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2005 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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- Cotton Incorporated
- The Cotton Foundation

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TABLE OF CONTENTS

ANIMAL AND DAIRY SCIENCE

AGRICULTURAL AND APPLIED ECONOMICS

CROP AND SOIL SCIENCE

ENTOMOLOGY

PLANT PATHOLOGY

THE 2005 CROP YEAR IN REVIEW

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The 2005 cotton production season -- while it stopped short of being spectacular -- was a good one for most Georgia producers. The Boll Weevil Eradication certified the crop at 1,213,520 acres. Most of the state had good to excellent rainfall in the summer months but excessive amounts occurred in the southwest portion of the state in mid-summer and in east Georgia in early October, the latter associated with Tropical Storm Tammy. September was unusually hot and dry, which limited boll rot in most areas, diminished the top crop in many fields, but matured some late bolls in others. Final yield was 853 lb/A, eclipsing the all-time record for the state of 843 lb/A which was achieved in 1994. The U.S. produced a second consecutive record crop, in excess of 23.7 million bales. Nation-wide yields averaged about 830 lb/A. Prices remain depressed.

Quality of the 2005 crop was similar to 2004 and superior to 2003. Color grade, staple, and strength were quite good, but challenges still remain in regards to uniformity. Georgia still ranks toward the bottom of the national average in fiber length uniformity.

Table 1. 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	1,495	---	502	---	1,563	---
2001	1,483	---	709	---	2,200	---
2002	1,440	---	600	---	1,688	---
2003	1,292	---	800	---	2,150	---
2004	1,284	---	675	---	1,800	---
2005*	1,214	—	853	---	2,150	---

*Yield based on planted acreage and total bale production estimate as of January 2006.

Table 2. 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
44 / 94	1 / * / *	34.7	3.4	29.2	4.54	80.2

Based on 2.1 million bales classed through January 13, 2006
Bales classed: short staple - 9.7 percent, high mic - 4.5 percent
* reflects less than 1 percent.

DP 555 BG/RR dominated the state's acreage, with over 72 percent of the crop planted in that variety (USDA AMS Survey). The Survey estimated that over 95 percent of the Georgia crop was planted in transgenic varieties, primarily in Bollgard/Roundup Ready and Roundup Ready (RR) varieties. Growers continued to rely heavily on RR technology, and as predicted, shifts in weeds spectrum have occurred. In south Georgia, tropical spiderwort has proliferated. This difficult-to-control species has been found in 33 Georgia counties. Scientist from UGA have also documented the occurrence of Palmer amaranth resistance to glyphosate in RR cotton in Central Georgia and to ALS-herbicides (ex. Staple, Cadre) in several locations. In terms of insect management, there are suspicions that corn earworm has become less sensitive to pyrethroid insecticides.

Table 3. Technology Distribution of Cotton Planted in Georgia in 2005.

Bollgard/Roundup Ready	Roundup Ready	Conventional	Other
87.8	8.4	1.9	1.8

USDA Agricultural Marketing Service Survey, August 2005.

UTILIZATION OF WHOLE COTTONSEED COATED WITH GELATINIZED CORN STARCH OR A BLEND OF MOLASSES AND FERMENTATION BYPRODUCTS

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Introduction

Whole cottonseed provides a unique blend of protein, fat, and fiber which make it ideal for feeding to lactating dairy cows. However, the lint that provides effective fiber in the ration for lactating dairy cows also causes handling problems and decreases bulk density. Coating WCS with gelatinized corn starch bonds the lint to the hull resulting in a flowable product (Laird et al. 1997). The resulting product supports similar amount of milk production as WCS (Bernard, 1999; Moore et al., 1998). However, digestibility of NDF was lower (Bernard et al., 1999) which may account for reduced milk fat percentage in some (Firkins et al., 2002), but not all (Bernard, 1999; Moore et al., 1998) trials.

Ruminal microorganisms that digest cellulose require ammonia as a substrate. We observed improves in ruminal fermentation (Bernard et al., 2001) and ruminal fiber digestion (Bernard et al., 2003) when urea was included in the gelatinized starch coating applied to WCS. We recently examined a coating of molasses and fermentation byproduct which would provide ammonia as well as peptides and amino acids and observed improved in vitro NDF digestibility (Bernard, unpublished data). This trial was conducted to determine the effect feeding WCS coated with two different types of coating on production and feed efficiency of lactating dairy cows.

Materials and Methods

Thirty-nine lactating Holstein cows averaging 164 days in milk were used in an eight-week trial to determine the effects of feeding whole cottonseed (WCS) compared with WCS coated with gelatinized corn starch or with a mixture of molasses and fermentation byproduct. The experimental protocol was approved by the University of Georgia Animal Care and Use Committee. The cows were trained to eat behind electronic gates (American Calan Inc., Northwood, NH) before beginning the trial. The trial consisted of a two-week preliminary period during which all cows were fed the herd ration and data collected to use as a covariate in the statistical analysis. At the end of the preliminary period, cows were assigned randomly to one of three experimental diets.

Treatments in the trial consisted of WCS or WCS coated with either 2.5% gelatinized corn starch (ST) or a mixture of molasses and fermentation byproduct (MF). The MF coating provided a rapidly soluble carbohydrate source as will as peptides and amino acids. All test products were included in the experimental diets to provide 12% of the ration dry matter (Table 1). Samples of all ingredients were collected three times each week for analysis of dry matter content (DM) and rations adjusted as necessary for any changes in DM content of ingredients. Experimental diets were mixed and fed once daily in amounts to provide 5% refusal.

Cows were milked twice daily at 0300 and 1600 h. Milk yield was recorded electronically (Alfa Laval Agri., Inc., Kansas City, MO) at each milking and yield averaged by week. Milk samples were collected at two consecutive milking each week and shipped to Dairy Farmers of America, Inc. laboratory (Knoxville, TN) for analysis of percentage milk fat and protein. Once each week, the body weight of each cow was recorded immediately after the 1600 h milking. To reduce variation, water was withheld after milking until cows had been weighed. Samples of dietary ingredients, experimental diets, and orts were collected three times each week and equal amounts combine to form a weekly composite. These samples are currently being analyzed for concentrations of DM, ash, crude protein, fat (AOAC, 1990), ADF, and NDF (Van Soest et al., 1991).

Data from weeks 2 through 6 of the experimental period were subjected to covariate analyses using PROC MIXED producers of SAS (1989). The model included covariate, treatment, week, and the interaction of treatment and week. Cow within treatment was included as a random variable and week was a repeated measure. Orthogonal contrast statements were used to compare WCS versus ST and WCS versus MF. Two cows did not complete the trial because of chronic mastitis and poor performance and their data were not included in the analyses.

Results and Discussion

Dry matter intake and performance results are summarized in Table 2. No differences were observed among treatments in DMI although DMI was numerically higher for MF compared with WCS ($P < 0.15$). Milk yield and composition was similar for all treatments and averaged 78.6 lb./d milk, 3.80 % fat, and 3.01 % protein. No differences were observed in dairy efficiency (ECM/DMI). Initial body weight of cows was similar (1332 lb.) between treatments. Cows gained an average of 118 lb. during the trial. No differences in intake, milk yield or composition were observed between primiparous and multiparous cows.

These results are similar to those previously reported when WCS coated with gelatinized corn starch were included in diets fed to lactating dairy cows (Bernard, 1999; Moore et al., 1998). In contrast to the observations of Firkins et al. (2002), inclusion of ST did not decrease milk fat percentage. The MF coating is palatable based on intake measured during the trial. The MF also supported similar milk yield and composition as either WCS or ST. No differences were observed in the conversion of DM consumed into ECM. This in contrast with the results of previous work in our laboratory in which an increase in efficiency was observed for cows fed WCS coated with starch plus either 0.5% urea or 2.0% yeast culture (Cooke and Bernard, 2005). The body weight gain is higher than normally expected. There were a higher proportion of primiparous cows (24) compared to multiparous cows (14) that would be expected to gain more than multiparous cows.

Results of this trial indicate that coating WCS with 2.5% gelatinized corn starch or a mixture of molasses and fermentation byproduct supports' similar performance and composition as WCS. The coatings do improve handling characteristics which will facilitate shipment to areas outside of the cotton producing area and use in feed mills not equipped to handle WCS.

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Table 1. Composition of experimental diets containing whole cottonseed, or whole cottonseed coated with either 2.5% gelatinized corn starch or a mixture of molasses and fermentation byproducts.

Ingredient	% of DM
Alfalfa hay	8.38
Corn silage	36.93
Steam flaked corn	18.60
Cottonseed	12.00
Brewers grains	11.08
Concentrate[1]	13.00
Composition[2]	
Crude protein	17.10
Undegradable protein	7.20
ADF	20.45
NDF	28.00
Starch	27.02
NE_l, Mcal/lb	0.77

[1]Concentrate contained (DM basis): 39.0 % CP; 0.95 Mcal/lb NE_l; 2.9 % ADF; 5.0 % NDF; 15.4 % fat; 3.39 % Ca; 0.60 % P; 1.32 % Mg; 2.88 % K; 123 ppm Cu; 2.56 ppm Se; 22,300 IU Vitamin A; 8,890 IU Vitamin D; and 111 IU Vitamin E.
[2]Composition based on formulations.

Table 2. Dry matter intake, milk yield and composition of Holstein cows fed diets containing whole cottonseed, or whole cottonseed coated with either 2.5% gelatinized corn starch (ST) or a mixture of molasses and fermentation byproducts (MF).

	Treatments			
	WCS	ST	MF	SE
DMI, lb/d	48.8	49.2	51.3	1.2
Milk, lb/d	79.0	80.1	80.1	1.5
Fat, %	3.88	3.84	3.74	0.12
Fat, lb/d	3.07	3.08	3.00	0.10
Protein, %	3.02	2.99	3.02	0.04
Protein, lb/d	2.39	2.39	2.42	0.05
ECM[1]	81.9	82.4	81.6	1.8
EFF[2]	1.68	1.67	1.59	0.05

[1]Energy corrected milk yield
[2]Efficiency of milk production, ECM/ DMI.

ECONOMIC IMPACTS FROM GOVERNMENT SUPPORT PROGRAMS

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Introduction

Commodity support programs for field crops are acknowledged for their importance in enhancing the incomes of agricultural producers. Communities benefit as increased farmer incomes purchase goods and services that lead to impacts throughout the economy. However, if the viability of farms is dependent upon commodity support programs, the complete quantification of economic impacts extends to the farm enterprise, and is not limited to personal income accruing to producers.

This report attempts to estimate the extent of economic impacts that are derived from government support programs. A model representing the Georgia cotton industry is applied for evaluating net returns and economic impacts of production. There are three objectives of this analysis. The first objective is to determine the impacts from multiplier effects of cotton production in the economies of Georgia and the U.S. Secondly, impact analysis measures the tax revenues generated from cotton production. After economic impacts and tax revenues are calculated, the final objective is to investigate the importance of government support programs to the viability Georgia cotton production.

Industry Model for Cotton Production

A simulation model for the Georgia cotton industry includes operating costs and fixed costs of production. Payments of debt for equipment are considered as wealth transfers that increase farmer equity, but have no economic impact after purchase. Annual economic impacts derive from operating expenses as the farm enterprise acquires operating inputs for production and stimulates economic activities associated with the inputs.

Variable costs in Table1 and annual fixed costs in Table 2 are estimated from crop enterprise budgets developed by the Department of Agricultural and Applied Economics of the University of Georgia. Costs are estimated aggregates of Bt and Bt/RR varieties, as well as non-irrigated and irrigated acreage. Model assumptions for yield and commodity prices (NASS), LDP rates, base acreages and base yields (FSA), and the average world price for cotton (FAS) are presented in Table 3. Impacts are derived for the Georgia cotton industry by first estimating the impact from 800 acres of production, calculating the impact per acre and then expanding to 1.3 million acres.

Revenues in Table 4 are from lint marketed, value of cottonseed, and government payments. Government payments for 800 acres total $109,531 from direct payments, counter cyclical payments, and loan deficiency payments. Total revenue less variable costs and fixed costs result in net returns to land and management of $40,744 for 800 acres of production. With net returns of $51 per acre, aggregate net returns total $66.3 million.

Economic Impacts

Impact analysis evaluates the effects, or economic benefits, of a production enterprise on industrial sectors. IMPLAN (MIG) is an economic input-output modeling program applied for impact estimation. IMPLAN can interpret the effects of an enterprise in a number of ways including output (sales), labor income (employee compensation and proprietary income), employment (jobs), and tax revenue. An IMPLAN model can be constructed for the economy of a single county, multi-county, state, or a national region. In general, input-output models work by separating the economy into various industrial sectors, such as agriculture, construction, manufacturing, trade, and services. The model then calculates how a change in one industry changes output, labor income, and employment in other industries. These changes, or impacts, are expressed in terms of direct, indirect, and induced effects.

- *Direct effects* represent the impact on the economy of some feature (i.e. construction or operations) of an enterprise.
- *Indirect effects* are changes in other industries caused by direct effects of an enterprise.
- *Induced effects* are changes in household spending due to changes in economic activity generated by both direct and indirect effects.

Thus, the total economic impact is the sum of direct, indirect, and induced effects.

Economic impacts for Georgia in Table 5 consist of total effects for 800 acres of production which are expanded to an aggregated industry total. Cotton production represents $1.38 billion of economic output in Georgia which leads to 16,250 part-time and full-time jobs. Income totals $374.2 million for farmers and the 16,250 employees impacted by cotton production. Excluding farm property taxes, cotton production creates $21.9 million in state revenues and an additional $9.7 million for local governments in Georgia.

Impacts from cotton production in Georgia are not limited to the state, but multiply throughout the U.S. economy. Table 6 presents U.S. economic impacts that result from cotton production in Georgia. Economic output totals $2.3 billion, which impacts 22,750 part-time and full-time jobs, or 6,500 jobs outside of Georgia. Income of $273.6 million outside of Georgia calculates to a total U.S. income impact of $647.8 million. Federal, state, and local taxes total $204.8 million for governments in the U.S.

Aggregate U.S. tax revenues in Table 6 calculate to revenues of $126,046 from 800 acres of Georgia cotton production. This compares to government payment receipts of $109,531 in Table 4. Thus, for every dollar of Federal government payments received by Georgia cotton farmers, $1.15 of tax revenues are returned to Federal, state, and local treasuries of governments in the U.S.

Impacts from cotton production indicate economic benefits for Georgia and U.S. economies that extend beyond the agricultural sector. The importance of government payments may be evaluated by determining the viability of cotton farming without government payments. Net returns to land and management of $40,744 for 800 acres of cotton production were previously discussed. Total government payments of $109,531 in Table 4 show that net returns without government payments would be -$68,787, or -$86 per acre. This level of negative net returns makes it unlikely that Georgia cotton production would remain a viable industry without support programs.

Summary

Cotton production in Georgia has a total economic output effect of $2.3 billion for the U.S. economy. This leads to 22,750 jobs and $648 million in income throughout industrial sectors of the economy. Tax revenues received by federal, state, and local governments due to Georgia cotton production are greater than commodity support payments received by Georgia cotton farmers. Negative returns without support from commodity programs make it unlikely that cotton production would be a viable enterprise and economic benefits to the Georgia and U.S. economies would be lost.

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Table 1. Cotton Variable Costs

Input	$/Acre
Seed	44.93
Lime	7.26
Fertilizer-Custom Application	57.59
Herbicides	25.00
Insecticides: In-Furrow	11.03
Insecticides: Spray	12.65
Growth Regulator	7.98
Boll Opener and Defoliant	15.32
Scouting	7.00
Fuel and Lube	18.30
Labor	23.88
Repairs, Maintenance	27.80
Irrigation	13.86
Crop Insurance	18.33
Ginning	68.45
Warehouse, Marketing	20.84
BWEP	3.75
Total Operating Expenses	290.93
Interest, Operating Capital	10.55
Total Variable Costs	394.51

Table 2. Cotton Fixed Costs

Input	$
Taxes and Insurance	10,670
Capital Interest	26,676
Capital Recovery	48,017
Other	18,885
Total	104,248

Table 3.Simulation Assumptions

Variable	Unit	Value
Yield	lbs./acre	700
Acres	number	800
GA Price	cents/lb.	0.56
U.S. Price	cents/lb.	0.55
AWP	cents/lb.	0.48
GA LDP Rate	cents/lb.	0.5285
DP Acres	number	800
DP Yield	lbs./acre	690
CCP Acres	number	800
CCP Yield	lbs./acre	700

Table 4. Cotton Revenue

Source	$
Lint	313,600
Seed	37,469
Government Payments	109,531
Direct Payment	31,296
Counter Cyclical Payment	51,075
Loan Deficiency Payment	27,160
Total Revenue	460,600

Table 5. Georgia Cotton Farming: Annual Economic Benefits to Georgia

	Direct Effect	Indirect Effect	Induced Effect	Total Effect	Aggregate Total
Output ($)	460,600	263,418	127,704	851,722	1,384,048,044
Labor Income ($)	33,012	154,292	42,947	230,251	374,158,542
Employment	3	6	1	10	16,250
State Taxes ($)				13,478	21,902,551
Local Taxes[1] ($)				5,989	9,732,801
Sum Taxes[1] ($)				19,468	31,635,352

[1]Excludes farm property taxes.

Table 6. Georgia Cotton Farming: Annual Economic Benefits to the U.S.

	Direct Effect	Indirect Effect	Induced Effect	Total Effect	Aggregate Total
Output ($)	460,600	559,777	396,358	1,416,735	2,302,195,073
Labor Income ($)	33,012	235,551	130,055	398,619	647,755,504
Employment	3	8	3	14	22,750
Federal Taxes ($)				78,894	128,203,147
State/Local Taxes[1] ($)				47,151	76,620,904
Sum Taxes[1] ($)				126,046	204,824,051

[1]Excludes farm property taxes.

YIELD, COST, AND NET RETURN OF SEED TECHNOLOGIES AND PRODUCTION SYSTEMS: A FOUR-YEAR SUMMARY

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Introduction

Seed technologies in cotton are changing rapidly. Transgenic cotton varieties offer benefits and convenience to the producer. By convenience we mean savings in the time and labor expense associated with field operations that these technologies make possible. While the value of such "convenience" is difficult to measure, the evidence is clear that cotton producers have readily accepted and value these seed technologies as a part of their herbicide, insecticide, and overall management program.

In 2005, 98 percent of Georgia's cotton acreage was planted to transgenic varieties. The majority of the acreage was in "stacked" (BR or Bollgard-Roundup Ready) varieties. In 2005, 73% of the state's acreage was planted to a single variety, DP 555 BGRR.

In recent years, Georgia acreage has trended away from straight RR (Roundup Ready) varieties and toward BR. This has been due to BR varieties consistently producing higher yields than RR varieties in Georgia trials. More recently, new technologies such as Liberty Link (LL), Bollgard II Roundup Ready (B2R), Roundup Ready Flex (B2RF and RF), and Widestrike (W, WR, WRF) have been introduced but are not yet used on a large scale.

The University of Georgia began conducting "systems trials" at Tifton in 2001 and at both Tifton and Midville in 2003. The purpose of these tests is to compare yield, fiber quality, costs, and net returns of conventional (non-transgenic) cotton and transgenic cotton (Bt, RR, BR, B2R, LL, etc.). A specific secondary objective is to determine the factor(s)—variety, system, yield, fiber quality, etc. that most contribute to increased economic returns.

This paper presents results of the 4 years 2001-2004. Results for 2005 are not yet available. This research continues for 2006.

Methodology

In the "systems trial", each technology is produced according to its' specific pest management (herbicide and/or insecticide) regime and following UGA Extension recommendations. Each year, the "Net Return Above System Costs" was calculated for each variety and each technology at each location. "System Costs" were seed, technology fee (if applicable), herbicides, insecticides, and application costs. The number of varieties in the systems trial by technology, year, and location is summarized in Table 1. Varieties selected have been those commercially available and based on trends in use in the state. The test has also included newer varieties and technologies-some tested before being largely available to producers.

Varieties/technologies included in the test have changed (some deleted, others added) as the test has progressed over time. The trial has included conventional/non-transgenic (CV) varieties, Bollgard (Bt) varieties, Roundup Ready (RR) varieties, “stacked” varieties (BR), Bollgard II stacked varieties (B2R), and Liberty Link (LL) varieties. In 2005, Roundup Ready Flex (RF), WideStrike Roundup Ready (WR), and Bollgard II Roundup Ready Flex (B2RF) were added but are not included in this paper.

All varieties at each location and each year were replicated 4 times in a random block design. Each technology was produced according to its’ intended herbicide and/or insecticide regime and in accordance with UGA Extension recommendations. Plots were mechanically harvested. Random samples of seedcotton from each plot were ginned at the USDA Cotton Ginning Laboratory in Stoneville, MS to determine gin lint turn-out, seed weight, and HVI fiber quality.

For each variety and technology, the Net Return Above System Costs was calculated. System Costs included seed, technology fee if applicable, herbicides, insecticides, and application costs. All other inputs and costs were the same regardless of technology.

The Net Return Above System Costs was calculated as:

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

NR = the Net Return Above System Costs for variety x, technology y
Y = lint yield (Lbs per acre) for variety x
LP = the November avg Ga price/lb adjusted for quality q for variety x (includes LDP)
C = the cottonseed yield for variety x
SP = the November average Georgia price received for cottonseed
S = seed cost per acre for variety x, technology y
H = herbicide costs per acre for technology y
I = insecticide costs per acre for technology y
A = herbicide and insecticide application costs per acre for technology y

Results

Relevant costs for the analysis were only those costs associated with variety and technology. All other inputs and costs were the same, thus need not be considered. System costs were seed, technology fee if applicable, herbicides, insecticides, and the cost of applications.

Seed and technology cost for Tifton are shown in Table 2. The Tifton test was planted in 36 inch rows at 3 seed per foot. Midville (2003 and 2004), not shown, was planted at the same seeding rate but in 38 inch rows so the cost per acre would be approximately 5% less. In the 4 years at Tifton, BR varieties averaged $39.73 per acre higher cost than conventional. In 2 years, 2003 and 2004, B2R averaged $8.68 per acre higher than BR. In 2003 (the only year that both RR and LL were both in the test), LL was $3.28 per acre more than RR.

Herbicide and insecticide costs are summarized in Tables 3 and 4. These costs are for chemicals only. Machinery, equipment, fuel, and labor costs of application and cultivation (in non-Roundup Ready technology only as needed) were calculated separately. Technology fee is included with seed cost in Table 2.

Over 4 years at Tifton, herbicide costs for RR (RR, BR, B2R) and non-RR varieties (conventional, Bt, and LL) was essentially the same (RR varieties averaged $0.75 per acre less). At Tifton in 2003 and 2004, herbicide costs for LL averaged $6.57 per acre less than RR. At Midville, herbicide costs averaged $64.80 per acre for non-RR varieties, $46,75 for RR varieties, and $36.89 per acre for LL.

At Tifton in 2001, no sprays were needed on either Bt (Bt, BR) or non-Bt (conventional, RR) cottons. In 2002, no sprays were needed on Bt cotton. For the 4 years of the study at Tifton, insecticide costs for Bt cotton averaged $16.36 per acre less than non-Bt cotton. In the 2 years of the study at Midville, Bt cotton averaged $8.19 per acre less than non-Bt.

Total "system costs" by year and location for each technology are presented in Tables 5 and 6. At Tifton, 4 years of conventional, non-transgenic cotton has averaged $105.91 per acre compared to $119.98 for BR. Six technologies have been tested at Tifton. RR had the lowest system costs in 1 of 3 years in the trial. Conventional technology was the least expensive in 1 of 4 years. In 2003 and 2004, B2R technology averaged $8.36 per acre higher than BR. In the 3 years that both were in the trial (2001-2003), BR technology was $4.26 per acre cheaper than RR.

Across both locations, Tifton and Midville, in 2003 and 2004, total system costs were the lowest for RR and LL technology (Table 6). B2R had the highest total system costs and averaged $8.31 per acre higher than BR

In 2001 and 2002 at Tifton, there were 13 varieties common to both years (Table 7). Average yield and net return was calculated for these varieties. Rather than a statistical means comparison, an alternative approach taken in this analysis is to *rank varieties by yield and net return then compare systems by how varieties of the same system rank in relation to other systems*. For the 13 varieties at Tifton in 2001-2002, 3 of the top-five yielding varieties were BR. Three of the 5 lowest yielding varieties were RR. Of the 5 top-yielding varieties, 4 were also in the top-five in Net Return. One of the 4 conventional varieties was in the top-five in both yield and Net Return. One conventional variety was not a top yielder but was among the highest in Net Return.

Across both locations in 2003 (Table 8), 3 of the top-five yielding varieties were BR. One conventional and one LL rounded out the top 5. All 5 varieties that were the top-five in yield were also the top-five in Net Return. The B2R varieties were in the middle or near the bottom in yield and Net Return. Three of the lowest five in Net Return were RR.

