the most important pest problems for cotton growers in Georgia today. In a recent random survey conducted by members of the University of Georgia's Cooperative Extension, it was found that nearly 70% of the commercial cotton fields included in the survey was infested with some level of plant parasitic nematodes. The southern root-knot nematode (*Meloidogyne incognita*) is the most important and widespread parasitic nematode on cotton in Georgia; however some growers are severely affected by reniform (*Rotylenchulus reniformis*), Columbia lance (*Hoplolaimus columbus*), and sting nematodes as well.

For the 2005 growing season, it was estimated that nematodes cost growers approximately $16.6 million in terms of lost yields and cost of nematicides to manage the problem. Cotton growers in Georgia typically manage nematodes with a combination of crop rotation and use of nematicides such as 1,3-dichlropropene (Telone II), aldicarb (Temik 15G) and oxamyl (Vydate C-LV). In 2003, researchers at the University of Georgia began evaluating a seed treatment from Syngenta, abamectin, for its efficacy in the management of parasitic nematodes on cotton. This work continued in 2004, 2005 and 2006. In 2005 and 2006, research was also conducted to evaluate the efficacy of two additional seed treatments, thiodicarb from Bayer CropScience, and a harpin protein N-Hibit from Eden Bioscience, for management of nematodes on cotton.

The objectives of the current study were to evaluate the efficacy of seed treatments that were reported to benefit cotton growers for efficacy both in small research plots and in large on-farm trials and to compare this efficacy to that of other nematicides commonly used by growers.

Materials and Methods

Assessment of the abamectin seed treatment from Syngenta was initiated in 2003 and continued during 2004, 2005, and 2006. Data from 2004, 2005, and 2006 will be presented here. A new seed treatment from Bayer CropScience that contains thiodicarb for control of nematodes was evaluated in five on-farm studies in 2006. The seed treatment from Eden Bioscience, N-Hibit, was evaluated in three on-farm trials and one small-plot study in 2005 and in an additional two on-farm studies in 2006. All seed treatments were placed in addition to the standard fungicide packages present on commercial cotton seeds.

Avicta (abamectin) was evaluated as a component of AVICTA Complete Pak with treated seed provided by Syngenta in 2004 and 2005 and on seed provided by the either Syngenta or the grower in 2006. AVICTA Complete Pak is a combination of the fungicide seed treatment Dynasty CST (azoxystrobin, fludioxonil, and mefenoxam), Cruiser (0.34 mg/seed) and abamectin (0.15 mg/seed).

The seed treatment assessed in 2006 for Bayer CropScience included thiodicarb, imidacloprid, and the Trilex Advanced Seed Applied System (trifloxystrobin, triadimenol, and metalaxyl).

The active ingredient in N-Hibit from Eden Bioscience is a harpin protein. In five of the trials where this product was assessed in this study, commercial seed was treated at a local treatment facility with 5.0 oz/100 lb seed + Cruiser insecticide at 0.34 mg/seed. In a single study (Taylor County), the N-Hibit was mixed with the seed at the time of planting at a rate of 3 oz/100 lbs seed.

Aldicarb (Temik 15G) was evaluated in each study at the rates of 3.5 and 5.0 lb/A. Temik 15G was applied to the open furrows at planting.
The fumigant Telone II was assessed in a number of the on-farm field trials at a rate of 3 gal/A. Telone II was applied with a single chisel in-row 12-inches deep to appropriate plots at least seven days prior to planting. Temik 15G, 3.5 lb/A, or seed treated with imidacloprid or thiomethoxam was used to control early season thrips.

Descriptions of the individual field trials are presented in Tables 1 and 2. The experimental design in each study was a randomized complete block with 3-6 replications depending on the location. Soil samples were collected at planting, mid-season, and at harvest and analyzed for nematode populations. Gall ratings were taken at the Gibbs Farm within 28 days after planting to assess damage to the young root systems. Lint yields were calculated at each site based upon an estimated 38% gin turnout for lint. Finally, data were analyzed using analysis of variance and mean separation was performed using Fisher's Protected Least Significant Differences at $p \leq 0.05$, $p \leq 0.1$or $p \leq 0.15$.