In 2004, yields and Net Return were significantly different by location so results could not be combined. At Tifton , 4 of the top-five varieties in yield were BR or B2R (Table 9). Four of the top-five yielders were also among the top-five in Net Return. One conventional variety was in the top-five at Tifton but did not rank as high at Midville. One LL variety was among the top-five in Net Return at Tifton but LL varieties did not perform as well at Midville. At Midville in 2004, the top-five yielders were BR and B2R and were also the top-five in Net Return (Table 10).

Summary and Conclusions

Seed technologies in cotton are changing rapidly. Transgenic cotton varieties offer benefits and convenience to the producer. While the value of "convenience" is difficult to measure, the evidence is clear that cotton producers have readily accepted and value these seed technologies as a part of their herbicide, insecticide, and overall management program. The purpose of these "systems trials" has been to evaluate these seed technologies for yield, fiber quality, costs, and net return.

These trials have been difficult to manage and analyze due to the fact that varieties within a technology change rapidly (new varieties are developed which need to be evaluated) and the technologies themselves have changed and continue to change. B2R and LL varieties were added to the test in 2003 and 2004 and RF (Roundup Ready Flex) and WR (Widestrike Roundup Ready) were added in 2005.

After 4 years of study, BR and B2R have generally been the most expensive technologies but have also proven to be among the most profitable. BR and B2R have been the most profitable on a consistent basis but *choice of variety within a system* is the most crucial factor. Some BR and B2R varieties, for example, have not performed as well as others.

LL and RR have generally been the cheapest technology but generally have been middle-of-the-pack or near the bottom in Net Return.

The difference in costs per acre between technologies can be 10 to 20% but less in some years. Even in years when costs are highly different, the difference in cost can be relatively minor in terms of the equivalent pounds of lint. This leads to the conclusion that *the highest yielders tend to also be the most profitable regardless of technology*. Technologies may offer new management options but if technology does not come with high yield, the technology will not prove most profitable compared to alternatives. Some conventional varieties continue to compete with transgenic varieties in both yield and net return.

Fiber quality has thus far not been a significant factor in choice of technology.

Acknowledgements

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Table 1. Summary of Technologies and Varieties, By Year and Location

	2001	2002	2003	2004	2005
	Tifton		Tifton and Midville		
Conventional	4	4	3	1	1
Bt	4	2			
RR	4	4	4		1
BR	4	5	5	8	1
B2R			2	5	3
LL			1	2	1
RF					3
WR					1
B2RF					5
Total	16	15	15	16	16

Table 2. Seed and Technology Cost Per Acre By System, Tifton 2001-2004

	2001	2002	2003	2004
Conventional	$9.32	$11.30	$11.44	$17.41
Bt	$38.68	$37.62		
RR	$18.29	$21.66	$25.76	
BR	$45.13	$50.93	$51.75	$60.58
B2R			$62.85	$66.85
LL			$29.04	$28.70

Table 3. Herbicide Cost Per Acre, By System, Tifton and Midville

	2001	2002	2003	2004
Tifton Non-RR	$27.77	$29.60	$29.08	$28.28
Tifton RR	$23.37	$24.05	$30.01	$34.32
Tifton LL			$28.84	$22.35
Midville Non-RR			$54.17	$75.44
Midville RR			$41.55	$51.94
Midville LL			$32.93	$40.86

Table 4. Insecticide Cost Per Acre, By System, Tifton and Midville

	2001	2002	2003	2004
Tifton Non-Bt	$0.00	$24.69	$36.66	$58.19
Tifton Bt	$0.00	$0.00	$9.60	$44.49
Midville Non-BT			$28.68	$16.53
Midville Bt			$23.63	$5.20

Table 5. Average Total System Costs Per Acre, By Technology, Tifton

	2001	2002	2003	2004
Conventional	$74.18	$100.92	$113.23	$135.31
Bt	$103.54	$95.55		
RR	$73.69	$103.11	$124.19	
BR	$100.53	$100.69	$112.56	$166.14
B2R			$123.00	$172.41
LL			$126.30	$140.07

Table 6. Average Total System Costs Per Acre By Technology, Tifton and Midville

	Tifton		Midville		Average
	2003	2004	2003	2004	
Conventional	$113.23	$135.31	$124.65	$143.25	$129.11
RR	$124.19		$119.35		$121.77
BR	$112.56	$166.14	$135.41	$137.38	$137.87
B2R	$123.00	$172.41	$145.96	$143.33	$146.18
LL	$126.30	$140.07	$113.84	$111.14	$122.84

Table 7. Comparison of Yield and Net Return Per Acre, Average of 13 Common Varieties, Tifton 2001-2002

Rank By Yield			Rank By Net Return		
Variety	Technology	Yield	Variety	Technology	Net Return
DP555BR	BR	1143	FM989	CV	$660.97
FM989	CV	1107	DP555BR	BR	$641.43
ST4892BR	BR	1091	DP458BR	BR	$606.15
DP458BR	BR	1057	PHGA161	CV	$603.13
DP33B	B	1027	ST4892BR	BR	$600.50
PHGA161	CV	1022	PEARL	CV	$581.00
PEARL	CV	1016	DP33B	B	$575.86
FM989BR	BR	1001	DP448B	B	$570.19
DP448B	B	997	FM989BR	BR	$568.84
ST580	CV	979	ST580	CV	$541.32
FM989R	RR	952	FM989R	RR	$539.65
ST4793R	RR	936	SG521R	RR	$508.70
SG521R	RR	929	ST4793R	RR	$490.10

Table 8. Comparison of Yield and Net Return, Average of Tifton and Midville, 2003

Rank By Yield			Rank By Net Return		
Variety	Technology	Yield	Variety	Technology	Net Return
DP491	CV	1202	DP491	CV	$799.13
DP555BR	BR	1198	DP555BR	BR	$769.04
ST5599BR	BR	1156	FM966LL	LL	$751.42
FM966LL	LL	1151	FM989BR	BR	$733.82
FM989BR	BR	1126	ST5599BR	BR	$731.39
DP494R	RR	1108	DP494R	RR	$711.60
SG215BR	BR	1096	PEARL	CV	$670.21
PEARL	CV	1039	SG215BR	BR	$655.12
DP424B2R	B2R	1037	PHGA161	CV	$642.06
SG521R	RR	1004	DP424B2R	B2R	$636.97
ST4646B2R	B2R	997	SG521R	RR	$589.51
PHGA161	CV	989	ST4646B2R	B2R	$582.76
ST4793R	RR	934	FM991RR	RR	$573.46
FM991R	RR	911	DP458BR	BR	$557.17
DP458BR	BR	905	ST4793R	RR	$550.50

Table 9. Comparison of Yield and Net Return, Tifton, 2004

Rank By Yield			Rank By Net Return		
Variety	Technology	Yield	Variety	Technology	Net Return
DP555BR	BR	1059	DP555BR	BR	$517.35
PEARL	CV	984	PEARL	CV	$515.92
DP543B2R	B2R	891	DP543B2R	B2R	$415.35
FM960B2R	B2R	828	FM960B2R	B2R	$383.06
SG215BR	BR	784	FM966LL	LL	$362.09
FM960BR	BR	784	FM960BR	BR	$360.58
ST5599BR	BR	750	SG215BR	BR	$354.36
FM966LL	LL	747	FM981LL	LL	$347.06
DP449BR	BR	733	DP449BR	BR	$325.58
FM981LL	LL	727	ST5599BR	BR	$324.22
FM991BR	BR	714	FM991BR	BR	$320.85
ST5242BR	BR	703	ST5242BR	BR	$292.32
DP444BR	BR	690	DP444BR	BR	$284.97
FM991B2R	B2R	647	FM991B2R	B2R	$264.36
DP424B2R	B2R	600	DP424BR	BR	$227.98
ST4646B2R	B2R	589	ST4646B2R	B2R	$201.40

Table 10. Comparison of Yield and Net Return, Midville, 2004

Rank By Yield			Rank By Net Return		
Variety	Technology	Yield	Variety	Technology	Net Return
DP555BR	BR	1597	DP555BR	BR	$933.50
DP449BR	BR	1463	DP449BR	BR	$863.85
FM960BR	BR	1427	FM960BR	BR	$852.10
DP424B2R	B2R	1361	DP424B2R	B2R	$787.14
DP543B2R	B2R	1303	DP543B2R	B2R	$746.36
ST5599BR	BR	1302	FM960B2R	B2R	$746.07
FM960B2R	B2R	1280	FM991BR	BR	$727.98
FM991BR	BR	1256	ST5599BR	BR	$713.48
PEARL	CV	1250	PEARL	CV	$711.30
FM991B2R	B2R	1185	FM991B2R	B2R	$649.57
ST4646B2R	B2R	1090	ST5242BR	BR	$601.48
ST5242BR	BR	1075	ST4646B2R	B2R	$597.34
SG215BR	BR	1048	SG215BR	BR	$581.36
FM966LL	LL	980	FM966LL	LL	$556.85
FM981LL	LL	940	FM981LL	LL	$547.70
DP444BR	BR	866	DP444BR	BR	$457.60

CONSERVATION TILLAGE IN GEORGIA COTTON PRODUCTION: RESULTS OF A 2005 SURVEY

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Introduction

In 1983, Georgia cotton acreage had declined to only 120,000 acres planted. By 1995, acres planted had increased to 1.5 million. This level of acreage would be reached again in 2000. Since passage of the current farm bill in 2002, Georgia cotton acreage has declined 10-15% in response largely to enhanced economic opportunity for peanuts. Cotton remains, however, by far the state's largest crop in acreage and value.

The revival of cotton in the state is truly a remarkable story. The resurgence in acreage can be attributed to successful eradication of the boll weevil, farm policy which allowed new and existing growers to build "base", increased use of irrigation, and new-higher yielding varieties suited to the state.

In more recent years, genetic or transgenic varieties including herbicide-tolerant Roundup Ready cultivars have, for some producers, eased the transition from conventional tillage practices to conservation tillage and to do so economically.

There are many factors that determine the profitability of the cotton enterprise. Some are within the farmers' control, many are not. Inputs such as seed, fertilizer, and chemicals are often the first target for farmers trying to trim cost. Other factors often overlooked, however, are timeliness and efficiency of operations, labor and machinery costs of trips over the field, and overhead or fixed costs of machinery and equipment.

Survey

In April and May of 2005, a survey was conducted to determine the use of conservation tillage practices in cotton production in Georgia and to determine farmers' perceptions about conservation tillage in cotton. The survey was sent to University of Georgia Cooperative Extension agents in all cotton producing counties. Agents were asked to complete the survey giving their best estimates and judgment based on their observations and the experience of cotton producers in the county. Ninety counties responded representing 97.6% of the state's cotton acreage planted in 2004.

For the purposes of the survey, the following definitions were given:

Conventional tillage was defined as "any set of tillage operations that include disking and turning the soil and planting into bare ground. It typically, but not necessarily, includes ripping and bedding".

No-till was defined as “no tillage of the soil whatsoever and the hard-pan is not broken. Planting is directly into previous crop residue, winter fallow, or cover crop”.

Strip-till was defined as “tillage on only a small seed-bed area (approximately 10 to 14 inches wide) and may include ripping under the row”.

Reduced tillage was defined as “any other set of practices not otherwise defined as conventional, no-till, or strip-till”.

For some survey questions, the answer was to be given as a percentage of the cotton acres in the county. To then determine the acres and percentage for the state, the percentage given for each county was first multiplied by the cotton acres in the county. Then the acreage in each county summed to arrive at the total for the state.

Results and Discussion

County and State Acreage Profile

County Extension agents were asked to estimate the percentage of cotton acres in the county produced in each of the 4 tillage categories as defined.

Of the 90 counties responding, 84 reported acreage of conventionally planted cotton (Table 1). Six counties had no conventional acreage. Of these 6, 4 counties were 100% strip-till and 2 counties were 100% no-till. Twenty-two counties were over 75% conventional tillage and 20 of these 22 were 100% conventional tillage.

Twenty-four of 90 counties reported some acreage of no-till cotton production. Of these 24 counties, 14 reported 10% or less of cotton acres as no-till and 19 reported 25% or less. Three counties reported over 75% of acres as no-till with 2 of these being 100% no-till.

Table 1. Tillage system, number of counties reporting acreage of that system and counties reporting by percent of acres in that system, 90 total counties.

Tillage	Total	10% or Less	11-25%	26-50%	51-75%	Over 75%
Conventional	84	2	13	25	22	22
No-Till	24	14	5	1	1	3
Strip-Till	73	9	14	25	17	8
Reduced-Till	33	22	6	5	0	0

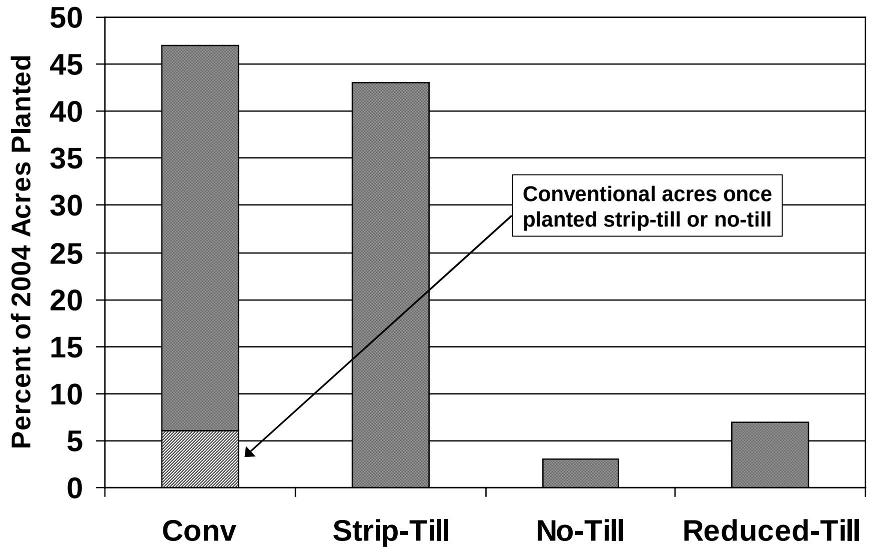
Seventy-three of the 90 counties responding reported acreage planted strip-till. Eight counties were over 75% planted as strip-till with 4 counties 100% strip till. Most counties (42 of the 73) reported 26 to 75% of the acreage planted strip-till.

Reduced-tillage practices (other conservation tillage not defined as no-till or strip-till) were reported by 33 of the 90 counties. In most instances (in 22 of the 33 counties) this was 10% or less of the acreage planted.

The 2004 cotton acreage planted by county was available through the USDA Georgia Agricultural Statistics Service. In the survey, agents were asked for the county 2004 cotton acres planted and this number used when no USDA estimate was available.

The total acres planted in each county was multiplied by the percentage of cotton in each of the 4 tillage categories to estimate the acres planted in the county for each tillage method. The acreage by tillage method for all 90 counties was then summed to arrive at an acreage total and percentage by category for the state (Figure 1).

Figure 1. Use of Tillage Practices In Georgia Cotton
Results of a April-May 2005 County Agent Survey



Over 50% of Georgia's cotton acreage is produced by a method other than the traditional conventional rip-bed method. Conventional tillage remains the largest single tillage method with 47 percent of acreage in conventional tillage while 53 percent is some form of conservation tillage (43 percent is strip-till, 3 percent is no-till, and 7 percent is reduced-till).

Extension agents were asked to estimate the percentage of 2004 cotton acres in the county that were at one time planted strip-till or non-till but had since reverted back to conventional tillage. Multiplying this percentage by the acres planted in the county and summing up across all counties provided an estimate for the state. Six percent of the total acres in the state are planted in conventional tillage but were once strip-till or no-till (Figure 1). This represents 13 percent of conventional acres.

Expectations on the Future of Tillage Practices

Extension agents were asked their opinion about the near future of tillage practices in their county. Specifically, the question was asked “In the next 2-3 years, do you expect the percentage of (strip-till/no-till) acres in your county to increase, decrease, or remain the same?” The survey was taken in 2005, thus this question could be applicable out to the period 2007-2008.

Eighty-eight of 90 surveys responded to the question about strip-till (Table 2). Of the 88 responses, 55 or 62.5% expect strip-till cotton acreage to increase. Thirty counties (34%) expect strip till acreage to stay the same. Interestingly, 53 of 73 (72.6%) of counties with strip-till production expect acreage to increase. However, in 15 counties responding having no strip-till acreage, only 2 (13.3%) expect acreage to increase.

Eighty-seven of 90 surveys responded to the question about no-till (Table 2). Of the 87 counties responding, 76 (87.4%) expect no-till acreage to remain the same or decrease. Among the 24 counties responding with no-till acreage, 15 or 62.5% expect acreage to remain the same or decrease. Among 63 counties responding without no-till acreage, 96.8% expect acreage to remain the same or decrease.

Table 2. Expected Change (2-3 Year Outlook) in Percentage of Acreage Planted to Strip-Till and No-Till Production.

Strip-Till	Total	Increase	Decrease	Same
Total Responses	88	55	3	30
Counties With Strip-Till	73	53	2	18
Counties Without Strip-Till	15	2	1	12
No-Till	Total	Increase	Decrease	Same
Total Responses	87	11	5	71
Counties With No-Till	24	9	2	13
Counties Without No-Till	63	2	3	58

Cotton Yields

Extension agents were asked the question “Compared to conventional tillage on the same soil type with average growing conditions, for your county would you say that yield per acre for (strip-till/no-till) would be higher, lower, or about the same?” Seventy-one of the 73 counties with strip-till acreage responded to the question. Twenty of the 24 counties with no-till acreage responded (Table 3).

Fifty-four of 71 counties (76%) said that cotton yield in strip-till production is the same as conventional yield. Fourteen counties (19.7%) said that strip-till yield is higher than conventional. Only 4.2% said strip-till yield was lower than conventional.

Ten of 20 counties responding (50%) said that cotton yield in no-till production is lower than conventional yield.

Table 3. How Strip-Till and No-Till Cotton Yields Compare to Conventional Tillage.

	Total Responses	Higher	Lower	Same
Strip-Till Yield	71	14	3	54
No-Till Yield	20	4	10	6

Planting Practices

In conventional tillage practices, previous crop residue and winter weeds are disked under and planting is done into bare ground. In strip-till and no-till production, previous crop residue, winter fallow, or winter cover crop is left and must be managed. Planting will be into previous crop residue and winter fallow, winter fallow, winter cover crop, or double-crop after harvest of the winter crop.

The survey asked county Extension agents to estimate the percentage of the strip-till and no-till acres in their county that were planted into previous crop residue and winter fallow, into winter fallow only, into a winter cover crop, and into winter crop residue (double-crop planted after harvest of winter crop). The percentage in each county was multiplied by the estimated acres of strip till and no-till in the county then summed across all counties to give an estimate for the entire state (Figure 2).

In Georgia, winter cover crops largely consist of rye, wheat, and oats. In strip-till production, 40.9% is planted into previous crop residue and winter fallow (PRWF), 36.8% is planted behind a winter cover crop (WCC), 10.9% is planted into winter fallow (WF), and 10.9% is double-cropped (DC) after harvest of the winter crop.

In no-till production, 38.3% is planted behind a winter cover crop, 29.8% is planted into previous crop residue and winter fallow, 20.6% is planted into winter fallow, and 10.6% is planted after harvest of the winter crop (double-cropped).

Double-crop cotton is not a significant percentage of acreage in either strip-till or no-till production. Compared to strip-till, no-till cotton production takes place more often on winter fallow and less often on previous crop residue and winter fallow. Planting into a winter cover crop is very important in both practices.

In strip-till production, the tillage operation and planting can be performed as separate operations requiring 2 trips over the field or strip-and-plant performed with one combined piece of equipment in one pass. Preference for how this is done may be a function of whether planting is into residue, fallow, or cover crop; the type and condition of the cover crop; farm size and acreage of cotton; labor availability; tractor horsepower requirement; ability to stay on the strip-till bed when planting separately; and weather.

The survey asked Extension agents the question “For strip-till, what would be your best estimate of the percentage of the strip-till acres in your county planted as follows: strip and plant in separate operations, strip/plant in the same operation?”

Figure 2. Comparison of Strip-Till and No-Till Planting
Results of a April-May 2005 County Agent Survey

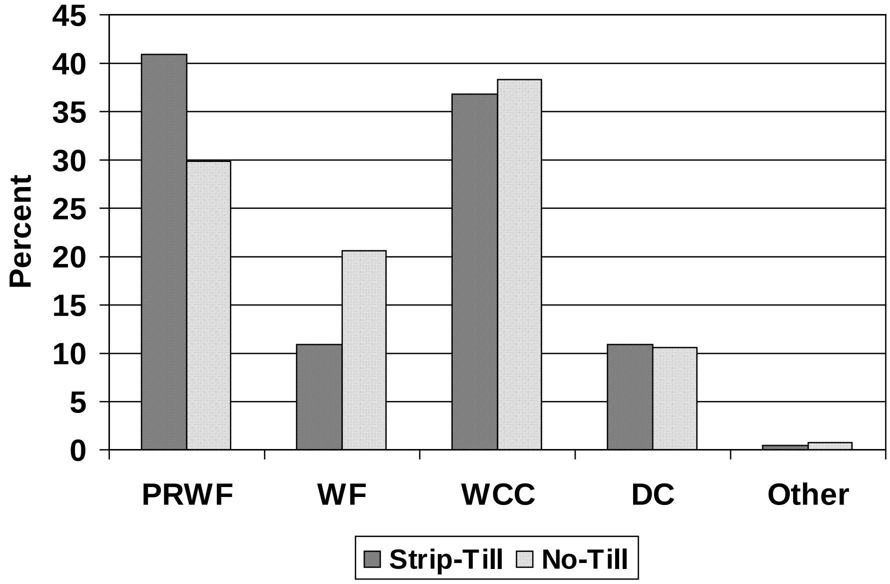
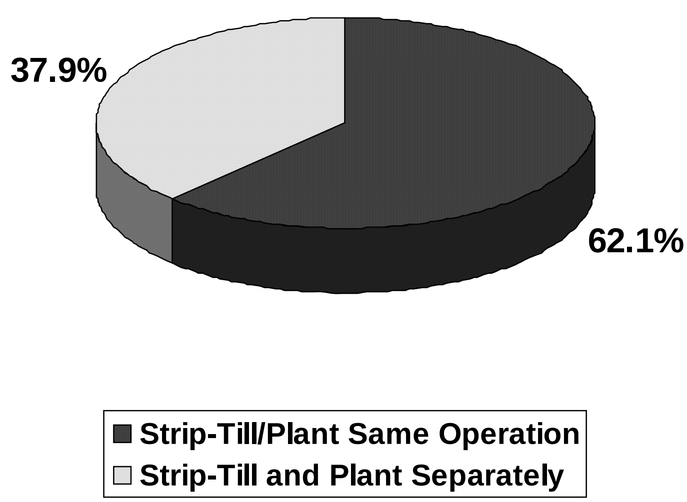


Figure 3. Cotton Planting In Strip-Till Production
Results of a April-May 2005 County Agent Survey



Seventy-two of the 73 counties with strip-till acreage (representing 99.96% of strip-till acres) responded to the question. In 22 of the 72 counties representing 19.3% of strip-till acreage in the state, all strip-till cotton in the county is planted in the same operation. In 43 of 72 counties representing 45.2% of the strip-till acreage in the state, 75% or more of the acreage is planted in the same operation. Statewide, 62.1% of strip-till acreage is tilled and planted in the same operation and 37.9% is tilled then planted separately (Figure 3).

Inputs in Strip-Till Compared To Conventional Tillage

The profitability of conservation tillage compared to conventional tillage is dependent on, among other factors, relative yields and costs. As previously reported in Table 3, in 68 of 71 counties responding with strip-till cotton production, strip-till yield was thought to be the same or higher than conventional tillage.

The survey asked county Extension agents how use of inputs in strip-till cotton production compared to conventional production– "higher", "lower", "about the same", or "don't know". The results are summarized in Table 4. All 73 counties reporting strip-till acreage responded to the question.

Use of seed and fertilizers was considered to be mostly the same for strip-till as in conventional tillage. Almost 1/4 (23%) of counties, however, reported more seed used in strip-till compared to conventional. For chemical inputs, use of insecticides, nematicides, and fungicides was reported mostly the same. For herbicides, however, 60% of counties reported higher herbicide use. Fuel and labor use is thought to be less in strip-till than in conventional tillage. Over 90% of the counties reported less fuel and labor use in strip-till cotton.

Table 4. Use of selected inputs in strip-till cotton production compared to conventional tillage.