Results and Discussion

The yield results from the field trials are presented in Table 3 and gall ratings from the Gibbs Farm, Coffee 2006, Mitchell Rohm & Haas Farm 2006, and Coarsey Farm 2006 trials are presented in Table 4. The average number of nematodes per 100 cm^3 soil collected at harvest from a site is presented in Table 1.

Where galls resulting from southern root-knot nematodes were assessed early in the season (approximately 30 days after planting), plants treated with Temik 15G typically had lower ratings than did plots planted to seed treated with AVICTA Complete Pak, AERIS Seed-Applied System, Cruiser, or Gaucho Grande.

Twenty-five data sets are presented in this paper comparing AVICTA Complete Pak to Temik 15G, 5.0 lb/A. AVICTA Complete Pak out-yielded Temik 15G, 5.0 lb/A, in 11 of these trials; however only in one of these trials were the yields statistically different. Temik 15G, 5.0 lb/A, out-yielded AVICTA in 14 trials; however yields were statistically different in only one of the 14 trials. The numeric yield advantage to Temik 15G over AVICTA Complete Pak was 119.5 lb lint/A. The numeric yield advantage to AVICTA Complete Pak over Temik 15G was 48.1 lb lint/A.

Ten data sets are presented in this paper where AVICTA Complete Pak is compared directly to Telone II, 3 gal/A. Plots treated with Telone II significantly out yielded plots planted with seed treated with AVICTA Complete Pak in four of 10 trials. Yield advantage to Telone II ranged from 224 to 615 lb lint/A.

In the five studies where they were compared, yields were not statistically different between the AVICTA Complete Pak and AERIS Seed-Applied System from Bayer CropScience. In the six studies where N-Hibit + Temik 15G was compared to Temik 15G, 5.0 lb/A, alone, the yields were not statistically different in any trial between the two treatments.

From studies conducted during 2004, 2005, and 2006 in Georgia, it becoming more possible to determine a “fit” for AVICTA Complete Pak is in the management of plant parasitic nematodes of cotton. In these tests, yields from plots planted with AVICTA Complete Pak-treated seed were often similar to plots where Temik 15G was applied at 5.0 lb/A at planting. However, as there were no statistical differences in yield between plots treated with Temik, AVICTA Complete Pak, or Cruiser alone, it is impossible to say exactly how effective the AVICTA Complete Pak was against nematodes. Still, there is some interest in the observation that the yield advantage to Temik 15G was approximately twice the value of the yield advantage to AVICTA Complete Pak in these trials.

In studies conducted at the Gibbs Farm in 2004 and 2005, early season gall rating could be statistically combined as the interaction between years was not significant. Gall ratings were significantly lower for Temik 15G, 3.5 lb/A, than for AVICTA Complete Pak and for Cruiser-treated seed. This was documented again at the Nugent farm and the Rohm & Haas farm in 2006.

Although only assessed in five trials, it was not possible to differentiate AERIS Seed-Applied System from AVICTA Complete Pak.

Use of N-Hibit seed treatment with Temik 15G did not increase yields over Temik 15G, 5.0 lb/A used alone in six trials.

Conclusion

From the data reported here, it appeared that use of Temik 15G provided better early-season management of southern root-knot nematodes than did AVICTA Complete Pak or AERIS Seed-Applied System. However, it was not possible to statistically differentiate the yield advantage to Temik 15G versus AVICTA Complete Pak from this study. Use of N-Hibit with Temik 15G did not increase yields over use of Temik 15G alone. Where Telone II was used in situations with high populations of nematodes, yields were significantly increased by up to 615 lb lint/A.

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Table 1. Characteristics of fields sites used in study cotton seed treatments.

County	Site	Year	Soil type	Reps[z]	Irrigation	Nematode	Fall Count[y]
Colquitt*	Perryman	2004	Loamy sand	4	No	Root-knot[x]	
Colquitt*	Perryman	2005	Loamy sand	4	No	Root-knot	855
Mitchell*	Windhausen	2005	Loamy sand	4	Yes	Root-knot	506
Coffee*	Nugent	2004	Loamy sand	3	Yes	Root-knot	177
Coffee*	Nugent	2005	Loamy sand	3	Yes	Root-knot	532
Tift**	Gibbs Farm	2004	Loamy sand	6	Yes	Root-knot	--
Tift**	Gibbs Farm	2005	Loamy sand	6	Yes	Root-knot	456
Burke**	Midville	2004	Loamy sand	5	Yes	Col. lance[w]	167
Burke**	Midville	2005	Loamy sand	4	Yes	Col. lance	72
Burke*	Storey	2005	Loamy sand	4	Yes	Reniform[u]	--
Taylor*	Green	2005	Loamy sand	4	No	Reniform	1311
Floyd*	Jordan	2005	Loamy sand	4	No	Root-knot	234
Elbert*	Evanson	2005	Loamy sand	4	Yes	Root-knot	207
Colquitt*	Perryman	2006	Loamy sand	4	No	Root-knot	288
Mitchell*	Windhausen	2006	Loamy sand	4	Yes	Root-knot	--[v]
Mitchell**	Rohm & Haas	2006	Loamy sand	4	Yes	Root-knot	--
Coffee*	Nugent-1	2006	Loamy sand	3	Yes	Root-knot	489
Coffee*	Nugent-2	2006	Loamy sand	3	Yes	Root-knot	391
Grady*		2006	Loamy sand	4	Yes	Root-knot	394
Bleckley*		2006	Loamy sand	3	Yes	Reniform	--
Colquitt*	Coarsey	2006	Loamy sand	4	Yes	Root-knot	--
Elbert*	Evanson	2006	Loamy sand	4	Yes	Root-knot	--
Floyd*	Jordan	2006	Loamy sand	3	No	Root-knot	--
Burke**	Midville-1	2006	Loamy sand	5	Yes	Col. lance	17
Burke**	Midville-2	2006	Loamy sand	6	No	Col. lance	--

*On-farm trials. Plots were 4-10 rows wide by length of field.
**Small-plot trials. Plots were 2-4 rows wide by 25-40 ft in length.
[z]Number of replications in the trial.
[y]Average number of nematodes/100 cm^3 soil across treatments in sample collected at harvest.
[x]Southern root-knot nematode, *Meloidogyne incognita*.
[w]Columbia lance nematodes, *Hoplolaimus columbus*.
[u]Reniform nematodes, *Rotylenchulus reniformis*.
[v]Final nematode results not available at time of report.

Table 2. Listing of nematicide treatments included in each trial.

Site	Variety	Cruiser	Gaucho Grande	Temik	Temik	Telone II [a]	AVICTA Complete Pak[b]	N-Hibit + Temik	AERIS Seed Trt[c]
		0.34 mg/seed		3.5 lb/A	5.0 lb/A	3 gal/A + 3.5 lb/A		3.0-5.0 oz/seed + 5.0 lb/A	
Perryman 04	DP 555	X		X	X	X	X		
Perryman 05	DP 555	X		X	X	X	X	X	
Windhausen 05	DP 555	X		X	X	X	X		
Nugent 04	DP 555	X		X	X	X	X		
Nugent 05-1	DP 555	X		X	X	X	X		
Nugent 05-2	DP 555	X			X		X	X	
Gibbs Farm 04	DP 555	X		X	X		X		
Gibbs Farm 05	DP 555	X		X	X		X	X	
Midville 04	DP 555	X		X	X		X		
Midville 05	DP 555	X		X	X		X		
Storey 05	DP 555				X		X		
Green 05	DP 555	X		X	X		X	X	
Jordan 05	DP 444	X		X	X		X		
Evanson 05	ST 5599	X		X	X		X		
Perryman 06	DP 555	X			X	X	X	X	X
Windhausen 06	DP 555	X			X	X	X		X
Rohm & Haas 06	DP 555		X		X		X		
Nugent 06	DP 555	X		X		X	X		
Nugent 06	DP 555	X			X		X	X	X
Grady 06	DP 555		X		X	X	X		X
Bleckley 06	DP 555	X		X	X		X		X
Coarsey 06	DP 555		X		X		X		X
Evanson 06	DP 445	X			X		X		
Jordan 06	DP 444	X			X		X		
Midville 06	DP 555	X			X		X		
Midville 06	DP 555		X	X	X	X	X		