Input	Total Responses	Higher	Lower	Same	Don't Know
Seed	73	17 (23%)	1 (1%)	54 (75%)	1 (1%)
Nitrogen	73	12 (16%)	8 (11%)	52 (71%)	1 (1%)
P and K	73	3 (4%)	4 (5%)	62 (85%)	4 (5%)
Other Nutrients	73	2 (3%)	3 (4%)	62 (85%)	6 (8%)
Herbicides	73	44 (60%)	17 (23%)	12 (16%)	0
Insecticides	73	10 (14%)	9 (12%)	53 (73%)	1 (1%)
Nematicides	73	3 (4%)	5 (7%)	60 (82%)	5 (7%)
Fungicides	73	8 (11%)	1 (1%)	57 (78%)	7 (10%)
Fuel	73	0	71 (97%)	2 (3%)	0
Labor	73	0	68 (93%)	4 (5%)	1 (1%)

Perceptions on the Benefits of Conservation Tillage

The survey asked the question "On a scale of 1 to 5 with 1 being "not important" and 5 being "very important", how would you rate the following as factors why cotton producers employ strip-till and no-till practices." The survey listed 10 specific categories and a blank "Other" category which agents could fill in and rate.

Table 5 is a summary of the results. Seventy-seven of the 90 counties responding to the survey reported acreage of strip-till or no-till cotton. Table 5 shows the number of responses out of these 77 counties to each of the 10 factors and the rating of each.

Of the 10 factors, the 2 most important factors identified as why cotton producers employ strip-till and no-till production were labor savings (4.12) and the availability of glyphosate-resistant technology (4.09). This was followed by reduced erosion (3.89), machinery savings (3.88), and conserving soil moisture (3.79). Higher yield (2.70) and government program incentives or cost share (2.94) were the lowest rated and relatively unimportant in the farmer's decision.

Fifty-seven of 75 responses (76%) rated labor savings as 4 or 5 on a scale of 1 to 5. Fifty-five responses (72%) rated reduced soil erosion as 4 or 5 and 51 of 73 responses (70%) rated machinery savings as 4 or 5.

Thirty-two of 70 responses (46%) rated government incentives and cost share as relatively not important (rated as a 1 or 2 on the 1-5 scale). Thirty-nine percent (28 of 71 responses) rated higher yield as relatively not important.

Table 5. Rating of factors in why Georgia cotton producers use strip-till and no-till production practices.

		Scale (1=Not important, 5=Very Important)					
Factor In Decision	Responses	1	2	3	4	5	Avg
Machinery savings (cost, time)	73	4	5	13	25	26	3.88
Labor savings (cost, time)	75	5	2	11	18	39	4.12
Other cost savings	74	7	9	18	18	22	3.53
Glyphosate-resistant technology	76	3	8	10	13	42	4.09
Improved soil quality	75	7	10	19	18	21	3.48
Reduced erosion	76	4	6	11	28	27	3.89
Crop protection from wind/sand	71	7	9	22	20	13	3.32
Higher yield per acre	71	13	15	27	12	4	2.70
Conserve soil moisture	75	2	3	24	26	20	3.79
Govt incentive or cost-share	70	7	25	13	15	10	2.94

Three survey respondents identified “Other” factors as being important. These were “convenience” (received a rating of 5), “reduced rain and irrigation run-off” (received a rating of 4), and “getting the crop planted in a timely manner” (received a rating of 3). Convenience and getting the crop planted in a timely manner may be related to machinery and labor savings. Reducing rainfall and irrigation run-off may be related to reducing soil erosion and conserving soil moisture.

Challenges In Conservation Tillage

The final question in the survey asked Extension agents an open-ended question– “What would you consider as the number one challenge to producers in their ability to employ strip-till and no-till cotton production practices successfully and profitably?” The results are presented in Table 6. A total of 98 responses were received from the 90 survey respondents (some agents gave more than a single answer).

For the purpose of summarizing the results, an attempt was made to place the responses into several general categories. Some responses within a category may be closely related to another category. Over 26% responded that the number one challenge is related to equipment (cost, selection, and use) and determining and adapting a system that works well for the particular operation.

Over 19% responded that the number one challenge has to do with management-related issues– managing practices and timing, reluctance to change from current practices, and need for improved education. Also included as management-related would be a lack of patience to recognize long-term rather than short-term benefits, staying with the program.

Almost one-third of the responses dealt with cover crop, soils, fertility, and planting issues. The challenges most often mentioned were managing cover crops, residue and getting a good stand. Other factors mentioned included soil-specific issues, fertilizer management, and increasing seed/technology fees.

Pest management (weed, insect, and nematode control) was given as the number one challenge by 18 of 98 responses (18%). The majority of this dealt with weed control.

Implications

Prior to the survey, it was believed that strip-till was the most prevalent of the conservation tillage practices employed in Georgia cotton production. The survey clearly supported that hypothesis. However, 7% of Georgia cotton is neither “strip-till” or “no-till” but some form of “reduced-till” system as reported by 33 of the 90 counties responding to the survey (Table 1). Given the increasing costs of production and the challenges in strip-till and no-till production, perhaps other reduced tillage practices also warrant economic and agronomic investigation. It is possible that “reduced tillage”, as defined and responded to in this survey, is a set of modified practices fitting the specific needs of the operation- compatible with location, soils, and other agronomic factors.

Table 6. Survey respondents perception of the number one challenge to the success and profitability of strip-till and no-till production practices in cotton.

CHALLENGES	Responses
EQUIPMENT Equipment cost, initial equipment investment, proper equipment selection, equipment availability, having the right equipment, efficient use of equipment	21 (21.4%)
SYSTEM Developing a system that fits well with tobacco and vegetables, adopting it to fit their farming practices, adapting strip-till rigs to their particular situation, determining a system/approach that works best for them, change in paradigm	5 (5.1%)
MANAGEMENT Time and management, management/timing	2 (2.0%)
MINDSET Reluctance to change/changing old habits, mindset, fear, making the commitment	10 (10.2%)
EDUCATION Lack of knowledge, educational efforts to strip-till's benefits	2 (2.0%)
LONG TERM Staying with the program/long-term results, not seeing the returns or benefits in the first couple of years, being patient to see benefits over time	5 (5.1%)
COVER CROPS, RESIDUE Managing cover crops, managing cover crops for soil improvement, residue management, decision to use or not use cover crops, getting producers to plant cover crops, dealing with previous years cotton residue	8 (8.2%)
SOILS Soil compaction, hardpan under conventional rows, breaking hardpan, flatwood and cold soils	4 (4.1%)
FERTILITY Fertility needs, soil ph and fertility harder to manage, fertilizer placement, learning to manage fertility compared to full tillage	4 (4.1%)
SEED TECHNOLOGY Increasing tech fees, beginning to look at other systems again, chemical and technology costs	3 (3.1%)
PLANTING Moisture management at planting time, getting a stand in dry or wet year, getting a good stand- nonirrigated, getting a good stand on heavier clay-type soils, planting on time, establishing a good seed bed, planting after burndown, getting a good stand	12 (12.2%)
WEED CONTROL Weed control, herbicide activation, glyphosate resistance, timeliness of herbicide applications, pigweeds, small seeded weeds, pusley, bermudagrass	15 (15.3%)
INSECTS AND NEMATODES Nematode control, insects	3 (3.1%)
YIELD Yield, getting yields up, thinking that yields are lower	3 (3.1%)
OTHERS Continuation of the current farm programs	1 (1.0%)
TOTAL OF ALL RESPONSES GIVEN	98 (100%)

Counties currently with strip-till acreage tend to be more favorable regarding it's outlook (Table 2). Counties currently with strip-till could be those where it has proven to work best and thus are more positive on it's future. Counties without strip-till tend to be less positive. Counties without strip-till could be those where it is not a good fit and thus do not expect acreage to increase further in the future. The acreage outlook for no-till is not as bright compared to strip-till production.

The results of the survey conclude that there is generally no yield advantage or disadvantage in strip-till production compared to conventional tillage (Table 3). This is further supported by very few agents responding that yield was a major challenge in success and profitability (Table 6) and the relative unimportance of yield as a factor in why producers choose strip-till and no-till practices (Table 5). Yield does, however, seem to be a challenge in no-till production (Table 3).

When county Extension agents were asked how the use of inputs in strip-till production compared to conventional tillage, the inputs where there seemed to be the widest difference of opinion (experience and observation) were seed, nitrogen, and herbicides (Table 4). While not specifically addressed by the survey, it is worth noting that these inputs typically comprise a very high percentage of the total cost of production per acre for cotton. Thus, it is possible that the relative profitability of strip-till compared to conventional tillage may, in part, depend on relative yields (and gross income) and fuel and labor savings compared to the use and cost of these and other inputs.

Extension agents responded that use of herbicides is mostly higher in strip-till cotton production compared to conventional (Table 4). The availability of glyphosate-resistant (Roundup Ready (RR)) technology was identified as a relatively very important factor in why producers have switched to strip-till and no-till production (Table 5). Weed control was given as the number one challenge in strip-till and no-till production in 15.3% of responses (Table 6). This survey was conducted in April and May 2005. Later, during the 2005 growing season, glyphosate resistance in Palmer amaranth (pigweed) was confirmed in some areas of central Georgia. Efforts are currently underway to determine how widespread this problem is and means to control it. This threat of resistance lowers the value of RR technology in the state and could potentially threaten strip-till acres or, at minimum, change the herbicide regime and cost in strip-till production.

This survey does not answer the question of whether or not conservation tillage of some type is more or less profitable than conventional tillage. However, the fact that over half of the cotton acreage in Georgia is conservation tillage is evidence that in works in some locations for some producers but may not work for everyone. Six percent of acreage in the state is planted conventional that used to be strip-till or non-till (Figure 1).

If conservation tillage is to increase, it must be proven profitable. In this regard, there are obvious agronomic and economic challenges ahead (Table 6). One major issue is equipment– the required investment in new equipment when existing equipment is already paid for, finding/adapting a system that works well and fits within the farm's total operation and other enterprises, and related to this – management of cover crops/residue and getting a good stand. Fuel prices have increased significantly since this survey was conducted. Machinery and labor savings were identified as very important (Table 5). Recent increases in fuel prices would seem to work to conservation tillage's advantage.

Another challenge is getting producers to (1) accept change and (2) make the commitment to stay with conservation tillage for more than just a few years in order to recognize longer-term benefits (Table 6). These are management, economic, and agronomic issues.

Summary and Conclusions

In recent years, genetic or transgenic varieties including herbicide-tolerant Roundup Ready cultivars have, for some producers, eased the transition from conventional tillage practices to conservation tillage and allowed them to do so economically.

In April and May of 2005, a survey was sent to University of Georgia Cooperative Extension agents in all cotton producing counties. County agents were the survey respondents and 90 counties representing almost 98% of the states 2004 cotton acres planted responded. The purpose of the survey was to determine the use of conservation tillage practices in cotton production in Georgia and to determine farmers' perceptions (in the judgment and experiences of county Extension agents) about conservation tillage in cotton.

Conventional tillage remains the largest single tillage method in cotton production with 47 percent of acreage in conventional tillage while 53 percent is some form of conservation tillage (43 percent is strip-till, 3 percent is no-till, and 7 percent is reduced-till). Over 60% of respondents expect strip-till cotton acreage to increase. Over 87% of respondents expect no-till acreage to remain the same or decrease.

The profitability of conservation tillage compared to conventional tillage is dependent on, among other factors, relative yields and costs. The survey results conclude that there is generally no cotton yield advantage or disadvantage to strip-till compared to conventional production. No-till yields, however, are generally believed to be less than conventional and thus, less than strip-till. For inputs, use of seed and fertilizers was considered to be mostly the same for strip-till as in conventional tillage. For chemicals, use of insecticides, nematicides, and fungicides was reported mostly the same while herbicide use was reported mostly higher. Fuel and labor use were clearly thought to be less in strip-till than in conventional tillage.

Machinery and labor savings, availability of glyphosate-resistant technology, reduced soil erosion, and conserving soil moisture were the highest rated reasons why cotton producers use strip-till and no-till production practices. The major challenges identified in the success and profitability of strip-till and no-till production were equipment cost and use, weed control, planting, and mindset (reluctance to change).

This survey was not specifically designed to answer the question of whether or not conservation tillage of some type is more or less profitable than conventional tillage. However, the fact that over half of the cotton acreage in Georgia is conservation tillage is evidence that in works in some locations for some producers but may not work for everyone. If conservation tillage in cotton production is to increase, it must be proven profitable and manageable within the total farm operation. It is hopeful that this survey has accurately described the use and perceptions of conservation tillage among Georgia cotton producers and identified benefits, opportunities and challenges in the successful use of conservation tillage.

Recent events such as Palmer amaranth resistance and increased fuel prices are factors that will help shape Georgia's future cotton acreage, profitability, management decisions, and tillage practices.

Acknowledgments

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GROWTH AND DEVELOPMENT OF COTTON (*GOSSYPIUM HIRSUTUM* L.) IN RESPONSE TO CO_2 ENRICHMENT UNDER TWO DIFFERENT TEMPERATURE REGIMES

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INTRODUCTION

It is well known that the carbon dioxide (CO_2) concentration of the global atmosphere has increased during the last few decades and continues to increase, mainly due to energy consumption from fossil fuels. Since the start of the Industrial Revolution period until today, the atmospheric CO_2 level has increased from 280 ppm to around 365 ppm, and continues to rise at about 1.8 ppm per year. It is expected that it might reach a concentration of 600 to 1000 ppm by the end of this century. Elevated [CO_2] enhances the productivity of C3 plants, including peanut, cotton and wheat. Along with an increase in [CO_2], climate projections indicate changes in other climate factors such as temperature. Elevated [CO_2] together with higher temperature could provide an opportunity to grow crops where currently cold temperatures limit growth of crops, such as cotton. Furthermore, these potential warmer conditions could allow for earlier planting and longer growing seasons where at present low temperatures or late frosts prohibit it. The objective of this study was to evaluate the interactive effects of low and high temperature on growth and development of cotton under different CO_2 concentrations ranging from 400 ppm to 800 ppm.

MATERIALS AND METHODS

The experiment was conducted in 2003 in the controlled-environment chambers of the Georgia Envirotron, located at the College of Agricultural and Environmental Sciences – Griffin Campus of the University of Georgia. Six Conviron growth chambers (model CG72), with a floor space of 93 ft^2 and a height of 7.22 ft, were used in this experiment. A central personal computer allowed for programming of the desired climatic conditions in the chambers and storing the climatic data. Lighting levels were adjustable at five different intensity levels. Carbon dioxide was automatically injected into the chambers and its level in the chambers was controlled using a CO_2 delivery system and chamber vents. An individual LICOR infrared gas analyzer (LI-800 GasHound CO_2 Analyzer, LI-COR, NE, USA) was used to monitor CO_2 levels for each chamber independently. All chambers were also equipped with a drip irrigation system.

The six treatments consisted of all combinations of the two day/night temperatures (77/59 F (T1) and 95/77 F (T2)) and three CO_2 concentrations (400, 600 and 800ppm). The experimental design was completely randomized, with four replicates (plastic pots) per treatment. Twenty eight pots were placed in each chamber. The distance between pots was maintained at 1.15ft x 0.98 ft (0.88 plants/ft^2). Pots were filled with washed sand. Five seeds of cotton, cultivar DP 448B, were sown in each pot and thinned to one plant per pot after emergence. Plants were watered daily with a modified half-strength of Hoagland's solution three or four times a week to provide an adequate supply of water and nutrition.

Growth analysis was conducted weekly during the growing season and at each sampling plant traits, including plant height, number of leaves, number of squares and number of bolls were measured weekly. The number of days to 50% emergence, squaring and flowering were also determined. Leaf area, leaf dry mass, root dry mass, square dry mass, boll dry mass and total above dry mass per plant were also measured at each sampling time.

RESULTS AND DISCUSSION

Table 1 shows the number of days from seeding to emergence, and days from emergence to squaring and flowering. Increasing the temperature from 77/59 F to 95/77 F decreased the days from seeding to emergence by 2 days across all CO_2 levels. On average, the length of emergence to squaring at 95/77 F was 51 days which was 34 days shorter than the number of days from emergence to squaring at 77/59F. The mean days from emergence to flowering for 77/59 F and 95/77 F were 104 and 66 days respectively. As was expected, the warmer environments shortened the duration of each individual development stage.

At both temperatures, increasing [CO_2] to 800 ppm hastened the emergence by 1 day. At 77/59 F, increasing [CO_2] to 600 ppm increased the number of days to squaring, but a further increase of CO_2 to 800 ppm decreased the squaring by 9 days compared to ambient [CO_2]. In this experiment, increasing the [CO_2] (800 ppm) decreased the days from emergence to flowering by 13 days compared with ambient [CO_2] (400 ppm). CO_2 effect as shortening crop growth duration demands possibly a change in farm management planning in the future with respect to crop rotations and timing of inputs, such as fertilizer and irrigation. Table 1 shows that the temperature showed a prominent effect on crop growth duration compared to CO_2. Increasing temperature from 77/59 F to 95/77 F reduced the days to squaring and flowering for all CO_2 levels.

Elevated [CO_2] up to 600 ppm decreased the leaf numbers. However, a further increase of CO_2 increased the leaf numbers at 95/77 F (Table 2). Crop height as another plant parameter showed a proportional change similar to LAI, with exception of 1.3% reduction by increasing CO_2 (600 ppm) at 95/77 F. However, a further increase of CO_2 (800 ppm) increased crop height (2.2%).

Table1. The number of days from seeding to emergence and days from emergence to squaring and flowering under CO_2 enrichment with two different temperature regimes.

Temperature (F) (day/night)	CO_2 level (ppm)	Emergence (DAS) [a)]	Squaring (DAE)[b)]	Flowering (DAE)
77/59	400	5	91	109
	600	5	96	107
	800	4	82	96
95/77	400	3	55	68
	600	3	54	66
	800	2	52	64

a)DAS: days after seeding, b)DAE: days after emergence

Table 2. Final leaf number and R:S ratio, averaged across the whole growing season, in response to CO_2 and temperature.

	CO_2 (ppm)		
	400	600	800
	Final leaf number (per plant)		
77/59 F	20.7	15.2	19.2
95/77 F	37.7	32.7	38.0
	R:S ratio (Root to Shoot weight)		
77/59 F	0.18	0.15	0.19
95/77 F	0.20	0.22	0.22

We found that plant height was more sensitive to temperature than CO_2. Leaf area is the main source for radiation absorbance and affects crop production. Figure 1 shows the trend of the Leaf Area Index (LAI) of cotton plants observed across all CO_2 and temperature levels. Our observed LAI data at the final growth analysis sampling prior to harvest showed that the elevated CO_2 (up to 600 ppm) increased the LAI by 3.1% at 77/59 F and 8.7% at 95/77 F, while a further increase of CO_2 (800 ppm) reduced the LAI by 1.3% and 3.1% at 77/59 F and 95/77 F, respectively. Our data also showed that the change in LAI was different among the three different [CO_2] levels. Increasing [CO_2] for both temperatures showed a positive impact on LAI growth rate. In general, a higher leaf area growth rate would accelerate crop canopy closure. This result might be indicative as taller cotton plants show higher canopy closure rate at elevated [CO_2]. Based on this assumption it is expected that under future climate change conditions cotton canopy closure would occur faster, which would be an advantage for locations facing problems of weed competition and could be considered as disadvantage where water stress would happen towards the end of growing season. Averaged over the entire growing season, temperature also impacted the LAI for all CO_2 levels and increased LAI (Fig. 1) by 6.3% at 400 ppm, 9.5% at 600 ppm, and 9.0% at 800 ppm CO_2. At any CO_2 level, increasing temperature showed a higher impact on LAI than increasing CO_2 at any level of temperature. In other words, when comparing CO_2 and temperature, temperature had a dominant effect on LAI of cotton plants.

Biomass accumulation and partitioning

On average for the entire growing season, increasing CO_2 at 77/59 F increased the total biomass by 50% at 600 ppm and at 70% for 800 ppm [CO_2]. When the temperature was increased to 95/77 F, total biomass for the entire growing season did not show any response to CO_2 at 600 ppm, but it increased 40% at 800 ppm. The increase in total biomass for elevated [CO_2] at both temperatures was higher and not proportional to the change in LAI to CO_2. This may indicate a higher resource use efficiency per absorbing leaf area rather than increasing the area for capturing of resources. The relationship between leaf area as solar radiation absorbing surface and plant biomass production was examined and we found that plants at more or less the same LAI produce higher biomass at elevated [CO_2], which reflects the higher resource use efficiency of plants when exposed to elevated [CO_2]. On average for the entire growing season we found that an increase in temperature increased total biomass by 5.5 times at 400ppm, 7.0 times at 600 ppm, and 5.7 times at 800 ppm of [CO_2].

Increasing the temperature increased the ratio of root to shoot (R:S) (Table 2). This indicated that due to the higher total biomass production at higher temperature plants partition relatively more carbohydrates to the roots and therefore try to explore more resources in the soil. In general, there seems to be a small increase in R:S when CO_2 increased. Temperature also showed a positive impact on root weight. Root weight at 95/77F increased by 41.4% for the 600 ppm and 6.2% for the 800 ppm of CO_2.

Reproductive growth

An increase in temperature and CO_2 up to 600 ppm increased the number of squares at final harvest (Table 3). The number of squares increased by 31.4% at 77/59 F for 600ppm [CO_2] but decreased by 6.6% at 800ppm [CO_2]. At higher temperature (95/77 F) the number of squares decreased by 20.3% at 600 ppm and 0.8% at 800 ppm of [CO_2]. Increasing temperature significantly increased the square numbers. Increasing temperature increased the square number by 433.9% at 400 ppm, 223.9% at 600 ppm and 407.3% at 800 ppm of [CO_2].

At 77/59 F, boll numbers increased by 25.4% at 600 ppm and 14.3% at 800 ppm. At higher temperature (by 95/77 F) boll numbers increased by 413.3% at 600 ppm and 233.3% at 800 ppm compared to ambient. While an increase in temperature increased the number of squares, it actually decreased the number of bolls at any CO_2 level. Boll numbers were reduced by 76.2% at 400 ppm, 2.5% at 600 ppm and 30.6% of [CO_2] by increasing temperature to 95/77 F (Table 3). The reduction of boll numbers due to temperature is because boll retention is highly sensitive to temperature. Breeding for high temperature tolerant cultivars during boll development is a key issue for adaptation to the expected increases in temperature due to climate change. An increase in [CO_2] to 800 ppm did not show any benefit at lower temperature in our experiment as the number of squares was reduced by 28.9% and the number of bolls was reduced by 8.9% respectively when compared to 600 ppm. Both elevated [CO_2] and an increase in temperature increased the boll weight (Table 3), except at the highest temperature 95/77 F and highest [CO_2]. The higher response of boll weight to temperature at 95/77 F might be due to the fact that optimum temperature of cotton, as a warm season tropical crop, is in the range of 78.8 F to 82.4 F. Our higher response to [CO_2] at 95/77 F for boll weight indicated the main role of temperature as promoting or damping the effect of [CO_2] on cotton production. Lint yield showed a similar response to [CO_2] as boll weight. Increasing temperature reduced lint yield at all [CO_2] levels (Table 3).