[a]Telone II is applied with either Cruiser, Gaucho Grande, or Temik 15G, 3.5 lb/A, for control of thrips.
[b]AVICTA Complete Pak is composed of Dynasty CST, Cruiser (0.34 mg/seed) and STAN (abamectin, 0.15 mg/seed).
[c]AERIS Seed-Applied System contains thiodicarb, imidocloprid, and the Trilex Advanced fungicide treatment (trifloxystrobin, triademinol, and metalaxyl).

Table 3. Lint yields from nematicide trials presented in this study.

Site	Cruiser	Gaucho Grande	Temik	Temik	Telone II[a]	AVICTA Comp. Pak[b]	N-Hibit + Temik	AERIS Seed Treatment[c]
	0.34 mg/seed		3.5 lb/A	5.0 lb/A	3 gal/A + 3.5 lb/A		3.0-5.0 oz/seed + 5.0 lb/A	
Yield (lb/A lint)								
Perryman 04	642 cd		632 d	678 cd	784 ab	727 bc		
Perryman 05	539 a		647 a	803 a	699 a	612 a	641 a	
Windhausen 05	1137 a		1086 d	1119 cd	1170 abc	1214 a		
Nugent 04	779 d		918 b	904 bc	1065 a	737 d		
Nugent 05-1	1103 d		1470 b	1283 bcd	1752 a	1137cd		
Nugent 05-2	1439 a			1646 a		1327 a	1465 a	
Gibbs Farm 2004-2005[d]	1051 a		1086 a	1175 a		1054 a		
Gibbs Farm 2005	1131 a		1184 a	1143 a		1070 a	1208 a	
Midville 04	1507 a		1446 a	1678 a		1483 a		
Midville 05	997 a		839 a	1018 a		1109 a		
Storey 05				722 a		755 a		
Green 05	242 a		197 b	223 ab		258 a	246 a	
Jordan 05	505 a		549 a	526 a		503 a		
Evanson 05	959 a		973 a	940 a		977 a		
Perryman 06	1017 f			1109 def	1340 a	1075 ef	1112de	1019 ef
Windhausen 06	1156 a			1183 a	1145 a	1192 a		1232 a
Rohm & Haas 06		969 a		980 a		964 a		
Nugent-1 06	1214cd			1378 ab	1474 a	1250 bcd		
Nugent-2 06	1316 c			1491 ab		1343bc	1354bc	1331 c
Grady 06		569 b		756 a	725 ab	808 a		771 a
Bleckley 06	1046 b		1156 ab	1135 ab		1051 b		1202 ab
Coarsey 06								
Evanson 06	904 bc			965 a		937abc		
Jordan 06	695 a			704 a		715 a		
Midville-1 06	1553 a			1368 a		1468 a		
Midville-2 06	1160 a		1063 a	1135 a	1147 a	1152 a		1036 a

*The data from the 2004 and 2005 Gibbs Farm trials was combined across years as the interaction between years was not significant.

**Means followed by the same letter are not different at p=0.05 according to Fisher's Protected LSD except for Grady 06 where p≤ 0.1.

Table 4. Early season gall ratings* from fields infested with the southern root-knot nematode.

Site	Cruiser	Gaucho Grande	Temik	Temik	AVICTA Comp. Pak*	N-Hibit + Temik	AERIS Seed Treatment
	0.34 mg/seed		3.5 lb/A	5.0 lb/A		3.0-5.0 oz/seed + 5.0 lb/A	
Gibbs Farm 2004-2005*	3.9 a		1.6 c	2.15 bc	3.05 ab		
Nugent-2 06	4.0 a			1.3 c	3.3 ab	2.0 bc	4.0 a
Rohm & Haas 06		2.5 abc		2.0 bc	3.5 a		
Coarsey 06	2.5 a			2.0 a	2.0 a		2.25 a

*Galls in 2004-2005 rated on a 1-10 scale where 0 = no observed galling, 1 = 10% galling, 2 = 20% galling, etc. Galls in 2006 rated on scale 1-5 based upon 1= no galling and 5= most severe.

** Data from 2004 and 2005 Gibbs Farm trials combined across years as the interaction between years was not significant.

***Means followed by the same letter are not different at $p \leq 0.05$ (Fisher's Protected LSD) at the Gibbs Farm, $p \leq 0.1$ at the Nugent Farm and $p \leq 0.15$ at the Rohm & Haas Farm .

FUNGAL FERMENTATION PRODUCTS FOR CONTROL OF ROOT-KNOT NEMATODES

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Introduction

Nematodes are a major constraint on cotton production in Georgia. As we move into a more competitive global environment for marketing cotton products, the total cost of production per acre becomes an increasingly critical factor the ability of our growers to compete. Plant-parasitic nematodes are a major factor in the net cost of production for cotton grown in Georgia. Results from a recent survey of cotton fields in Georgia showed that 69% of the sampled fields had root-knot nematodes (Kemerait, R., 2005). In 2005, according to Georgia Cooperative Extension Service estimates, plant-parasitic nematodes caused $72 million in crop losses on cotton, and incurred 81% of the cost of pesticides used for disease control (Martinez, A. , et. al., 2005). Although average damage levels due to nematodes may average 10% on cotton, these losses are not evenly distributed, and growers with problem fields are experiencing much higher levels of crop loss.

Options for management of nematodes in cotton are limited. The development of new nematode management options is a key factor in offering more choices to growers, and increasing the competition among nematode-control marketers. Commercially-acceptable cotton cultivars that are resistant to nematodes are not yet available, and breeding of new resistant cultivars is proceeding slowly. Chemical control of nematodes on cotton relies mainly on Temik (aldicarb), and Telone (1-3 dichloropropene). The use of traditional chemical pesticides for control of nematodes is both expensive and hazardous. The primary emphasis of this project is the development of novel nematicidal compounds derived from microbial culture filtrates. These nematicides are more targeted against nematodes and are less hazardous to the environment than traditional pest-control chemicals. Our hypothesis is that the effective use of new biologically-based nematicides can significantly reduce production costs and enhance consumer acceptance of the resulting cotton products, both for fiber and feed.

Materials and Methods

The search for bioactive compounds begins with the collection of soil samples from locations in Georgia with differing soil types and habitats. Soilborne fungi are then isolated from these samples by dilution-plating and use of selective growth media. Using this procedure, thousands of isolates of fungi are obtained. Candidate fungi are then selected from these collections and evaluated for production of nematicidal compounds. For evaluation, each fungus is placed in flasks containing nutrient agar and fermented with aeration on platform shakers for 10 days. As an in-vitro assay, liquid cultures are micro-filtered (0.22 µm) and pipetted into sterile microwell plates with freshly-hatched Southern root-knot nematode (*Meloidogyne incognita*) juveniles. Sterile water is used as a control treatment. Nematode survival rates are determined at 2, 4, 24, and 48 hours after suspension, with 6 replications per isolate. At the same time that the in-vitro assay is performed, liquid fungal-culture filtrates are also applied to a sterile soil mix in 6" greenhouse pots. Control treatments of sterile water, and a filtrate of the nutrient agar used for fermentation are also applied. Southern root-knot nematode (*M. incognita*) eggs are added to the pots, and cotton cv. DP555 is planted in each pot to serve as a susceptible host. Each treatment is applied to 6 replications. Plants are grown on greenhouse benches for 45 days. Plant roots are then removed from the pots and washed, and the nematode eggs are collected and counted. Total numbers of nematode eggs are compared using ANOVA followed by mean separation (LSD) for each fungal-isolate treatment and the controls. After mass screening of the fungal collection, a few isolates are selected and further evaluation using additional evaluation protocols. The methods used are similar to the greenhouse screening, but with different soil types, culture media, and fermentation protocols.