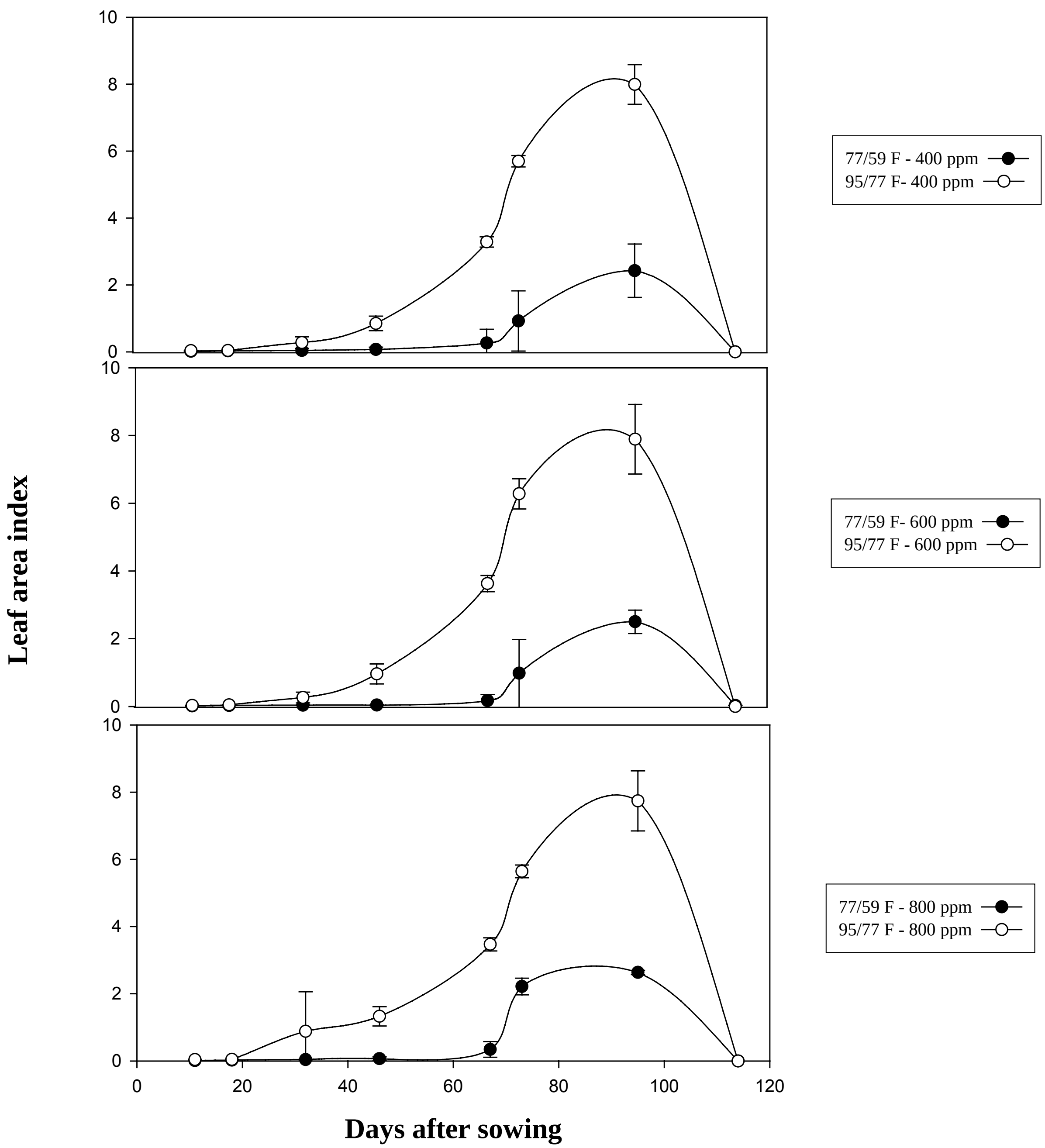

Fig. 1. LAI trend of cotton at two levels of temperature and three levels of CO_2.

Table 3. Square number, boll number and boll weight at final sampling of the growth analysis and seed + lint yield at final harvest in response to CO_2 and temperature

CO_2 (ppm)			
	400	600	800
Square number (per ft^2 ground)			
77/59 F	26.7	35.1	24.9
95/77 F	141.5	113.7	142.6
Boll number (per ft^2 ground)			
77/59 F	13.9	17.4	15.9
95/77 F	3.3	17.0	11.03
Boll weight (lb $acre^{-2}$)			
77/59 F	52.7	84.8	335.8
95/77 F	54.7	1861.0	1277.0
Seed + Lint yield (lb $acre^{-2}$)			
77/59 F	5539.3	5543.7	6384.9
95/77 F	394.7	2524.5	707.2

Conclusion

The response of indeterminate crops such as cotton to CO_2 and temperature is more complicated than determinate crops like rice plants. Increasing the [CO_2] positively stimulated growth and development of cotton with greater response at temperatures close to optimum. The vegetative and reproductive developments were affected by both [CO_2] and temperature, but with a dominant effect of temperature. Increasing CO_2 and temperature did not increase the surface area of absorbing resources, but positively impacted the resource use efficiency of cotton crops. However, the number of days to reach the maximum crop absorbing leaf area surface and subsequently soil cover was higher at higher CO_2 concentrations and higher temperatures. In general, increasing CO_2 and temperature increased the total biomass of cotton plants together with heavier bolls. Seed + lint yield also showed positive response to elevated CO_2, although the increase was higher at the 77/59 F temperature compared to temperature combination of 95/77 F.

COTTON GROWTH AND DEVELOPMENT MONITORING DURING 2005

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Introduction

The preliminary results presented in this report are part of our crop monitoring research in southwest Georgia that started during the 2003 cropping season. The main objective of this project was to obtain on-farm management practices and crop growth, development and yield data to be used for evaluating the performance of the crop simulation models that are part of the Decision Support System for Agrotechnology Transfer (DSSAT), which includes the new CSM-CROPGRO-Cotton model (Hoogenboom et al., 2004).

During the 2005 crop season we monitored one cotton field in Mitchell County and two cotton fields in Baker County. Local weather conditions, the farmers' management practices, including irrigation amounts, crop growth and development, including dry matter of plant components as well as leaf area index (LAI) and canopy height were collected every two weeks. The monitoring started during mid-April and ended during mid-October. A total of 11 field visits covered the complete growing season for the three cotton fields. The observed irrigation amounts were obtained from the database of the Agricultural Water Pumping (AWP; www.AgWaterPumping.net) program of which the main objective was to determine agricultural water use in Georgia (Hook et al., 2004).

Weather Conditions

The cotton field in Mitchell was planted earlier (April 18) than the two cotton fields in Baker (May 23 for Baker 1 and May 18 for Baker 2). The weather conditions were characterized by cool temperatures from April through May and above normal rainfall during the growing season. The late planting for the Baker fields partially avoided the cool temperatures that remained through the end of May. During the six-month growing season, the highest total rainfall was recorded in July. However, most of the rainfall occurred during the first ten days of July, followed by at least two weeks of dry conditions. Dry conditions also prevailed during the third week of June, third week of August, and throughout September (Figure 1).

Irrigation

A total of 1.89 inches of irrigation was applied during the June-September period in the Baker 1 field. Despite the high total rainfall for July, the total amount of irrigation for this month (1.07 inches) was more than three times the amount applied during the other months. Irrigation was applied during the third week of July when rainfall was low and evapotranspiration was high. The amounts of irrigation for June, August, and

September were similar (Figure 2). No irrigation data were available for the Mitchell and Baker 2 fields.

Comparison between the Different Fields

The Mitchell field was sown with ST 5242BR, an early maturing variety, using a conventional tillage system. The two fields in Baker were sown with DP 555 BG/RR, a later maturing cotton variety, using a reduced tillage system. The DP 555 BG/RR was the most popular variety planted in Georgia for the 2005 season, accounting for almost 73 percent of the total cotton acreage (http://risk.cotton.org/varseast.htm). The field in Mitchell County was sown during the third week of April while the two fields in Baker County were sown during the third week of May. All fields had the same row spacing but the Mitchell field had the highest plant population (Table 1).

The yield for the early maturing cotton variety ST 5242BR for the Mitchell field was at least 30% lower when compared with the later maturing cotton variety DP 555 BG/RR for the Baker fields. The Baker 2 field had a higher seed cotton yield than the Baker 1 field but the lint yields were similar (Table 2). The difference in yield between Baker 1 and Baker 2 fields could be attributed to the higher number of bolls per plant for the Baker 2 field that resulted in a higher rate of increase in boll weight (Figure 3). The harvest index was lower for the fields in Baker County than for the field in Mitchell County, which was due to the higher aboveground biomass for the Baker fields (Table 2).

In spite of some environmental constraints, 2005 represented a very good growing season for cotton. The average lint yield for the three fields was 1,692 lb/A, which was higher than the average lint yield for two fields in 2003 (1,541 lb/A) and for three fields in 2004 (1,508 lb/A). The lint yield for the Baker 1 field in 2005 (1,818 lb/A) was higher than the yield in 2003 (1,479 lb/A). For the Baker 2 field, the lint yield in 2005 (1,973 lb/A) was higher than the yield in 2004 (1,461 lb/A).

Table 1. Cropping system comparison.

CHARACTERISTIC	FIELD		
	Mitchell	Baker 1	Baker 2
Variety	ST 5242BR	DP 555 BG/RR	DP 555 BG/RR
Sowing date	04/18/05	05/23/05	05/18/05
Harvest date[a]	09/01/05	10/18/05	10/18/05
Tillage	Conventional	Reduced Tillage	Reduced Tillage
Area (acres)	62	190	100
Row spacing (inches)	36	36	36
Plant Population (plants/acre)	40,486	33,943	34,988
Days to harvest	136	148	153
Rainy days[b]	61	58	61
Total Rainfall (inches)[b]	25.9	25.1	26.0
Total PET (inches)[b]	25.2	21.9	22.6
Total Irrigation (inches)	nd[c]	1.89	nd[c]

[a] At maturity; the farmer harvested at least 2 weeks later, [b] From sowing to harvest, [c] No data

Table 2. Comparison of biomass, yield and yield components.

VARIABLE	FIELD		
	Mitchell	Baker 1	Baker 2
Seed Cotton Yield (dry matter, lb/A)	2923	3891	4612
Lint Yield (dry matter, lb/A)	1285	1818	1973
Lint (%)	44	47	43
Boll Unit Weight (dry matter, oz/boll)	0.28	0.22	0.24
Total aboveground Biomass (dry matter, lb/A)	5106	9220	9906
Lint Harvest Index	0.25	0.20	0.20
Seed Cotton Harvest Index	0.57	0.43	0.46

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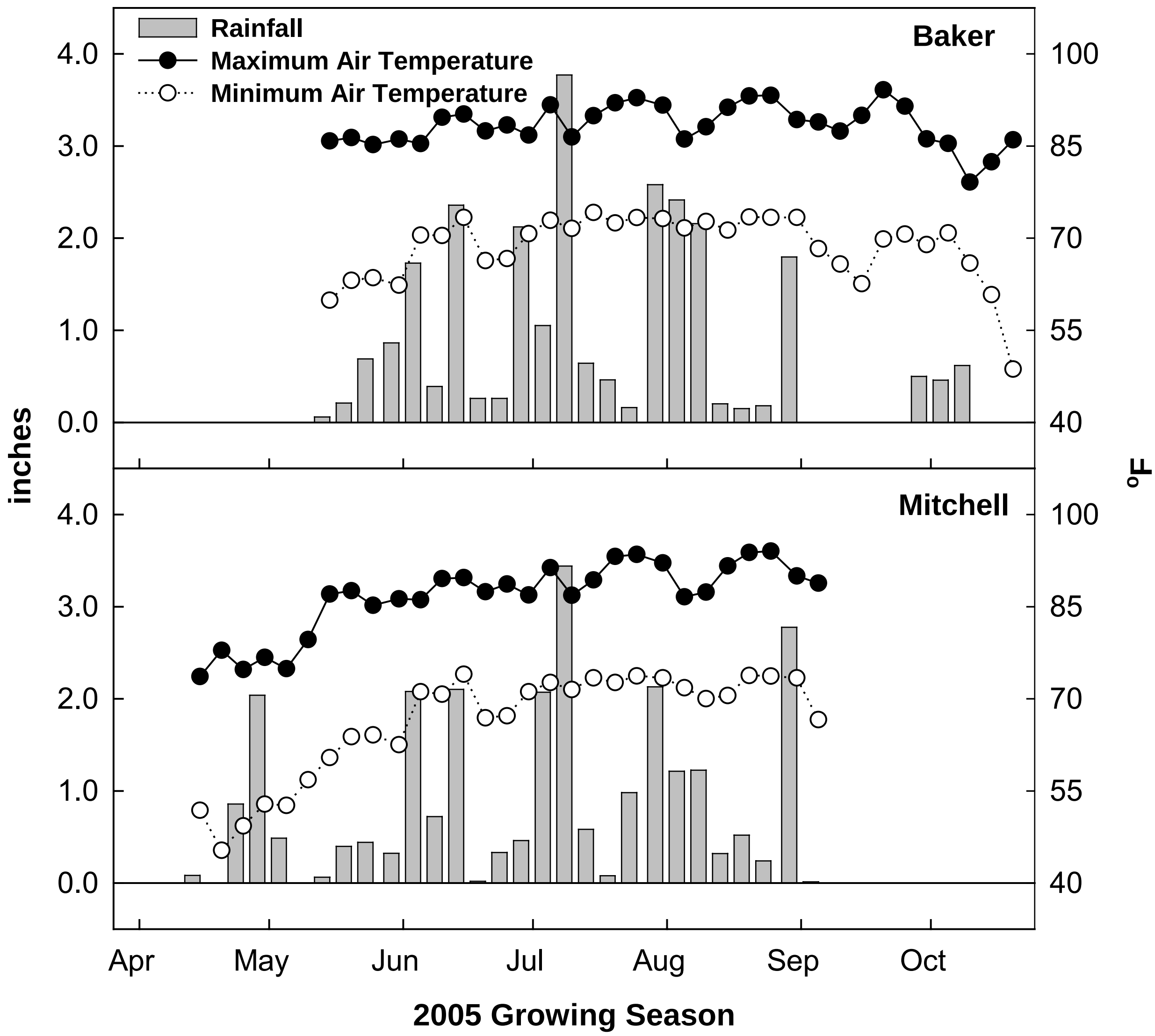

Figure 1. Five-day average minimum and maximum air temperature and five-day total rainfall during the growing season.

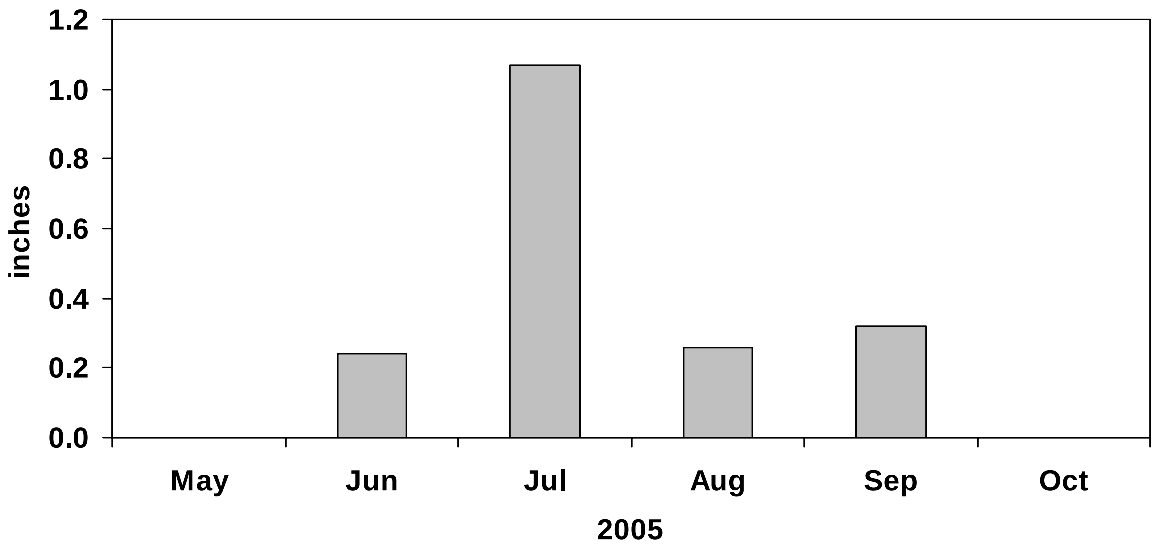

Figure 2. Total monthly irrigation amounts observed for the Baker 1 field.

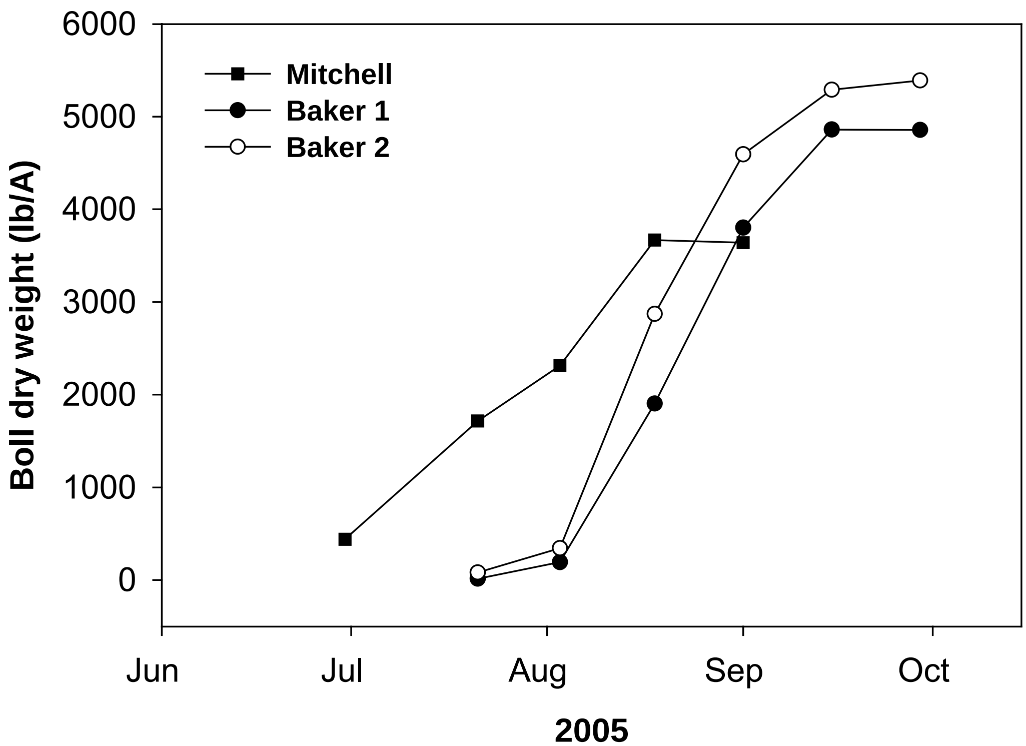

Figure 3. Boll development during the growing season.

APPLICATION OF WEATHER DATA FOR MANAGEMENT OF COTTON PRODUCTION IN 2005

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Introduction

The year 2005 was a relatively dry year when compared to 2003 and 2004. Most of our weather observation sites had a negative water balance, demonstrating the need for supplemental irrigation. However, during the last five 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, 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, as well as other input conditions such as soil and crop management. Although weather and decision support system has 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 include planting dates, deficit irrigation, when to start and stop irrigation, replanting decisions, 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 68 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, while in 2005 a weather station was also installed at the Sunbelt Agricultural Exposition Center in Moultrie. 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 weather data are automatically recorded by the data logger that is the central core for operation of each weather station and storage of data. Each weather sensor 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 College of Agricultural and Environmental Sciences-Griffin Campus 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 the world wide web, i.e., 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 hourly 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. 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, users can calculate chilling hours for any period of time 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 been the capability to graph daily weather data, as shown for maximum and minimum temperature and daily total rainfall for Moultrie in Figure 2 and Figure 3.

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 2005 were compared with the previous growing seasons for 2000 through 2004. 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 Elberton, McRae and Alapaha in 2003, Albany, Tiger and Clarks Hill, South Carolina in 2004 and Moultrie, Unadilla,Vienna and Wootbine in 2005. We defined the start of the growing season as May 1 and the end of the growing season as November 1. In reality this can vary from location to location. Cumulative degrees days for the 2000 through 2005 growing seasons are shown in Table 1. The maximum number of degree days for 2005 was found in Valdosta at 3272, Albany at 3108 and Savannah at 3092. The minimum number of degrees in 2005 was found in Rome at 2313, Eatonton at 2368 and Watkinsville at 2379. The same sites also had maximum and minimum values for degree days in 2003 and 2004. For all sites, except for Savannah, the cumulative total number of degree days was very similar for 2004 and 2005. For the five-year period from 2000 through 2005, both 2001 and 2003 had the lowest number of degree days, except for a few sites, while the number of degree days for 2000, 2002, 2004 and 2005 was very similar.

Cumulative precipitation for May 1 until November 1 is shown in Table 2. Similar to the previous years rainfall varied significantly across the state and among weather stations for this period. Rome and Vidalia were the driest locations, with respectively 15.3 and 15.75 inches. Savannah, Valdosta and Griffin had the highest amount of precipitation, with respectively 31.0, 31.1 and 31.7 inches of rain. When comparing the period 2000 through 2005, the growing season of 2004, in general, was still the wettest, except for Camilla, Dublin, Midville, Rome, Statesboro, Vidalia and Watksinville.

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. Twenty-two out of the 25 sites shown had a negative water balance, while only four sites had a positive water balance, ranging from 0.27 to 3.45 inches. Unfortunately the water balance does not provide much information with respect to both the rainfall distribution and intensity, and only provides a seasonal summary. During the period from 2000 through 2005 six sites had a negative water balance for all six years. These include Cairo, Camilla, Dearing, Eatonton, Fort Valley and Valdosta. This is somewhat of concern and could mean that for these sites an investment in supplemental irrigation should be recommended.

Summary and Conclusions

Temperature and rainfall display a very strong variability between years, as well as between 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 from 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

This work was sponsored in part by a grant from the United States Department of Agriculture - Risk Management Agency, and Federal and State Funds allocated to the University of Georgia - College of Agricultural and Environmental Sciences.

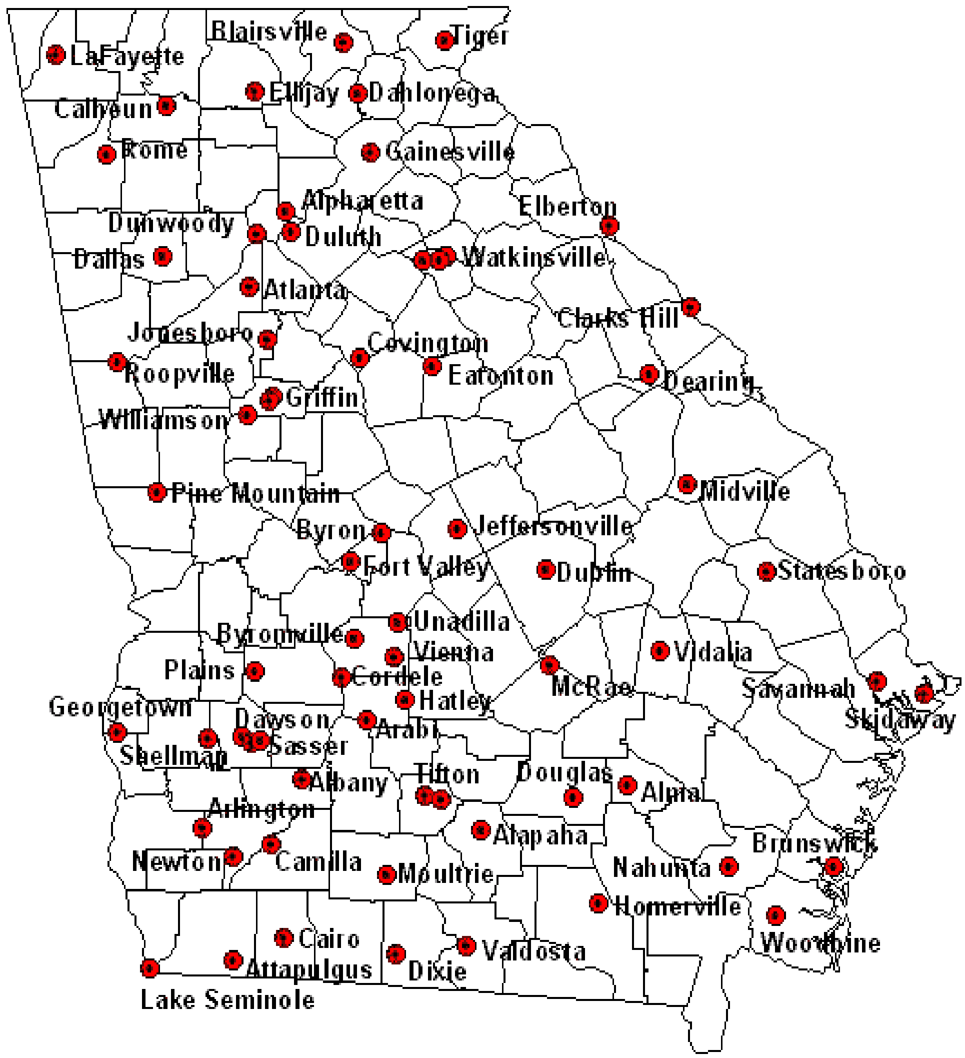

Figure 1. Location of the weather stations of the Georgia Automated Environmental Monitoring Network - College of Agricultural and Environmental Sciences.

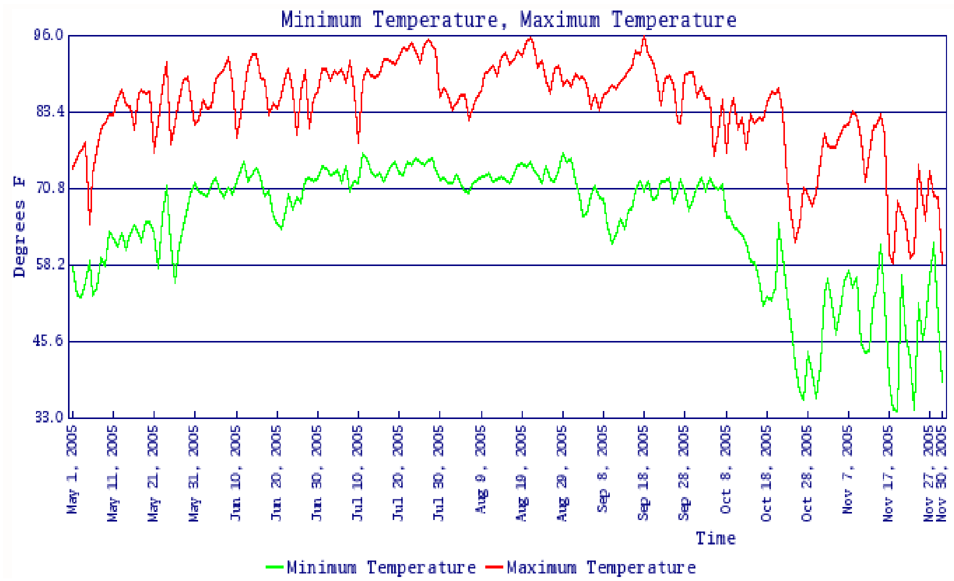

Figure 2. Daily maximum and minimum temperature for Moultrie, Georgia for May 1 through November 30, 2005.

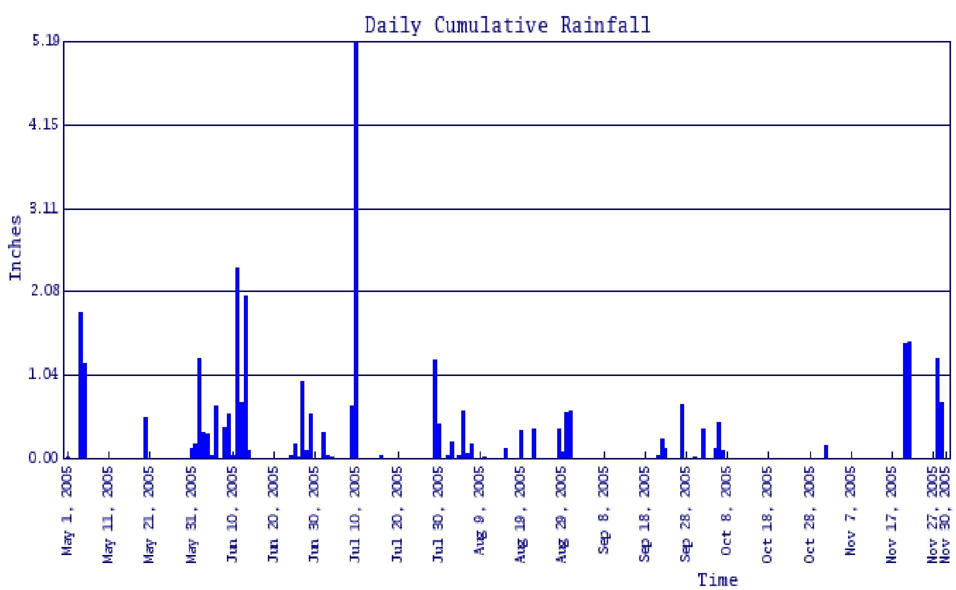

Figure 3. Daily total rainfall for Moultrie, Georgia for May 1 through November 30, 2005.

Table 1. Degree Days from May 1 until November 1 with a base of 60 degrees Fahrenheit.

Site	2000	2001	2002	2003	2004	2005
Alapaha	N/A	N/A	N/A	2728	2863	2882
Albany	N/A	N/A	N/A	N/A	3123	3108
Alma	2875	2766	3089	2820	2978	2987
Arlington	2823	2544	2966	2699	2826	2857
Attapulgus	2827	2687	3064	2789	2911	2704
Cairo	2836	2512	3112	2811	3050	2990
Camilla	3031	2765	3176	2836	3043	2990
Cordele	2966	2692	3034	2745	2927	2939
Dearing	2795	2597	2817	2501	2811	2736
Dublin	2739	2587	2923	2581	2850	2848
Eatonton	2566	2245	2516	2203	2431	2368
Ft. Valley	2741	2484	2743	2435	2695	2727
Griffin	2506	2222	2489	2202	2386	2386
Jeffersonville	N/A	N/A	N/A	2403	2663	2616
McRae	N/A	N/A	N/A	N/A	2747	2761
Midville	2830	2666	2916	2569	2829	2827
Moultrie	N/A	N/A	N/A	N/A	N/A	2926
Pine Mountain	2375	2107	2471	2248	2343	2393
Plains	2637	2351	2831	2531	2722	2739
Rome	2309	2053	2443	2090	2276	2313
Savannah	2591	2548	2940	2738	2749	3092
Statesboro	2567	2420	2936	2628	2840	2565
Tifton	2928	2692	3075	2766	3024	2940
Valdosta	3061	2933	3193	2986	3239	3271
Vidalia	2892	2706	2949	2703	2915	2966
Watkinsville	2512	2220	2509	2173	2407	2379

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

Site	2000	2001	2002	2003	2004	2005
Alapaha	N/A	N/A	N/A	40.79	35.70	18.98
Albany	N/A	N/A	N/A	N/A	33.40	30.68
Alma	23.74	19.68	26.17	35.23	33.45	23.39
Arlington	18.66	16.23	28.36	23.49	32.61	28.56
Attapulgus	20.20	30.54	27.82	25.39	28.83	28.28
Cairo	20.84	26.23	19.99	27.29	28.11	27.85
Camilla	22.59	24.86	25.70	25.71	23.77	24.71
Cordele	11.19	18.47	19.40	27.71	34.72	19.81
Dearing	17.84	17.15	23.02	22.22	28.32	28.31
Dublin	17.70	16.55	22.95	32.42	31.73	17.93
Eatonton	14.24	18.46	17.48	25.11	32.95	23.33
Ft. Valley	16.30	14.04	24.40	17.04	20.56	23.94
Griffin	16.09	12.86	21.75	32.80	35.52	31.71
Jeffersonville	N/A	N/A	N/A	28.80	29.00	22.52
McRae	N/A	N/A	N/A	N/A	35.79	17.30
Midville	15.60	12.89	18.52	35.20	30.45	28.71
Moultrie	N/A	N/A	N/A	N/A	N/A	28.37
Pine Mountain	14.09	16.48	18.67	34.56	38.87	24.11
Plains	18.11	24.37	19.50	26.00	32.07	29.53
Rome	16.58	18.59	26.23	31.85	24.12	15.30
Savannah	20.27	22.54	38.28	24.52	37.85	31.00
Statesboro	15.33	13.89	25.67	36.34	24.37	28.86
Tifton	18.31	19.33	17.21	31.78	33.62	18.97
Valdosta	23.43	26.31	24.93	25.97	31.96	31.12
Vidalia	16.95	18.07	28.06	40.37	35.87	15.75
Watkinsville	16.30	22.39	19.48	34.27	30.36	29.02

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

Site	2000	2001	2002	2003	2004	2005
Alapaha	N/A	N/A	N/A	14.26	9.61	-6.61
Albany	N/A	N/A	N/A	N/A	1.37	-0.43
Alma	-5.26	-7.52	-3.38	5.72	2.40	-7.93
Arlington	-13.20	-14.29	-2.77	-5.32	2.52	-0.88
Attapulgus	-5.48	9.75	-2.62	-3.03	-2.17	-2.38
Cairo	-10.59	-3.31	-9.79	-1.26	-2.26	-1.53
Camilla	-9.73	-5.26	-7.30	-4.13	-8.18	-6.80
Cordele	-22.58	-13.01	-14.36	-3.74	1.10	-14.25
Dearing	-12.07	-8.99	-6.85	-5.76	-2.18	-0.95
Dublin	-15.58	-14.58	-8.91	2.94	-0.60	-12.80
Eatonton	-17.53	-10.88	-12.05	-1.24	-3.87	-3.48
Ft. Valley	-15.33	-16.66	-4.35	-7.00	-3.97	-0.24
Griffin	-16.82	-17.56	-7.38	5.18	7.10	3.45
Jeffersonville	N/A	N/A	N/A	2.12	-1.20	-8.18
McRae	N/A	N/A	N/A	N/A	5.35	-12.36
Midville	-17.45	-18.82	-11.90	7.17	3.52	1.16
Moultrie	N/A	N/A	N/A	N/A	N/A	-3.02
Pine Mountain	-15.34	-10.96	-8.64	9.17	13.37	-1.17
Plains	-13.19	-5.27	-9.77	-1.13	2.79	-0.91
Rome	-11.41	-7.41	-0.97	7.12	-1.47	-11.23
Savannah	-11.05	-7.36	6.98	-4.16	8.94	1.74
Statesboro	-14.50	-14.78	-2.78	8.50	-5.40	0.27
Tifton	-15.66	-12.58	-15.52	0.80	2.61	-11.97
Valdosta	-8.91	-4.59	-5.48	-2.96	-0.04	-0.86
Vidalia	-14.96	-11.65	-2.49	11.26	2.38	-15.49
Watkinsville	-12.79	-7.54	-9.78	7.39	1.17	0.95

COTTON GROWTH AND DEVELOPMENT UNDER DIFFERENT IRRIGATION REGIMES

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Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most important row crops in Georgia. Currently, the crop accounts for approximately 1,396,000 acres per year. The average yield for the past 10 years has been 660 lb/acre with a high inter-annual variability. Fiber quality is also frequently mentioned as a concern for cotton that has been produced in Georgia. Efforts to solve these problems for cotton have been conducted and new technologies have been adopted. For instance, in recent years farmers have planted mainly genetically modified (GM) cultivars. Within the strategies to improve cotton yields, irrigation scheduling is an important management practice that can help to obtain high and stable yields with adequate fiber quality. There are several, well documented irrigation scheduling methods. A new approach for determining irrigation scheduling consists of using decision systems, such as the Decision Support System for Agrotechnology Transfer (DSSAT) (Tsuji et al., 1994; Jones et al., 2003; Hoogenboom et al., 2004). The DSSAT encompasses models for 27 different crops, including the Cropping System Model CSM-CROPGRO-Cotton model which has been one of the most recently developed models. The main goal of irrigation scheduling is to obtain high and stable yields and to use water efficiently. Most of the irrigation studies have been conducted under rainfed conditions, meaning that supplemental water is provided through irrigation if needed. However, there is insufficient information about the response of cotton to different irrigation scheduling techniques when all water applications are completely controlled throughout the growing season. The objective of this study was to determine the impact of different irrigation scheduling regimes on cotton growth and development under completely dry conditions.

Material and Methods

Two experiments were conducted in four automatic rainout shelters located on the Griffin Campus of the University of Georgia. The rainout shelters are 39.3 feet long and 13.1 feet wide. Each rainout shelter corresponded to one irrigation treatment and each treatment had 3 replicates. The decision when to irrigate and how much water to apply was determined daily based on simulations with the cotton crop simulation model CSM-CROPGRO-Cotton for each individual treatment. As an example for each treatment when the actual soil water content in the top layer dropped below a specific threshold of the available water content (AWC), irrigation was applied until the soil water reached 100% of AWC. The irrigation treatments corresponded to 40%, 60% and 90% of the irrigation threshold (IT) and 100% ETc in 2004 and 30%, 40%, 60% and 90% of the irrigation threshold in 2005. Due to problems with the electronic control system of the rainout shelters, only the 40% and 60% IT treatments for 2004 and the 40%, 60% and 90% IT treatments for 2005 were analyzed. Experimental errors were one of the main concerns for the treatments that were not analyzed.

For the irrigation scheduling the CSM-CROPGRO cotton model was set to consider the observed weather data until the decision date. For the remainder of the growing season the average daily weather data for the last 10 years (Tmax, Tmin and solar radiation) were used for the 2004 growing season, while for the 2005 growing the daily weather data for the last 10 years were used. Irrigation depth is fixed for the entire growing season in the model but it was modified manually according to development of the crop to be able to have more realistic irrigation scheduling.

The cotton cultivar DP 555 BG/RR was planted on May 19th, 2004 and May 17th, 2005. The plants population was 45,000 plants per acre. Rows were spaced 3 feet, plant spacing was 3.9 inches and the planting depth was 1.5 inches. Fertilization was conducted following the recommendations based on the results of the soil analysis. Pests were controlled with specific chemical applications. The plant growth regulator Pentia® was applied in the two cotton experiments (2004 and 2005 growing seasons).

Soil physical and chemical analysis was conducted at depths of 2, 6, 12, 24 and 36 inches. The soil was characterized by its high sand content (92%) in the profile. Soil water content was monitored with Time-Domain-Reflectometry (TDR) in both experiments and with a PR2 probe during the 2005 experiment. The TDR probes were 11.8 inches in length and 3 probes were installed in each rainout shelter or treatment. Three access tubes were installed for the PR2 probe within the rows and one access tube between the cotton rows for each treatment. The PR2 measured the volumetric soil water content at depths of 3.9, 7.8, 11.8, 15.6, 23.4, and 39 inches.

Phenology records were obtained on a daily basis. Growth analysis included plant height, Leaf Area Index (LAI), dry matter weight for leaves, stems and roots. For reproductive development, we recorded boll position in the stem, number of squares and bolls, boll weight, and lint weight. Approximately every 18 days destructive samples were collected for 3.3 ft of linear row. All plants were cut at the base, individual plant components were separated and oven dried at 70^{o}C until constant weight and then weighed. For the final harvest, 9.8 linear feet was manually cut for each replicate and plants were separated into the different plant components similar to the procedures used for growth analysis.

An analysis of variance was conducted to determine the effect of irrigation treatment on cotton lint yield and yield components using the SAS-GLM procedure. In addition, mixed model procedures were used to analyze the growth variables for the destructive samplings conducted during the cropping season. For the 2005 experiment, an analysis of paired data to determine the differences between the means in soil water content was performed using the t-test at a significance level of $P > 0.05$.

Results and Discussion

Irrigation and soil water content

For 2005, the total amount of water applied through irrigation for the entire growing season was 11.4 inches for the 40% IT treatment, 21.7 inches for the 60% IT treatment and 26.4 inches for the 90% IT treatment. The total soil water measured with the PR2 access probe for the entire growing season for 2005 for the main soil profile up to a depth of 47.2 inches was on average 2.7 inches for the 90% IT treatment. This was significantly different from the others which, on average had 2 inches for the 40% IT treatment and 1.9 inches for the 60 % IT treatment. A preliminary analysis indicated that the period in which significant differences in soil water content were observed between the three irrigation treatments was between emergence and July 7^{th}, or until 3^{rd} square stage. For this period, the 90% IT treatment had an average of 4.3 inches in the profile, which was significantly different from the 60% IT treatment (3.5 inches) and 40 % IT treatment (3 inches).

Biomass accumulation

There was a low accumulation of biomass during the first 45 days of the growing season during the months of May and June with a rapid increase in July through middle of September. Water stress was the main cause for the low values for biomass accumulation, especially for 40 % IT treatment, which was significantly different from the 60% and 90% IT treatments (Figure 1).

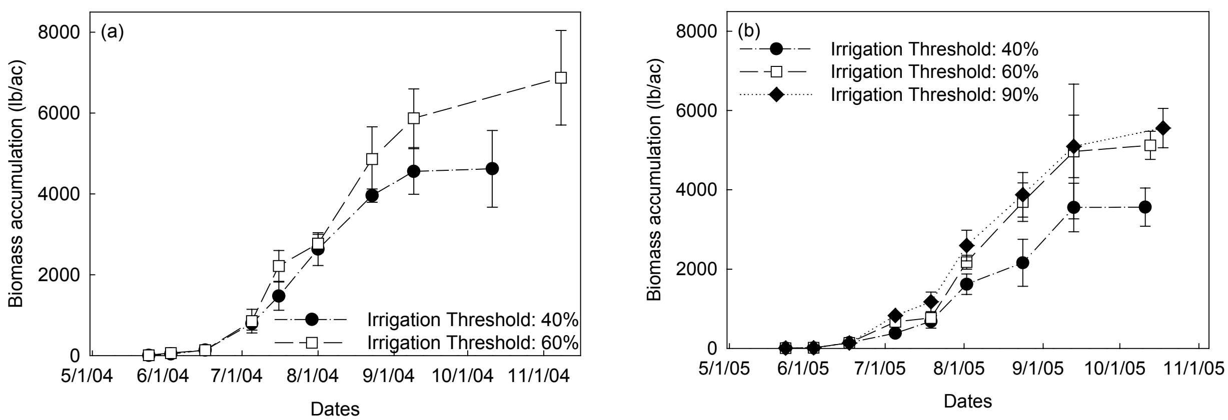

Figure 1. Biomass accumulation for cotton grown under different irrigation treatments for the years 2004 (a) and 2005 (b).

Yield and yield components

Water stress impacted the number of bolls per square meter. Thus, we observed the lowest number of bolls m^{-2} for the 40 % IT treatment, which was significantly different from the other treatments (Table 1). As the irrigation threshold increased, the number of bolls m^{-2} also increased. As the yield is the product of the number of bolls m^{-2} and individual boll weight, we found that lint yield increased as the irrigation threshold increased, e.g. from 40% IT to 90% IT treatment. The regression analysis between yield components and lint yield showed that the number of bolls m^{-2} was the most important yield component in determining the yield (r^2= 0.86).

The statistical analysis for lint yield showed that there were no significant differences between the 60 and 90% IT treatments, since the difference between these two treatments was only 2%. However, the 40% treatment was significantly impacted by the low soil water content and the yield for this treatment was on average only 61% of the yield obtained with the 60% IT treatment.

Table 1. Lint yield and yield components for cotton grown under different irrigation treatments for the years 2004 and 2005.

Year – Irrigation Threshold	Lint (lb/acre)	Seeds and lint (lb/acre)	Bolls number (Nr m^{-2})	Boll weight (g)
2004 - 40%	831 (b)	1767 (b)	59 (c)	3.4 (a)
2004 - 60%	1293 (a)	2643 (a)	90 (a)	3.2 (a)
2005 - 40%	694 (b)	1550 (b)	46 (d)	3.7 (a)
2005 - 60%	1174 (a)	2542 (a)	70 (bc)	4.1 (a)
2005- 90%	1258 (a)	2690 (a)	73 (b)	4.1 (a)

Boll position

The analysis of the position of the bolls for the 2005 experiment revealed that when the IT increased, mainly from 40% to 60%, the first bolls were formed on the lower nodes and the final bolls formed on the higher nodes (Figure 2). Thus, a wider range of nodes produced bolls when more water was applied to the crop. This might also explain the high values for the number of bolls per unit land area for the more-frequently irrigated treatments. There was also a high coefficient of determination (r^2) between the number of bolls per unit land area and lint yield.

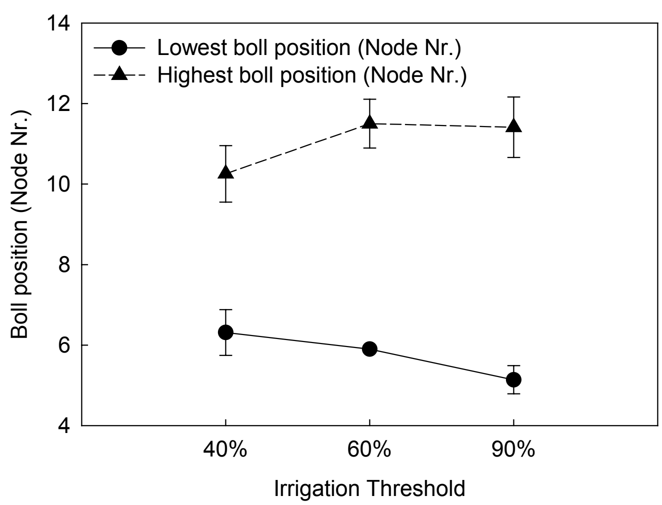

Figure 2. Boll position as a function of the different irrigation treatments for cotton grown in 2005.

Fiber quality

The cultivar DP 555 BG/RR is characterized by its high yield and good fiber-quality potential for many cotton growing areas. The results from these two experiments also showed the high quality of fiber for the DP 555 BG/RR cultivar. However, the best values for some of the properties associated with fiber quality were obtained for the 60% IT treatment in 2004, especially with respect to fiber length, uniformity, short fiber index and strength (Table 2). For the experiment conducted in 2005 there was a tendency for lower values for some of the properties related to fiber quality than in 2004, which can be explained in part by environment conditions during the reproductive stage and also by different methods used to gin the cotton in both years. The cotton harvested in 2004 was manually ginned and the 2005 cotton was ginned in a table top gin machine.

Table 2. Fiber quality properties for cotton grown under different irrigation treatments in 2004 and 2005.

Year – Irrigation threshold	Length (inches)	Uniformity (%)	Short Fiber Index	Strength (g tex^{-1})	Elongation (%)
2004 - 40%IT	1.1 (b)	84.0 (b)	3.4 (b)	30.3 (ab)	8.3 (a)
2004 - 60% IT	1.2 (a)	86.4 (a)	2.7 (b)	33.0 (a)	7.9 (ab)
2005 - 40% IT	1.1 (b)	82.6 (b)	7.3 (a)	31.1 (ab)	7.3 (b)
2005 - 60% IT	1.1 (b)	82.2 (b)	8.1 (a)	29.4 (b)	7.5 (b)
2005 - 90% IT	1.1 (b)	82.4 (b)	8.3 (a)	29.7 (b)	7.5 (b)
	Micronaire	Maturity	Reflectance	Yellow content	Color grade
2004 - 40%IT	4.9 (a)	87.0 (a)	78.3 (a)	8.1 (a)	31-2
2004 - 60% IT	4.8 (a)	87.3 (a)	72.4 (b)	6.2 (b)	51-1
2005 - 40% IT	4.9 (a)	88.0 (a)	73.3 (b)	6.1 (b)	51-1
2005 - 60% IT	4.5 (a)	86.7 (a)	73.6 (b)	8.6 (a)	41-5
2005 - 90% IT	4.7 (a)	87.3 (a)	73.4 (b)	7.6 (ab)	41-2

Conclusions

Cotton growth and development was affected by the different irrigation treatments. The method used permitted us to quantify with accuracy the effect of the different irrigation treatments on cotton growth and development, and particularly on lint yield and lint quality. Since the higher biomass accumulation as well as the higher lint and best fiber quality were found with the treatments that had a 60 and 90% irrigation threshold, the 60% irrigation threshold is one of the recommended irrigation practices, as it would conserve water compared to the 90% irrigation threshold level. The treatment with the 40% threshold resulted in a significantly lower lint yield and lowest fiber quality in both 2004 and 2005 and it is not recommended for use under field conditions.

This study showed that the dynamic crop growth model CSM-CROPGRO-Cotton can be a promising tool for irrigation scheduling. However, a variable irrigation management depth should be used and a fairly accurate soil characterization is required. Further work includes the evaluation of the CSM-CROPGRO cotton model with the results obtained from these two experiments and also the evaluation of the model with data from farmer’s field in order to be able to use the model for irrigation scheduling at the field level as well as for yield forecast applications at the state level.

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EFFECT OF SEEDING RATE AND PENTIA ON PH 475 WRF

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Introduction

New varieties and technologies are becoming available to cotton producers across the U.S. Widestrike, a two-gene Bt cotton technology, was commercialized in 2005, and combinations of Widestrike with Roundup Ready technology are expected in 2006. A study was conducted to examine the influence of two plant populations and various plant growth regulator application regimes on a new variety, PH 475 WRF.

Materials and Methods

'PH 475 WRF' Cotton was planted on May 12, 2005, at a rate of approximately 3.5 seed/ft at the Sun Belt Ag Expo, Moultrie, Georgia. Row spacing was 36 inches. Plot size was 4 rows by 40 feet and there were 4 replications. Seedbed preparation included conventional tillage, in-row subsoiling and bedding. Pest management was appropriate for WRF technology. Selected plots were hand thinned on May 18 and 28 to achieve final populations of about 1.5 and 3.0 plants/ft. A two by four factorial study was implemented, two seeding rates by four Pentia treatment regimes. Pentia treatments were initiated when cotton reached node 7 to 8 (see Table 1). Application dates were June 16 (node 7-8), July 5 (node 13-14), and July 18 (2 weeks later). One row from each plot was machine harvested on October 12. A composite sample was taken to determine lint turnout.

Results and Discussion

The desired populations (1.5 and 3.0 seed/ft) were effectively achieved (data not shown). In mid-June, excessive rainfall resuled in wet conditions and considerable fruit shed. Even through late June, square retention was very erratic. Probable causes include saturated soils and plant bugs. Counts on field borders on June 22 measured whole plant fruit retention at only 54 percent. Later in the season nodes above white flower and nodes above cracked boll were also extremely variable. Cotton height data reflect the effects of only the initial Pentia application.