During the 2006 project, several advanced-stage fungal isolates were selected for a first trial in field plots. The objective of this study was to evaluate the efficacy of the fungal products over an entire growing season in the field. The four selected fungal isolates were fermented in quantities sufficient to treat the soil in small-scale, containerized field plots at rates equivalent to those used in greenhouse studies. Plots located at the CAES Plant Science Farm in Oconee County were inoculated with root-knot nematodes and planted with cotton DP555. The fungal treatments, along with a water control, were applied to 10 replicate plots each. Root-knot nematodes were assayed 8 times during the growing season, and cotton was harvested at maturity.

Results and Discussion

During 2006, four fungal isolates were selected for evaluation in a replicated field trial, to determine season-long efficacy. Soil applications of two of the isolates, Isolate C, and Isolate D, decreased the numbers of root-knot nematodes in soil assays that extended into early September (Table 1). Although nematode population densities were reduced by several of the treatments, significant increases in cotton yields were not observed for any of the treatments. Further research in the greenhouse has shown that the control obtained with these culture filtrates can be increased by improving the fermentation and application procedures. If a product resulting from this project exhibited extended control of root-knot nematodes in the field, it would be a valuable tool for protecting the current crop, and could also provide carry-over benefits to subsequent crops. These studies need to be repeated, and eventually could be scaled up to larger treatment areas, if large-scale fermentation facilities were available.

Additional work in greenhouse studies during 2006 were directed primarily toward optimization of the fermentation and application protocols for several promising fungal isolates. A complete factorial design experiment was conducted to examine combinations of fermentation duration and application timing for fungal Isolate B. By optimization of these two factors, efficacy of the culture filtrates in controlling root-knot nematodes on cotton was increased by 57%. The effects of specific fermentation media constituents, and fermentation temperatures on the nematicidal activity of culture filtrates were also examined in greenhouse experiments. We continue to observe variability in nematode control results from the soil-treatment evaluations, but the degree of variability has been reduced by continued research on fermentation and application protocols. This is a key area of our research, because the reduction in variability is essential in the commercial acceptance of any nematode control product. The goal of this project is to provide a commercially viable product for use by growers in nematode control.

Acknowledgments

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Table 1. Evaluation of fungal culture filtrates for control of root-knot nematodes (*Meloidogyne incognita*) on Cotton DP 555 in field plots.

	Number of root-knot nematode juveniles/ 100 cm^3 soil					
	Nematode assay date					Yield
Fungal isolate	17 Jul	14 Aug	28 Aug	12 Sep	15 Oct	seed cotton lbs/ A
Isolate A	88 a[a]	249 a	534 ab	895 a	531 a	1,411 ab
Isolate B	63 ab	274 a	221 b	810 a	658 a	1,386 ab
Isolate C	20 b	105 b	242 b	335 b	628 a	1,428 ab
Isolate D	24 b	229 ab	284 b	333 ab	284 a	1,240 ab
Control	146 a	248 a	683 a	727 a	785 a	1,224 b
Nematode control[b]	--	--	--	--	--	1,659 a

[a]Means of 10 replicate plots. Rows with the same letters within a column are not significantly different (P=0.05).
[b]No nematode inoculum added - control for level of nematode damage.

Literature Cited

Kemerait, R. 2005. Cotton Disease and Nematode Management. Pp. 30-39 in *2005 Georgia Cotton Production Guide*, Cooperative Extension Service, University of Georgia. Pub. CSS-05-01.

Martinez, A. , 2006. 2005 Georgia plant disease loss estimates. Cooperative Extension Service, Univ. of Georgia College of Ag. and Env. Sciences. Pub. SB41-08.

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