Yield data are in Table 1. Lint turnout was 47.6 percent, which is unusually high even for a table top gin. There were no significant differences in lint yield among treatments. The main effects of seeding rate on yield averaged 1979 vs 1879 lb/A for 3.0 and 1.5 plants/ft, respectively.

Table 1. Effect of Seed Rate and Pentia on PH 475 WRF, Sun Belt Ag Expo, 2005.

Treatment		Plant height, inches (July 5)	Lint yield, lb/A
Seeding rate, No./ft	Pentia		
1. 3.0	Untreated	27.6	1922.3
2. 3.0	4 oz, node 7-8 16 oz, node 13-14	24.8	2008.7
3. 3.0	16 oz, node 13-4	28.8	1911.5
4. 3.0	8 oz, node 7-8 8 oz, node 13-14 8 oz, 2 weeks later	24.6	2073.5
5. 1.5	Untreated	26.7	1967.6
6. 1.5	4 oz, node 7-8 16 oz, node 13-14	23.1	1749.5
7. 1.5	16 oz, node 13-4	26.8	1818.6
8. 1.5	8 oz, node 7-8 8 oz, node 13-14 8 oz, 2 weeks later	22.1	1983.0
	LSD (0.10)	1.8	263.1
	CV	5.7	11.2

LARGE BLOCK VARIETY TRIALS AT SOUTHWEST GEROGIA RESEARCH AND EDUCATION CENTER

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Variety testing is a valuable tool for the entire cotton industry. Field trials permit direct comparisons of the yield potential of varieties and technology in a given environment, but small plot experiments often provide unrealistic fiber quality data because of boll sampling techniques and the use of small, table top gins. Seed cotton processed in gins designed for small samples often lack seed cotton pre-cleaning and lint cleaning, and therefore over estimate fiber quality data such as lint turnout as well as fiber length, strength, and length uniformity.

The development of the UGA Micro Gin facility in Tifton, Georgia, affords the opportunity for research-size samples to be processed in a manner approximating commercial ginning. The facility came on-line in the summer of 2004. Quantity and quality of output through the Micro Gin continues to improve.

Materials and Methods

A large plot variety trial was planted on May 25, 2005, at the SW Georgia Research and Education Center at Plains, Georgia, to compare yield and fiber quality of three varieties. Experimental design was a randomized complete block with 7 replications. Plot size was 12 rows by the length of the field, which varied from about 950 to 1250 ft. Each of the varieties was a Bollgard/Roundup Ready cultivar and was grown with appropriate management practices. Multiple-acre plots allowed the harvest of large amounts of cotton suitable for processing through a commercial gin and standard quality assessment in the USDA cotton classing system. The center 4 rows from plots in replications 2 through 5 were machine harvested on November 11 and weighed with a boll buggy outfitted with scales. Samples (20 to 30 lbs) were collected from these plots for ginning in the UGA Micro Gin and for hand ginning (100 g) on a table top gin. The following week, the remainder of the plot area was machine harvested with seed cotton placed in modules by variety. Samples from the commercial gin (McClesky Cotton Company) were handled in the USDA Classing Office in Macon, GA, while UGA Micro Gin samples were forwarded to the International Textile Center at Texas Tech University for fiber quality analysis.

Results and Discussion

Yield and turnout data are reported in Table 1. Since yields were calculated from module weights there is no replication of module and no direct statistical analysis of yield data from the commercial gin. Four replicates weighed in a boll buggy allow statistical comparisons of yields. Based on module weights, ST 6636 BR was competitive with DP 555 BG/RR. Both provided yields superior to FM 991 BR. Lint turnout was higher for DP 555 BG/RR than the other two varieties. As expected, turnout was much higher for the table top gin than for the other gins.

Table 1. Yield and gin turnout of three varieties planted in large plots in 2005 at the SW Georgia Research and Education Center at Plains, Georgia.

Variety	Lint yield, lb/A		Lint turnout by Gin, %		
	Module	UGA Micro	Commercial	UGA Micro	Table top
DP 555 BG/RR	1130	1191	38.3	39.0	45.9
ST 6636 BR	1156	1044	36.2	33.3	40.4
FM 991 BR	956	935	35.5	34.1	41.4
LSD (0.10)	--	84	–	1.0	1.3
CV		5.8		2.1	2.1

Varieties replicated 7 times in plots 12 rows by 950 to 1250 ft. Module and commercial gin data taken from all replications; Micro Gin and table top gin data taken from the center 4 rows from replications 2 through 5. For commercial ginning, each variety was harvested and put into a single module by variety. The test was planted May 25, 2005. Subplots for the Micro Gin and table top gin were harvested November 11; the remainder of the cotton was harvested November 14-16.

Fiber length, micronaire, and strength of all three varieties were quite good (Table 2). As is typical of most Fiber Max varieties, strength of FM 991 BR was particularly good. Uniformity data were higher from the UGA Micro Gin and table top gin than from the commercial gin. Uniformity was least for DP 555 BR. Low uniformity remains a troublesome characteristic of this popular variety. For all bales of the three varieties, grade/leaf from the commercial gin were 31-3 or 31-4 (data not shown).

Table 2. Fiber quality of three varieties from large plot field trials processed on a commercial gin, the UGA Micro Gin, and a table top gin, 2005.

Variety	Commercial gin				UGA Micro Gin				Table top gin			
	len, inch	mic	stre, g/tex	unif	len, inch	mic	stre, g/tex	unif	len, inch	mic	stre, g/tex	unif
DP 555 BR	1.12	4.34	29.1	79.9	1.12	4.00	28.8	81.8	1.13	4.25	29.4	81.8
ST 6636 BR	1.10	4.16	30.1	81.3	1.12	3.95	29.5	83.3	1.15	3.95	31.0	84.1
FM 991 BR	1.11	4.19	31.9	81.2	1.12	4.15	30.9	83.2	1.15	4.23	32.2	83.6
LSD (0.10)	0.8	0.09	1.1	0.9	0.02	0.23	0.5	0.2	0.03	0.31	1.8	1.4
CV	2.2	2.2	3.9	1.2	1.2	4.1	1.2	0.2	2.1	5.4	4.2	1.3

Commercial gin data taken from the middle 7 bales of each module. Micro Gin data taken from 20 to 30 lb samples collected from replications 2 through 5.

ROUNDUP READY FLEX VARIETIES VERSUS DP 555 BG/RR

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Introduction

Scientists with The University of Georgia have been working with the weed management aspects of Roundup Ready Flex (RF) technology for several years. Commercialization is expected for the 2006 growing season, with seed supplies sufficient for almost 3 million acres across the U.S. To increase experience with RF varieties, in 2005 Monsanto encouraged seed company providers to submit entries to Official Variety Trials managed by public institutions and also sponsored specific RF trials managed by Extension scientists. Of the latter group, one such trial was established at a non-irrigated site on the ABAC Farm at Tifton, Georgia. The field had not been planted in cotton for many years.

DP 555 BG/RR is the most widely planted variety in Georgia. A USDA survey indicated that it was planted on 73 percent of the acreage in the state in 2005. Because of its high yield potential, DP 555 BG/RR was used as a control variety in this experiment.

Materials and Methods

Cotton was planted on May 3, 2005, with a cone planter at a rate of 3.0 seed/ft. Plot size was 2 rows by 40 feet and there were 4 replications. The field had been strip-tilled but had limited surface residues of small grain and corn stubble. Varieties included RF, Bollgard II/RF, and WRF technologies. Two treatments of DP 555 BG/RR were included, one which received glyphosate applications identical to the RF varieties and one for which the mid-post (9 to 10-leaf over-the-top) application was omitted. Preplant fertilization included 330 lb/A of 17-4-15 and 1 ton/A of lime. A sidedress application of 28-0-0-5 at 15 gal/A was made on June 14. Plots were hand thinned in late May to eliminate clumps of plants and to reduce populations to 1.5 to 2 plants/ft. Weed control treatments included PRE (May 6) - Roundup Weather Max (22 oz) + Prowl (1 qt); EARLY POST (cotyledon to 1-leaf, May 16) - MON 3539 (22 oz); EARLY POST (4-leaf, May 25) - MON 3539 (22 oz); MID POST (9 to 10-leaf, June 13) -MON 3539 (22 oz) except on 'DP 555 BG/RR RR Program;' and minimal hand weeding as needed. All glyphosate treatments were applied over-the-top. Pentia was applied at 16 oz/A on June 30 and July 8. Plots were machine harvested on September 23. Small seed cotton samples were taken from 2 replications and subjected to hand ginning to determine lint turnout. Lint samples were sent to the LSU Fiber Lab.

Results and Discussion

A good stand was achieved with all varieties and there were minimal differences in early season vigor (data not shown). Few instances of drought/heat stress were observed throughout the season until late August and September. Late-season drought/heat was intense, and it limited upper boll production as well as boll rot.

Yield and lint percent (turnout) data are provided in Table 1, fiber quality data in Table 2. Several varieties produced lint yields comparable to DP 555 BG/RR but none statistically greater. Among these are RF as well as B2RF and WRF varieties. It is interesting to note there was no difference between DP 555 BG/RR which received the standard Flex program (Treatment 1) and which received only two early post over-the-top Roundup applications (Treatment 25). Favorable uniformity and short fiber content data reflect the results of processing on a table top gin. Micronaire is surprisingly good with most varieties.

Table 1. Yield and turnout of Roundup Ready Flex Trial, ABAC Farm, 2005.

Variety	Seed cotton yield, lb/A	Lint, lb/A	Lint, %
1 DP 555 BG/RR RR Flex Program	4843.8 ab	2092.5 a	0.4320 c
2 3020 GA	4442.2 b-f	1821.3 cde	0.4100 m
3 3520 GA	4358.3 c-f	1773.8 c-g	0.4070 n
4 4020 GA	4766.6 abc	1954.3 abc	0.4100 m
5 PHY 475 WRF	4260.7 efg	1827.8 cde	0.4290 d
6 PHY 485 WRF	4957.2 a	2096.9 a	0.4230 f
7 PHY 415 RF	4610.1 a-e	1922.4 a-d	0.4170 i
8 PHY 425 RF	4605.6 a-e	1925.1 a-d	0.4180 h
9 STX 6611 B2RF	4664.5 a-e	1856.5 b-e	0.3980 r
10 STX 6622 RF	4521.6 b-f	1930.7 abc	0.4270 e
11 STX 5885 B2RF	4410.5 b-f	1724.5 efg	0.3910 t
12 STX 4664 RF	4626.0 a-e	2100.2 a	0.4540 a
13 BCG-1505 RF	4113.2 fg	1637.1 fg	0.3980 r
14 BCG-1004 BBIIF	4689.5 a-e	1941.5 abc	0.4140 k
15 BCG-3255 BBIIF	4678.2 a-e	1871.3 b-e	0.4000 q
16 BCG-4021 BBIIF	4662.3 a-e	1836.9 cde	0.3940 s
17 BCG-4630 BBIIF	4812.0 ab	2025.9 ab	0.4210 g
18 BCG-9124 BBIIF	4698.6 a-d	1949.9 abc	0.4150 j
19 BCG-9775 BBIIF	4641.9 a-e	1782.5 c-g	0.3840 u
20 DPX 04X495 F	4326.5 def	1782.5 c-g	0.4120 l
21 DPX 04X462 F	3850.1 g	1620.9 g	0.4210 g
22 DPX 04X419 DF	4514.8 b-f	1815.0 c-f	0.4020 p
23 DPX 04X436 DF	4322.0 def	1746.1 d-g	0.4040 o
24 DPX 04T126 DF	4483.0 b-f	1860.5 b-e	0.4150 j
25 DP 555 BG/RR RR Program	4616.9 a-e	2054.5 a	0.4450 b
26 STX 0404 B2RF	4723.5 a-d	2102.0 a	0.4450 b
LSD (P=.10)	434.91	181.24	0.00042
CV	8.1	8.13	0.09

Means followed by same letter do not significantly differ (P=.10, LSD)

Table 2. Fiber Quality of Roundup Ready Flex Trial, ABAC Farm, 2005

Variety	Length, inches		UNIF		Short fiber, %		Strength, g/tex		mic	
1 DP 555 BG/RR RR Flex Program	1.165	f-j	82.50	def	6.35	a-d	31.30	a-d	4.20	a-d
2 3020 GA	1.160	g-j	83.40	a-e	5.05	def	27.65	j	3.95	def
3 3520 GA	1.190	def	83.90	ab	5.50	b-f	28.15	ij	3.90	def
4 4020 GA	1.230	a	83.40	a-e	5.30	c-f	28.85	f-j	3.70	ef
5 PHY 475 WRF	1.155	hij	83.70	abc	4.95	def	31.60	abc	3.95	def
6 PHY 485 WRF	1.160	g-j	84.00	ab	4.55	f	31.80	abc	4.25	a-d
7 PHY 415 RF	1.155	hij	83.55	a-d	5.60	b-f	29.65	d-i	4.20	a-d
8 PHY 425 RF	1.150	ij	83.80	abc	5.20	def	30.65	a-g	4.40	abc
9 STX 6611 B2RF	1.160	g-j	83.05	a-e	6.05	a-e	28.60	hij	4.15	bcd
10 STX 6622 RF	1.180	d-h	83.40	a-e	5.95	b-f	30.00	c-i	4.20	a-d
11 STX 5885 B2RF	1.195	cde	83.95	ab	4.95	def	31.90	ab	4.05	cde
12 STX 4664 RF	1.155	hij	82.30	ef	6.75	abc	31.05	a-e	4.00	c-f
13 BCG-1505 RF	1.195	cde	83.35	a-e	5.95	b-f	31.15	a-e	3.95	def
14 BCG-1004 BBIIF	1.205	a-d	84.10	a	4.65	ef	30.65	a-g	4.25	a-d
15 BCG-3255 BBIIF	1.175	e-i	83.80	abc	4.95	def	28.20	ij	3.90	def
16 BCG-4021 BBIIF	1.175	e-i	83.75	abc	5.10	def	29.10	f-j	3.60	f
17 BCG-4630 BBIIF	1.180	d-h	84.10	a	5.70	b-f	29.60	d-i	4.10	cde
18 BCG-9124 BBIIF	1.200	b-e	84.10	a	5.00	def	30.70	a-f	4.00	c-f
19 BCG-9775 BBIIF	1.225	ab	84.10	a	4.95	def	29.05	f-j	3.85	def
20 DPX 04X495 F	1.200	b-e	82.70	c-f	6.35	a-d	29.40	e-j	4.00	c-f
21 DPX 04X462 F	1.205	a-d	81.70	f	7.50	a	30.50	a-g	4.00	c-f
22 DPX 04X419 DF	1.220	abc	82.95	a-e	6.95	ab	28.80	g-j	3.90	def
23 DPX 04X436 DF	1.180	d-h	83.00	a-e	6.15	a-d	29.45	d-j	4.05	cde
24 DPX 04T126 DF	1.185	d-g	83.20	a-e	6.00	b-f	30.70	a-f	4.20	a-d
25 DP 555 BG/RR RR Program	1.145	j	83.10	a-e	5.90	b-f	30.35	b-h	4.55	ab
26 STX 0404 B2RF	1.140	j	82.85	b-f	6.15	a-d	32.30	a	4.60	a
LSD (P=.10)	0.0260		1.180		1.483		1.882		0.435	
CV	1.29		0.83		15.31		3.67		6.25	

Means followed by same letter do not significantly differ (P=.10, LSD)

THE EFFECT OF PLANT SPACING ON YIELD AND QUALITY USING 2-SEED HILL-DROP METHOD ON COTTON IN BERRIEN COUNTY, GEORGIA

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Introduction

The most commonly grown cotton variety in Georgia is DP 555 BG/RR. Growers plant this variety due to its proven high yield capacity. With the ever-increasing costs of technology associated with this and other transgenic varieties, growers seek to minimize their input costs per pound of lint to create an opportunity for profit. Previous field trials in 2004 looked at varying plant populations and their effect on yield. No significant differences were found in yield due to 1, 2 or 3 plants per foot of row in the trials conducted in 2004. Since there was limited data relating to plant spacing affect on yield and quality characteristics, the objective of this experiment was to determine any yield and quality differences due to plant spacing. Economic analysis was also conducted to determine differences in net return due to yield, fiber quality, and seed cost (plant spacing).

Methods and Materials

In 2005 a field trial was conducted at a Berrien County location to compare DP 555 BG/RR planted on Irvington loamy sand soil type in 36" rows at 10" and 14" plant spacing using the hill drop method at 2 seed per hill. Experimental design was a randomized complete block design with 3 replications per treatment. Each plot was 16 rows wide (48') and between 780 and 805 feet long. Planting date was May 16, 2005. Final plant stand was 1.5 plants per foot for the 10" plant spacing and 1.2 plants per foot for the 14" plant spacing. Harvest date was October 24, 2005. Seed-cotton weights were taken in the field using a boll buggy with scale. Random samples of seed-cotton from each plot were sent to the UGA Micro Gin at Tifton, GA. Before and after ginning weights were taken to determine lint turn-out (percentage) and lint yield per acre.

From the ginned cotton of each replication (plot), 3 random samples were taken and these lint samples sent to the International Textile Center at Texas Tech University for HVI classing. Fiber quality from the 3 samples for each plot was then averaged to arrive at an average fiber quality for each plot or yield replication.

Lint value (income) was based on the base loan rate for Berrien County (52.7 cents per pound) adjusted for fiber quality. Seed cost was the only relevant cost to consider in the analysis. All other inputs and costs were the same regardless of seed spacing. The value (lint income), seed cost, and net return were calculated for each plot (replication) and then averaged for each test (seed spacing).

Seed cost was calculated based on the seed spacing and 36-inch rows (2 seed every 10 inches = 2.4 seed per foot of row and 34,848 seeds/acre, 2 seed every 14 inches = 1.7 seed per foot of row and 24,891 seed per acre). Seed was priced at $396 per bag including technology fee.

The basis for comparing 10-inch vs. 14-inch seed spacing was the net return above seed cost. All other inputs and costs were the same in both tests and thus irrelevant to the analysis.

Results and Discussion

There was no significant difference in lint yield when comparing the 10" plant spacing to the 14" plant spacing. Gin turn-out, loan value, income and net return also expressed no significant difference between plant spacing.

Fiber quality and Loan Value are presented in Table 1. There was no difference in Color/Leaf Grade. There were, however, differences in Staple, Strength, and Micronaire. The plots planted in 14-inch seed spacing were shorter in Staple, lower in Strength, and higher in Micronaire. There was no difference in fiber length Uniformity.

Although 3 of the 5 quality parameters were impacted by seed spacing (population), there was no statistical difference in Loan Value. This is likely because although quality factors can differ numerically (even statistically), it may result in little or no change in Value per pound of lint because premiums and discounts for some quality factors are the same for a range of quality. For example, the 2005 loan premium was 25 points (0.25 cents per pound) for strength 29.5 to 30.4 and zero for strength 25.5 to 29.4.

Although the Loan Value per pound was not “statistically different” between the 10-inch and 14-inch tests, it is worth noting that the Loan Value for each plot of the 14-inch test was below the lowest Value of any plot in the 10-inch test.

Table 2 presents a comparison of Yield, Income, and Net Return. There was no statistical difference in lint turn-out (Gin T/O), Lint Yield, Income per acre, or Net Return. Yield was essentially the same at both 10-inch and 14-inch spacing. Because of the difference in Loan Value, Income was lower for the 14-inch spacing but not statistically different. At 14-inch seed spacing, Seed Cost (including technology fee) was lowered by $15.77 per acre but there was no difference in Net Return. The savings in Seed Cost was offset by lower Loan Value per pound of lint.

In summary, reducing the seed rate resulted in cost savings but no difference in Net Return. Yield was not different but fiber quality was less. There was no difference in Net Return thus no income advantage or disadvantage to reduced seeding rate. But fiber quality was better at the higher seeding rate.

Although no difference in Net Return, because fiber quality was higher quality with the 10" plant spacing versus the 14" plant spacing, this experiment would support the plant spacing of 10" versus the 14" due to the contribution of higher quality cotton from Georgia producers with no economic loss due to increased seed costs.

Table 1. Comparison of Fiber Quality Characteristics and Loan Value, By Seed Spacing

Seed Spacing	Color/Leaf	Staple	Strength	Mic	Uniformity	Loan Value
Rep 1	31/1	35.8	29.8	4.33	82.43	58.15
Rep 2	31/2	36.2	29.8	4.17	81.70	58.40
Rep 3	31/1	36.2	30.7	4.20	82.17	58.60
10-Inch Avg	31/1 a	36.1 a	30.1 a	4.23 a	82.10 a	58.38 a
Rep 1	31/1	35.6	29.2	4.47	81.37	57.90
Rep 2	41/1	35.7	28.5	4.33	80.93	55.40
Rep 3	31/3	35.1	28.7	4.33	82.53	57.25
14-Inch Avg	31/2 a	35.5 b	28.8 b	4.36 b	81.61 a	56.85 a

Means (Averages) within the same column followed by the same letter are not statistically different. Means (Averages) within the same column followed by a different letter are statistically different at the 90% level or better. Loan value in cents per pound of lint, adjusted for quality from the Berrien County base warehouse loan rate of 52.7 cents per lb.

Table 2. Comparison of Yield and Per Acre Net Return, By Seed Spacing

Seed Spacing	Gin T/O	Lint Yield	Loan Value	Income	Seed Cost	Net Return
Rep 1	38.2%	1,305	58.15	$758.86	$55.18	$703.68
Rep 2	37.7%	1,249	58.40	$729.42	$55.18	$674.24
Rep 3	38.0%	1,239	58.60	$726.05	$55.18	$670.87
10-Inch Avg	38.0% a	1,264 a	58.38 a	$738.18 a	$55.18	$683.00 a
Rep 1	37.6%	1,264	57.90	$731.86	39.41	$692.45
Rep 2	38.1%	1,292	55.40	$715.77	39.41	$676.36
Rep 3	38.6%	1,261	57.25	$721.92	39.41	$682.51
14-Inch Avg	38.1% a	1,272 a	56.85 a	$723.18 a	$39.41	$683.77 a

Means (Averages) within the same column followed by the same letter are not statistically different. Means (Averages) within the same column followed by a different letter are statistically different at the 90% level or better. Yield, Income, Seed Cost and Net Return are per acre. Loan Value is cents per pound of lint.

ECOLOGY AND MANAGEMENT OF TROPICAL SPIDERWORT IN GEORGIA

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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). In 1983, the U.S. Department of Agriculture designated tropical spiderwort as a federal noxious weed (USDA-APHIS 2000). 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.

Tropical spiderwort is an exotic invasive herbaceous perennial of tropical climates that grows as an annual in temperate climates (Holm et al. 1977). Tropical spiderwort is a monocot and possesses the unique ability to produce both aerial and subterranean flowers (Maheshwari and Maheshwari 1955; Walker and Evenson 1985). Aerial flowers are chasmogamous (typical, open flowers), lilac or blue, and self-fertilized. Subterranean flowers develop on the rhizomes and are cleistogamous (flowers are self-fertilized and do not open). Walker and Evenson (1985) reported that subterranean flower formation begins by 6 wk after plant emergence, while aerial flowers form 8 to 10 wk after emergence. Plants grown from underground seeds are capable of producing 8,000 seeds/m^2, while those originating from aerial seeds may produce 12,000 seeds/m^2 (Walker and Evenson 1985). In addition, broken vegetative cuttings of stems are capable of rooting and reestablishing themselves following cultivation.

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 evaluate response of tropical spiderwort to weed management systems in Roundup Ready cotton and to determine the factors that have allowed tropical spiderwort to become a weed in our agroecosystems.

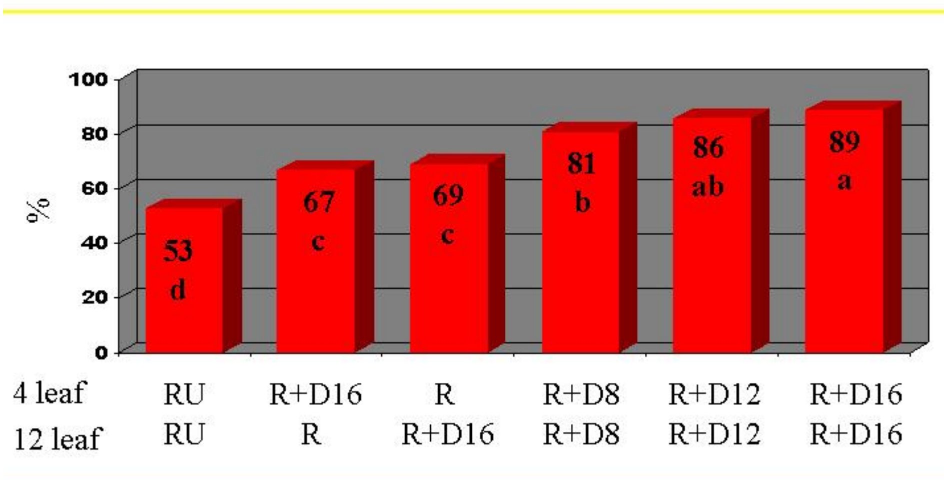
Managing Tropical Spiderwort in Roundup Ready Cotton

Studies were conducted in grower fields during 2004 and 2005 with naturalized populations of tropical spiderwort near Cairo, GA. Soils were Tifton loamy sands (thermic Plinthic Kandiudults) with organic matter ranging from 1.0 to 1.4% and pH ranging from 5.8 to 6.2.

The first experiment compared six herbicide systems focusing on application rate and timing of Dual Magnum. Systems included Roundup WeatherMax (22 oz/A) applied to 4- and 12-leaf cotton, Roundup plus Dual Magnum (16 oz/A) applied to four-leaf cotton followed by Roundup applied to 12-leaf cotton, Roundup applied to four-leaf cotton followed by Roundup plus Dual Magnum (16 oz/A) applied to 12-leaf cotton, and three sequential systems of Roundup plus Dual Magnum at 8, 12, or 16 oz/A applied to four-leaf cotton followed by the same herbicide applied again to 12-leaf cotton. These herbicides were applied topically to four-leaf cotton and directed to 12-leaf cotton. Prowl applied preemergence was a component of all treatments. A non-treated control was included.

At season's end, Prowl followed by Roundup applied twice controlled tropical spiderwort only 53% (Figure 1). Dual Magnum (16 oz/A) applied with glyphosate to 4- or 12-leaf cotton increased control only 14 to 16%. Waiting until 12-leaf cotton to apply Dual Magnum allowed the weed to become too large for control by Roundup, thus the residual activity from Dual Magnum was of minimal benefit. Dual Magnum applied at only the four-leaf stage provided excellent mid-season control, but late-emerging tropical spiderwort lessened late-season control. Roundup plus Dual Magnum applied sequentially at 8, 12, and 16 oz/A controlled tropical spiderwort 81, 86, and 89%, respectively, late in the season.

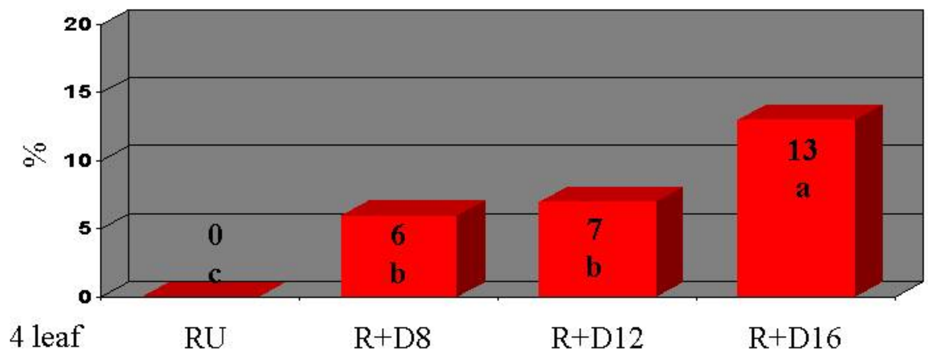
Figure 1. Late-season tropical spiderwort control.*



*Prowl PRE over trial area.

Cotton was injured 0, 6, 7, and 13% by Roundup alone or mixed with 8, 12, or 16 oz/A of Dual Magnum, respectively (Figure 2). Cotton quickly recovered from the cosmetic burn from the Dual mixtures and no injury was detectable 21 days after application.

Figure 2. Cotton Response to Herbicide Treatments at 4 day.*



*Prowl PRE over trial area.

A second experiment evaluated the most effective lay-by herbicide options to control emerged tropical spiderwort and to provide residual control. Treatments included a factorial arrangement of Roundup WeatherMax (22 oz/A), Roundup plus Aim (1.5 oz/A), Roundup plus Valor (1 oz/A), Direx (2 pt/A) plus MSMA (2 lb ai/A), and Valor (2 oz/A) plus MSMA applied alone or mixed with Dual Magnum at 16 oz/A. Prowl was applied preemergence and Roundup plus Dual Magnum (12 oz/A) were applied topically to four-leaf cotton in all treatments. Lay-by herbicides were precision directed at 15 GPA to 18-inch cotton with minimal injury.

At 9 days after application, all treatments except Roundup alone or mixed with Dual Magnum provided 89 to 99% control (Figure 3). At this time, Dual Magnum was of benefit only with Roundup plus Aim (+9%). Dual Magnum did not improve control with combinations containing Valor or Direx because both of these herbicides often offer up to 2 weeks of residual control.

By harvest, Aim mixed with Roundup did not improve control as the weed continued to emerge in the absence of residual activity (Figure 4). Roundup plus Valor, Valor plus MSMA, and Direx plus MSMA were more effective (77 to 81%) than Roundup plus Aim due to the residual activity from Valor and Direx. Dual Magnum included with lay-by applications increased late-season control 10 to 18% when in combination with Roundup plus Valor, Direx plus MSMA, or Valor plus MSMA and 30% when in combination with Roundup plus Aim.

Figure 3. Percent Spiderwort Control at 9 day after Layby.*

Layby Options	- Dual Mag.	+ Dual Mag
RU	73 c	78 c
RU + Aim	89 b	98 a
RU + Valor	93 ab	99 a
MSMA + Direx	96 ab	99 a
MSMA + Valor	92 ab	97 a

*Prowl PRE followed by Roundup + Dual Mag (12 oz) EPOST.

Figure 4. Percent Spiderwort Control at Harvest.*

Layby Options	- Dual Mag.	+ Dual Mag
RU	50 e	70 d
RU + Aim	58 e	88 ab
RU + Valor	77 cd	88 ab
MSMA + Direx	77 cd	95 a
MSMA + Valor	81 bc	91 ab

*Prowl PRE followed by Roundup + Dual Mag (12 oz) EPOST.

The Ecology of Tropical Spiderwort in Agroecosytems of the Southeast US

There are numerous factors that have allowed tropical spiderwort to become a weed in our agroecosystems and several of these factors include 1) its amazing growth habit, 2) unique emergence characteristics, 3) the ability to tolerate drought stress, 4) the slow growth habit of cotton, and 5) its ability to capitalize on unused resources following crop harvest.

Amazing growth habit. Greenhouse studies evaluated tropical spiderwort growth. Five-leaf tropical spiderwort plants were transplanted into 30-cm diameter pots and growth evaluated over 11 weeks. There were five plants evaluated and the study was repeated over time. Plant growth was nearly linear between one and six weeks, with plants with 50 leaves, 10 shoots, and 10 aerial spathes (leafy bract that encloses the flowers and fruit). However, tropical spiderwort growth was geometric between six and 11 weeks after planting, with weekly additions of 70 leaves (Figure 5), 10 shoots (Figure 6), and 26 aerial spathes (Figure 7).

Figure 5. Leaf production between 6 and 11 WAP.

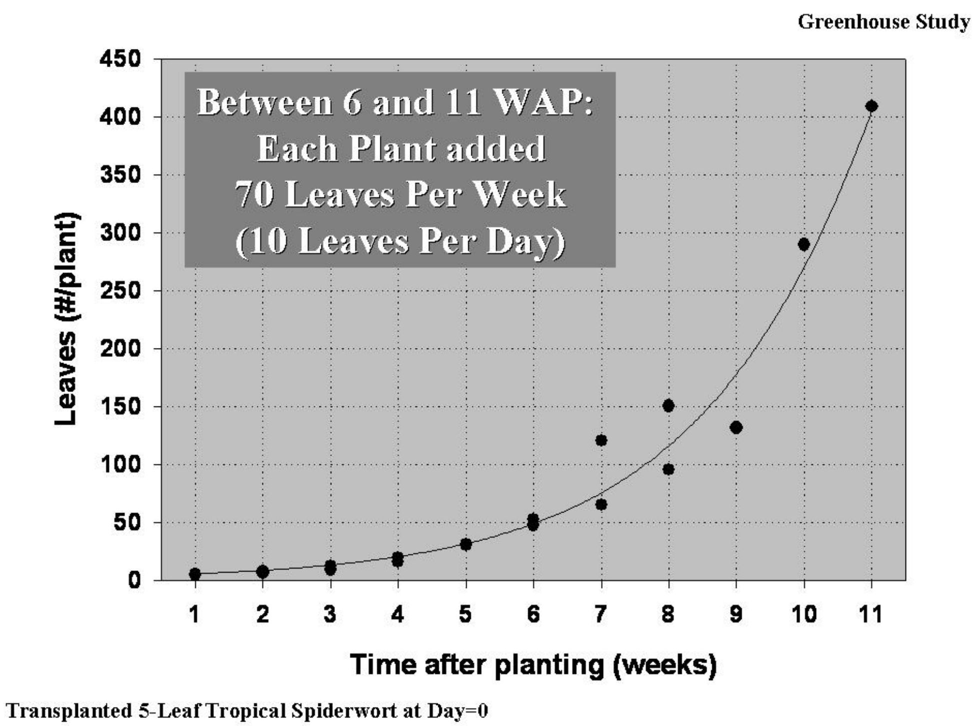


Figure 6. Shoot production between 6 and 11 WAP.

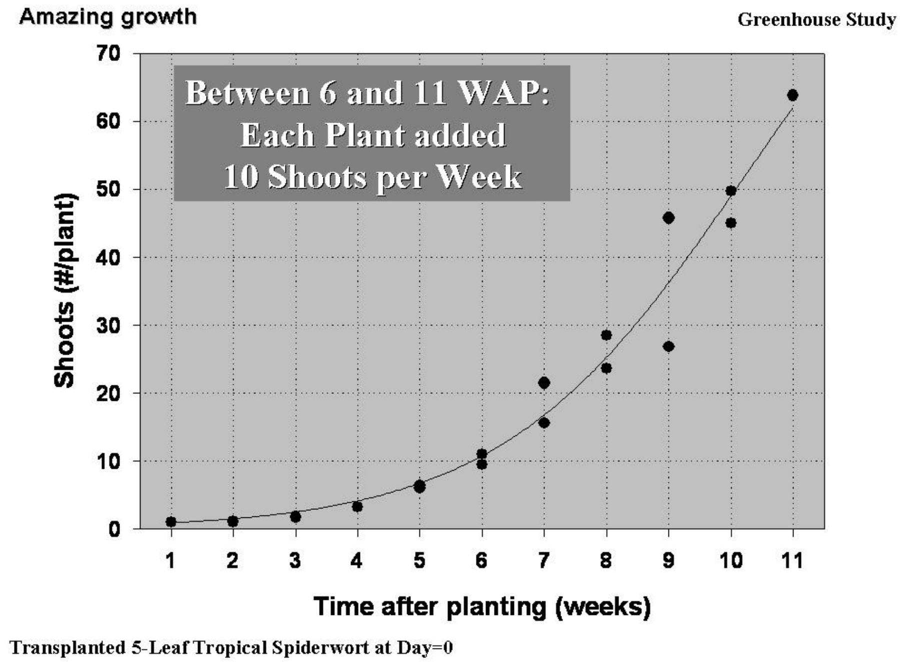
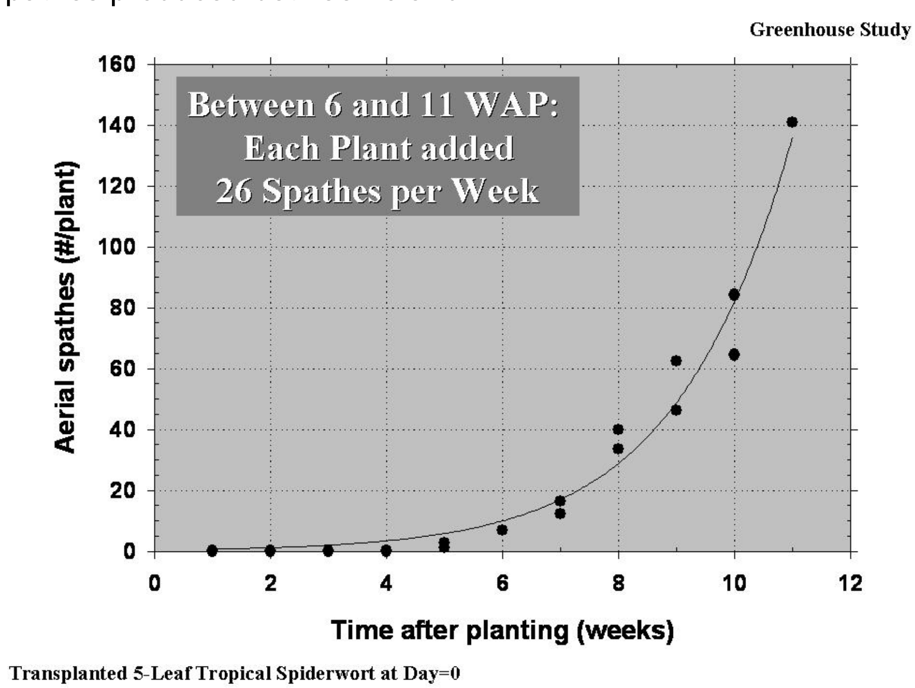
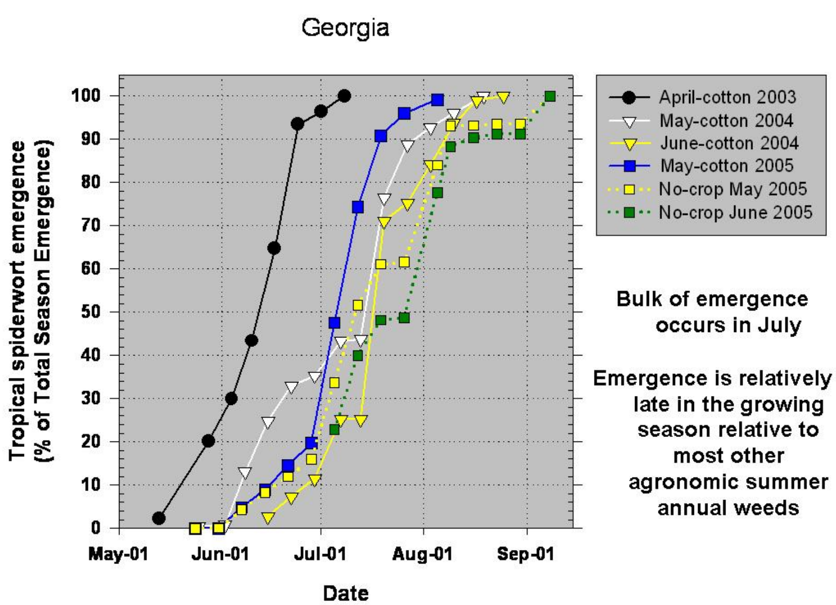


Figure 7. Spathes produced between 6 and 11 WAP.



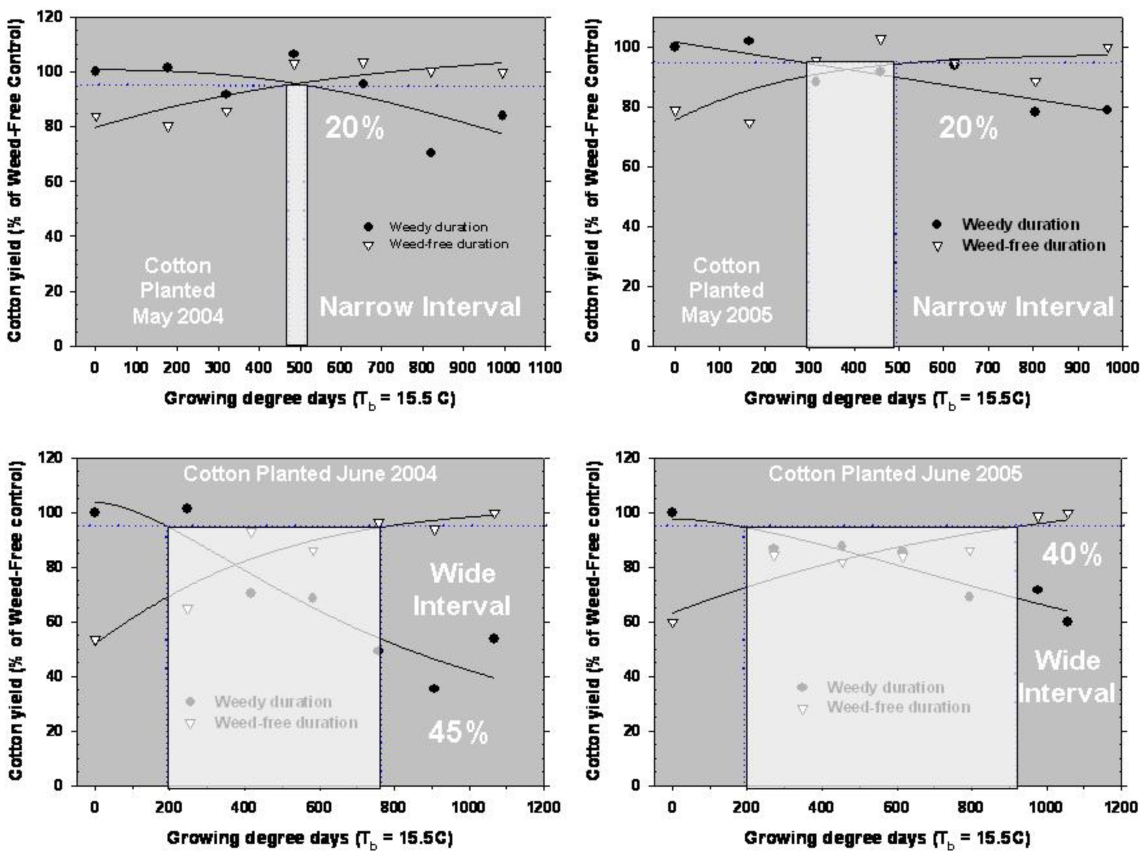
Emergence characteristics. The ability to predict tropical spiderwort emergence is critical for optimizing timing of control tactics. The lack of soil residual activity from glyphosate coupled with the plant size-linked tolerance of tropical spiderwort to glyphosate underscores the importance of understanding tropical spiderwort germination and emergence dynamics. The bulk of tropical spiderwort emergence (50 to 70%) in cotton fields in 2004 and 2005 occurred in July (Figure 8), which is at least a month later in the growing season than peak emergence for most other agronomic summer annual weeds. While up to 36% of the tropical spiderwort population emerged prior to July 1 (which will need to be addressed with some type of weed control tactic), the relatively late emergence characteristics of tropical spiderwort can be exploited to the benefit of the crop. In 2003, tropical spiderwort emergence was nearly a month earlier than was observed in 2004 and 2005. Excellent growing conditions in 2003 allowed cotton to form a light-limiting canopy in late-June and tropical spiderwort emergence was halted during the first week of July. A weak cotton canopy in 2003 would have likely allowed more tropical spiderwort emergence and may have shifted peak emergence to more resemble the results in 2004 and 2005.

Figure 8. Tropical spiderwort emergence pattern.



Based on observations of tropical spiderwort emergence patterns and these data, it was hypothesized that early planted cotton (i.e. April or May) would be more competitive than late planted cotton (i.e. June) as the crop would have more time to establish prior to peak tropical spiderwort emergence and would form a crop canopy faster. Studies were conducted to evaluate the interval that cotton must be kept free of tropical spiderwort in order to avoid a yield loss of greater than 5%. There is a time at the beginning of the season that cotton can tolerate the presence of tropical spiderwort (or any weed) as resources (i.e. water, nutrients, and especially light) are not limited. Likewise, there is also a point at which cotton has established itself and newly emerged tropical spiderwort populations will not influence cotton yield. The interval between these two times is the critical period of weed control (CPWC) during which all tropical spiderwort needs to be controlled. May-planted cotton had narrow CPWC intervals between 475 and 525 growing degree days (GDD; calculated with a base temperature of 10 C) in 2004 and approximately 300 to 500 GDD in 2005 (Figure 9). In contrast, June-planted cotton had wide CPWC intervals between 200 and 750 GDD in 2004 and 200 and 900 GDD in 2005. These data indicate that cotton was more competitive and required less aggressive management tactics when cotton was planted in May relative to June. Also supporting this contention is the maximum yield loss in the weedy controls; when tropical spiderwort competed with May-planted cotton for the entire season, yield loss was 20%. However, yield loss was at least double in the weedy control in the June-planted cotton.

Figure 9. Critical weed free period for cotton.



Drought stress. Preliminary studies indicated that tropical spiderwort is affected by drought stress, but maintained green leaves and produced spathes under extreme drought. Single plants were grown in the greenhouse for eight weeks in replicated trials. Treatments included four weekly watering regimes: field capacity (1X), half of field capacity (½X), one-fourth of field capacity (¼X), and one-eighth of field capacity (1/8X). Tropical spiderwort width was a more robust measurement of growth than was plant height, as tropical spiderwort is a low-growing, sprawling plant. Plant width was reduced greater than 50% by watering at ½X relative to 1X (Figure 10). Plants from all watering regimes produced aerial and subterranean spathes and numbers increased in a linear manner with amount of water (Figure 11). In spite of the severe lack of moisture in the 1/8X treatment, reproduction by aerial and subterranean spathes did occur, though the study was terminated prior to seed maturation, therefore seed viability was not evaluated.

Figure 10. Tropical spiderwort response to drought stress.

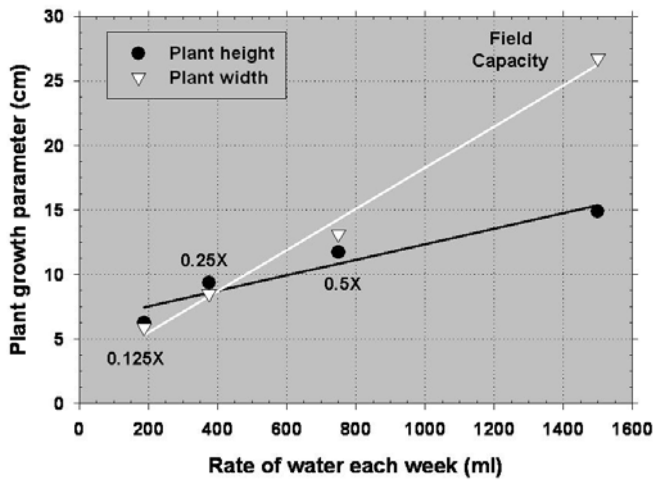
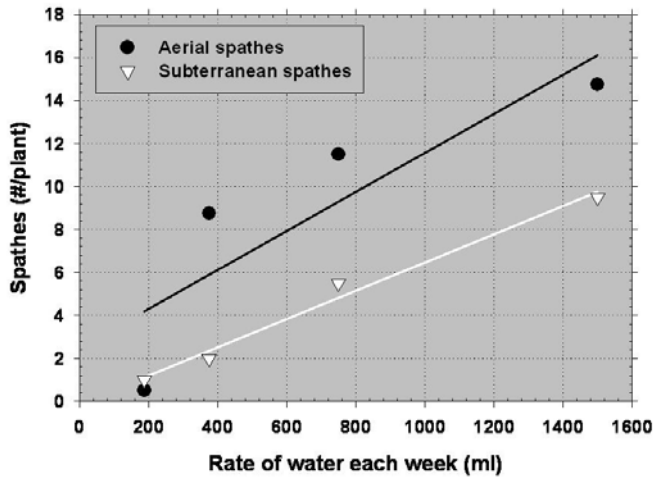


Figure 11. Tropical spiderwort spathes production relative to water amount available.



Crop types affects tropical spiderwort emergence and growth. Field studies were conducted in Grady County, Georgia in 2004 and 2005 to evaluate the effect of crop type on tropical spiderwort emergence and growth. Corn, cotton, peanut, and soybean were planted the final week of April in replicated plots with a naturalized tropical spiderwort population. Tropical spiderwort emergence was similar among crops early in the season, with divergence among crop types occurring around 450 GDD in 2004 and 300 GDD in 2005 (T_b=10C) (Figure 12). Total season emergence was greatest in cotton in both seasons. Peanut and soybean had 30 and 40% less emergence than cotton, respectively. Cotton is slow to form a light-limiting canopy relative to soybean and peanut; low light levels tended to suppress tropical spiderwort emergence. Emergence in corn was variable between seasons, but 8 to 22% less than cotton. Tropical spiderwort biomass in the non-cropped (fallow) plots were greater than in any of the crop treatments (Figure 13). However, only soybean had less tropical spiderwort biomass than peanut, which had the most tropical spiderwort biomass per plant in the four crops. Therefore, while cotton allowed the most new tropical spiderwort seedlings to emerge throughout the season, once established tropical spiderwort plants growing in competition with peanut attained the greatest growth.

Figure 12. Spiderwort emergence in cotton compared to other agronomic crops.

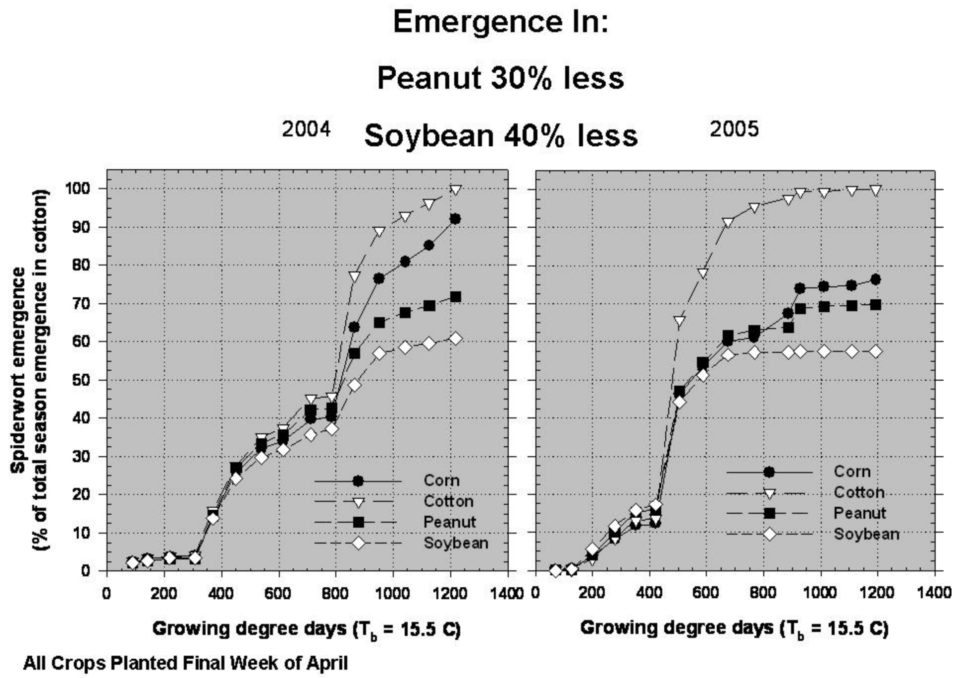
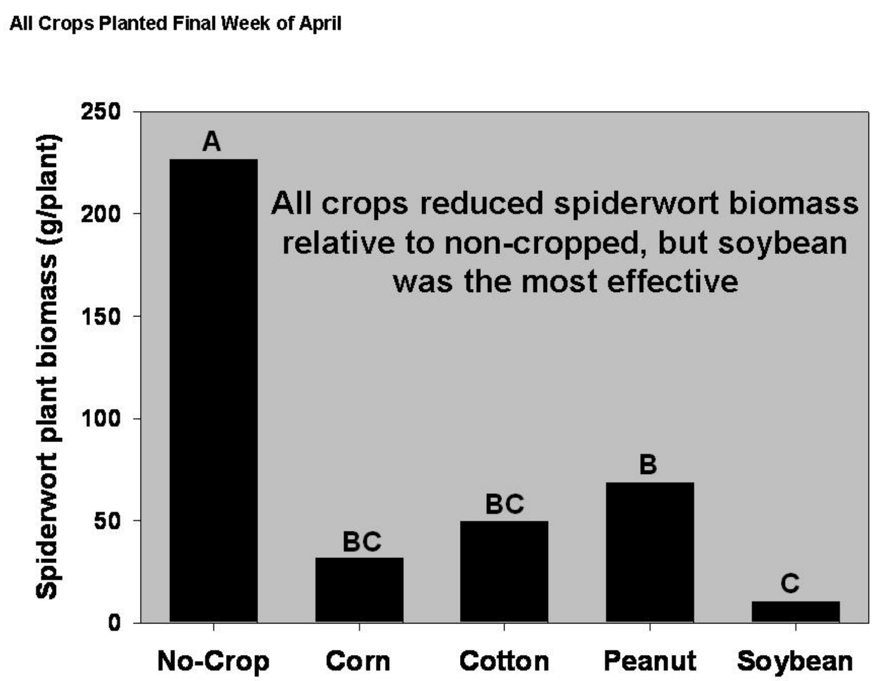


Figure 13. Tropical spiderwort biomass as impacted by agronomic crop.



Corn is often planted prior to the last week in April in Georgia, therefore the comparisons of growth between the crops in the above study may not reflect the differences in actual planting dates that occur in south Georgia. Another study was conducted in 2005 where corn was planted April 14; cotton, peanut, and soybean planted May 16; and 1-leaf tropical spiderwort transplanted June 16. These dates were selected to simulate the differences in crop planting dates as well as the late emergence characteristics of tropical spiderwort. At 12 weeks after tropical spiderwort transplanting (WATr), tropical spiderwort plants in corn and soybean were less than one-third the plant width of those in cotton and peanut (Figure 14). Similarly, there were less than 5 aerial spathes per plant in corn and soybean treatments, while peanut and cotton had 40 and 55 aerial spathes per plant, respectively (Figure 15). Leaf area, leaf biomass, and total plant biomass revealed similar trends (data not shown).

Figure 14. Spiderwort spathes produced in various agronomic crops.

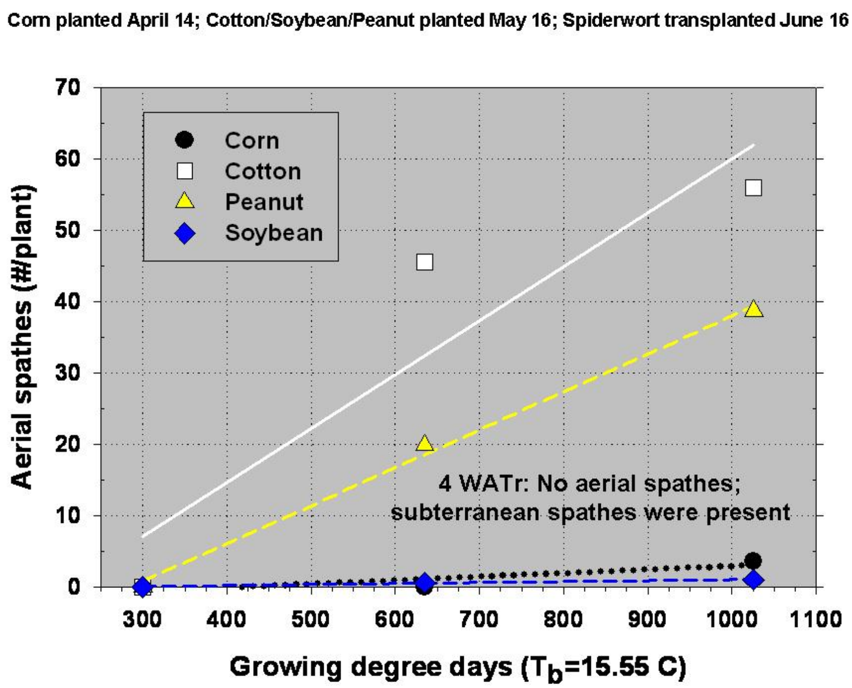
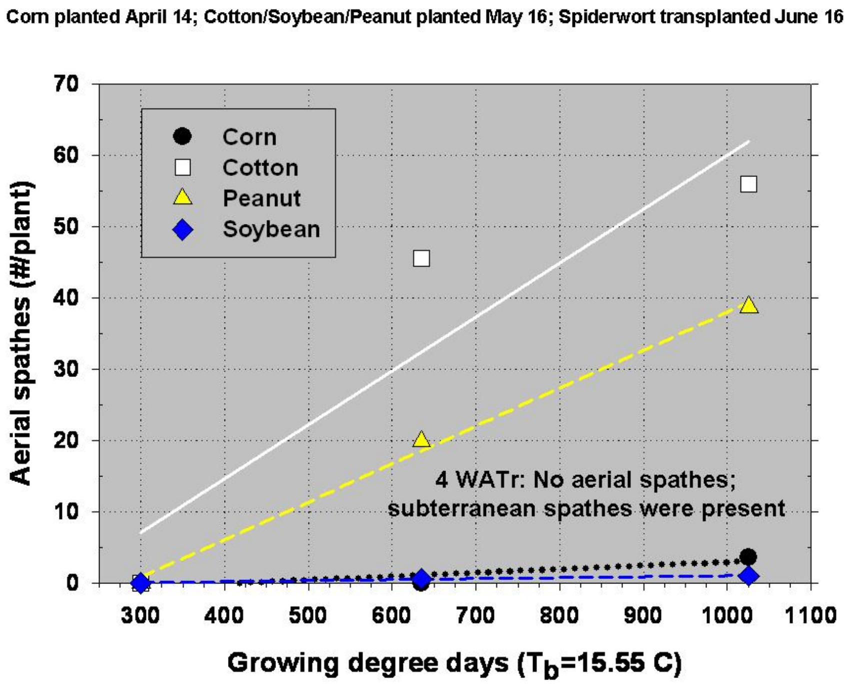


Figure 15. Spiderwort spathes produced in various agronomic crops.



Conclusions

It is vital that cropping systems are developed that possess low susceptibilities to tropical spiderwort invasion (preventing new establishment) and high tolerance to tropical spiderwort presence (suppressing impact of an existing population). Characteristics of these cropping systems will include: 1) an effective use of aggressive control tactics, including the use of s-metolachlor in cotton and effective herbicides rotation crops, 2) optimizing the benefits of cultural practices (i.e. early planting dates, aggressive crop cultivars, inclusion of some type of tillage), and 3) elimination of tropical spiderwort safe-sites (conditions that allow for tropical spiderwort germination, emergence, and establishment) such as after a corn crop is harvested.

It is likely that as long as conservation tillage and glyphosate are relied on heavily in agronomic crop production, this weed will continue to spread across the Southeast. Additionally, with no new management technology being developed to assist in controlling this weed a growers' ability to manage this pest economically compared to most other pests will not exist.

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WILL POSTEMERGENCE-DIRECTED HERBICIDE APPLICATIONS BE NEEDED AFTER COMMERCIALIZATION OF ROUNDUP READY FLEX COTTON?

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Introduction

Cotton is currently the dominate agronomic crop in Georgia. It is planted on about 1.2 million acres, with over 94% of the acreage devoted to glyphosate-resistant cultivars (USDA-AMS 2002; USDA-ERS 2003). Traditional cotton herbicide programs that include cultivation, preplant incorporated and preemergence herbicides, plus postemergence-directed herbicides having both postemergence and residual herbicides, have been largely replaced by weed management systems often consisting of only glyphosate (Culpepper and York 1998; Wilcut et al. 1996). Growers enjoy the ease and economic value of Roundup Ready technology; however, there are still several limitations.

Current Roundup Ready cotton technology does not recommend an application of glyphosate overtop of Roundup Ready cotton past the fifth leaf stage of development. In 2006, Roundup Ready Flex cotton will be commercialized and available for growers. Roundup Ready Flex cotton will allow glyphosate applications overtop of cotton from emergence through bloom. Growers will attempt to replace all previous postemergence-directed herbicide applications with glyphosate or glyphosate mixtures applied topically. Thus, it is critical that replicated field trials determine if weeds can be managed in Roundup Ready Flex cotton without the use of postemergence-directed herbicide applications.

Materials and Methods

'DP 555 B/RR' cotton was planted in late April or early May in 2004 and 2005 at either the Ponder Farm Research Station, Tifton, Georgia, or at the Sunbelt Expo, Moultrie, Georgia. The experimental design was a randomized complete block with treatments replicated four times. Plots were four rows by 25 feet in length and all inputs for cotton production followed those recommended by the University of Georgia Cooperative Extension Service, with the exception of herbicide treatments. The middle two rows of each plot were harvested with a spindle picker modified for plot work.

Results and Discussion

Visual Cotton Response and Seed Cotton Yield: Soil applied herbicides and Roundup WeatherMax applied alone did not injure cotton (data not shown). Dual Magnum, Envoke, or Staple mixed with Roundup injured 6-leaf cotton 12, 12, and 18%, respectively, at 7 days after application when averaged over three locations. Cotton quickly recovered and injury was not detectable by 18 days after application. Applications made overtop of 12- to 13-leaf cotton caused less than 10% injury. Seed cotton yield was measured at two of the three locations and yields were similar among herbicides systems reported. Yield differences would not be expected as weed control during the first eight weeks was excellent (data not shown).

Weed Response: Roundup WeatherMax applied topically to 1-, 6-, and 13-leaf cotton controlled large crabgrass, Texas panicum, bristly starbur, Florida beggarweed, sicklepod, pitted morningglory, and Palmer amaranth at least 92% at harvest (Tables 1, 2, 3, and 4). The addition of Cotoran, Dual Magnum, Prowl, Staple, or Envoke to the Roundup only system did not improve weed control for any of these weeds.

The Roundup only system controlled smallflower morningglory 93%. The addition of Cotoran, Dual Magnum, Envoke, Prowl, or Staple to the Roundup only system improved late-season control by 6% (Table 3). Similar results were noted with Florida pusley. The addition of most residual herbicides to the Roundup only program improved control to pusley control to at least 92%. When Cotoran was applied PRE or Envoke was applied to 6-leaf cotton, pusley control was at least 95%.

Tropical spiderwort and doveweed were much more challenging to manage with Roundup Weathermax applied alone. Three applications of Roundup provided 49 to 59% control of these weeds late in the season (Table 4). The addition of Dual Magnum to the Roundup only system improved spiderwort control at least 21% while Staple or Dual Magnum added in the Roundup only system improved doveweed control 15 to 30%. For doveweed and tropical spiderwort, the most effective system only provided 86% control which is usually unacceptable.

Conclusions

Topical applications of Roundup WeatherMax when applied to 1-, 6-, and 13-leaf cotton provided excellent control of seven common weed species in Georgia. The addition of residual herbicides mixed with Roundup in the Roundup only program further improved control to at least 90% for two additional weed species. Thus for nine weeds present in this experiment, Roundup Ready Flex programs applying herbicides topically was effective. However for tropical spiderwort and doveweed, a Roundup Ready Flex program will require precision postemergence-directed applications to obtain adequate late-season control.

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Table 1. Late-season grass response to Roundup Ready Flex systems.*

Herbicide systems**				Weed species***	
PRE	1 lf cotton	6 lf cotton	13 lf cotton	Large crabgrass	Texas Panicum
--	RU	RU	RU	99 a	95 a
--	RU	RU + Dual	RU	99 a	96 a
--	RU	RU	RU + Dual	99 a	98 a
--	RU	RU + Envoke	RU	99 a	97 a
--	RU	RU	RU + Envoke	99 a	97 a
--	RU	RU + Staple	RU	99 a	95 a
--	RU	RU	RU + Staple	99 a	97 a
--	RU	RU + Staple	RU + Dual	99 a	97 a
Prowl	--	RU	RU	99 a	98 a
Prowl + Cotoran	--	RU	RU	99 a	97 a
Prowl + Staple	--	RU	RU	99 a	98 a

*Values within a column followed by the same letter are not different at P = 0.05.
**Abbreviations: Dual = Dual Magnum; PRE = preemergence; RU = Roundup WeatherMax.
**Herbicide rates per acre: Cotoran 1 qt, Dual Magnum 1.3 pt, Envoke 0.1 oz, Prowl 2.4 pt, Roundup at 1-leaf 22 oz, Roundup at 6- or 13-leaf 28 oz, Staple 0.8 oz.
***Large crabgrass was present at 1 location. Panicum was present at two locations.

Table 2. Late-season starbur, beggarweed, and sicklepod response to Roundup Ready Flex systems.*

Herbicide systems**				Weed species***		
PRE	1 lf cotton	6 lf cotton	13 lf cotton	Bristly starbur	Florida beggarweed	Sicklepod
--	RU	RU	RU	93 a	97 a	99 a
--	RU	RU + Dual	RU	96 a	97 a	99 a
--	RU	RU	RU + Dual	90 a	98 a	99 a
--	RU	RU + Envoke	RU	99 a	99 a	99 a
--	RU	RU	RU + Envoke	90 a	99 a	99 a
--	RU	RU + Staple	RU	98 a	97 a	99 a
--	RU	RU	RU + Staple	97 a	96 a	99 a
--	RU	RU + Staple	RU + Dual	96 a	97 a	99 a
Prowl	--	RU	RU	93 a	99 a	99 a
Prowl + Cotoran	--	RU	RU	99 a	96 a	99 a
Prowl + Staple	--	RU	RU	91 a	99 a	99 a

*Values within a column followed by the same letter are not different at P = 0.05.
**Abbreviations: Dual = Dual Magnum; PRE = preemergence; RU = Roundup WeatherMax.
**Herbicide rates per acre: Cotoran 1 qt, Dual Magnum 1.3 pt, Envoke 0.1 oz, Prowl 2.4 pt, Roundup at 1-leaf 22 oz, Roundup at 6- or 13-leaf 28 oz, Staple 0.8 oz.
***Starbur and sicklepod were present at one location. Beggarweed was present at two locations.

Table 3. Late-season pusley and morningglory response to Roundup Ready Flex systems.*

Herbicide systems**				Weed species***		
PRE	1 lf cotton	6 lf cotton	13 lf cotton	Florida pusley	Smallflower morningglory	Pitted morningglory
--	RU	RU	RU	87 d	93 b	92 a
--	RU	RU + Dual	RU	93 bc	99 a	91 a
--	RU	RU	RU + Dual	90 cd	99 a	92 a
--	RU	RU + Envoke	RU	96 ab	99 a	93 a
--	RU	RU	RU + Envoke	90 cd	99 a	95 a
--	RU	RU + Staple	RU	93 bc	99 a	94 a
--	RU	RU	RU + Staple	87 d	99 a	96 a
--	RU	RU + Staple	RU + Dual	95 ab	99 a	94 a
Prowl	--	RU	RU	92 bc	99 a	95 a
Prowl + Cotoran	--	RU	RU	98 a	99 a	97 a
Prowl + Staple	--	RU	RU	90 cd	99 a	92 a

*Values within a column followed by the same letter are not different at P = 0.05.
**Abbreviations: Dual = Dual Magnum; PRE = preemergence; RU = Roundup WeatherMax.
**Herbicide rates per acre: Cotoran 1 qt, Dual Magnum 1.3 pt, Envoke 0.1 oz, Prowl 2.4 pt, Roundup at 1-leaf 22 oz, Roundup at 6- or 13-leaf 28 oz, Staple 0.8 oz.
***Smallflower morningglory, Florida pusley, and pitted morningglory were present at 1, 2, and 3 locations, respectively.

Table 4. Late-season spiderwort and doveweed response to Roundup Ready Flex systems.*

Herbicide systems**				Weed species***		
PRE	1 lf cotton	6 lf cotton	13 lf cotton	Palmer amaranth	Tropical spiderwort	Doveweed
--	RU	RU	RU	99 a	59 c	49 c
--	RU	RU + Dual	RU	99 a	80 ab	64 b
--	RU	RU	RU + Dual	99 a	86 a	70 ab
--	RU	RU + Envoke	RU	99 a	63 c	44 c
--	RU	RU	RU + Envoke	99 a	61 c	43 c
--	RU	RU + Staple	RU	99 a	68 c	78 a
--	RU	RU	RU + Staple	99 a	76 b	75 ab
--	RU	RU + Staple	RU + Dual	99 a	86 a	79 a
Prowl	--	RU	RU	99 a	64 c	44 c
Prowl + Cotoran	--	RU	RU	99 a	65 c	44 c
Prowl + Staple	--	RU	RU	99 a	60 c	52 c

*Values within a column followed by the same letter are not different at P = 0.05.
**Abbreviations: Dual = Dual Magnum; PRE = preemergence; RU = Roundup WeatherMax.
**Herbicide rates per acre: Cotoran 1 qt, Dual Magnum 1.3 pt, Envoke 0.1 oz, Prowl 2.4 pt, Roundup at 1-leaf 22 oz, Roundup at 6- or 13-leaf 28 oz, Staple 0.8 oz.
***All weeds were present at one location.

2005 COTTON VARIETY TRIALS

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Introduction

The 2005 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. RRFlex varieties were included in the trials for the first time. Data collected from the University of Georgia Variety Testing Cotton Program can be found at the Statewide Variety Testing Website: www.griffin.uga.edu/swvt. Also, the data is published in the UGA Agricultural Experiment Station Research Report Number 703, January 2006.

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 and in 2005 Deltapearl has been chosen as the standard variety planted in all tests. 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. RRFlex varieties were included in both the standard and early maturing strains tests. 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). Prior to harvest, 25-boll samples are hand picked from each plot and then two samples are combined at ginning to measure lint fraction. Fiber samples are 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 Cotton Team Website maintained at http://www.ugacotton.com Dr. Phil Jost, East Georgia Extension Cotton Specialist. Also, the data is available at the Statewide Variety Testing Website: www.griffin.uga.edu/swvt.

Results and Discussion

Growing conditions overall improved for the third year in a row during the 2005 crop season as more normal rainfall along with cooler temperatures occurred across most of the state. These favorable weather patterns were a much needed relief to Georgia farmers who battled drought conditions and extremely high temperatures during the five crop years prior to 2003. Planting of the 2005 spring crop was impeded is some areas in the state due to wet cold soils but 1.21 million acres of cotton were seeded on time. This number of acres planted to cotton was a decrease of 5% from 2004. Most areas of the state received favorable weather until September and October when dry conditions returned to the state. The cotton crop turned out much better than expected as 2.0 million bales were harvested, 16% more than in 2004.

Among varieties in the Dryland Earlier Maturity Trials, 14 standard and six RRFlex varieties stand out as varieties with high yield and relative yield stability in the dryland trials (Table 1). Others that performed well include the yet to be commercialized entries DPLX03X179R and GA2002212 (Table 1). When summarized over two years, DP 455 BG/RR, FM960BR, and DP 445BG/RR were top yielders (Table 2).

Among the best performing earlier maturing varieties produced under irrigation, DP 455 BG/RR was the highest yielder averaged over locations (Table 3). Other varieties from Delta and Pineland, Stoneville and PhytoGen Seed Companies performed well (Table 3). In the RRFlex group DP 117B2RF and ST 4554B2RF were the two top performers. DP 455 BG/RR was the highest yielder when averaged over two years and locations in the Irrigated Early Maturity Trials conducted at Bainbridge, Midville, Plains, and Tifton (Table 4), however, there was no significant difference among varieties in that data set.

Later maturity trials produced without irrigation also revealed the consistent performance of DP454BG/RR, DPLX04Y170BR, ST6636BR, ST5595BR, DP 455 BG/RR, and DP 494 RR (Table 5). Both RRFlex varieties ST 6611B2RF and ST 4357B2RF were top yielders. (Table 5). Averaged over locations and years, ST 5599BR was the front runner along with four Delta and Pine Land varieties (Table 6). DP491 continues to be noted for excellent staple length and generally non-discount micronaire reading, plus a high lint fraction, which is difficult to achieve (Table 5). Generally, as breeders lengthen the cotton fiber towards 1.2 inches and beyond, lint fraction declines along with yield.

Under irrigation, DPLX04Y170BR, ST6636BR, DP 445 BG/RR, DP 449 BG/RR and DP

454 BG/RR led the standard later maturing trials averaged over locations (Table 7), while STX 0414B2RF was top yielder among the RRFlex varieties. Averaged over years and locations, DP555BR was the best performer (Table 8). 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 2006 and beyond (Tables 9, 10). DX25105N of Syngenta Seed Company was the higher yielding performer among standard earlier maturing entries in the strains trial, there were six varieties from Beltwide and Royster Clark in the RRFlex group that performed well. CS37, Deltapearl, FMx9166B2LL, CS44, GA2003138, GA2002125, GA2002131 and GA2002118 were the better performers among later maturing types (Table 10).

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, 2005

	Lint Yield[a]									
Entry	Athens	Midville	Plains	Tifton	4-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	lb/acre					%	%	in	g/tex	units
ST4575BR	1572 [5]	**1726** [9]	**1581** [12T]	**1499** [12]	**1595** [2]	41.2	85.5	1.18	30.3	4.8
DP 454 BG/RR	**1859** [1]	1375 [33]	**1717** [2]	1374 [24]	**1581** [4]	41.4	86.0	1.18	30.8	4.1
DP 445 BG/RR	1504 [13]	1580 [14]	**1587** [11]	**1643** [1]	**1578** [5]	41.5	86.2	1.20	30.9	4.8
DP 455 BG/RR	1365 [26T]	**1732** [8]	**1581** [12T]	**1514** [10T]	**1548** [6]	42.8	84.6	1.20	32.8	4.2
ST4686R	1559 [7]	1579 [15]	1435 [26]	**1558** [5]	**1533** [8]	41.5	85.3	1.17	30.9	4.8
DPLX04Y170BR	1592 [3]	1335 [37]	**1574** [13]	**1605** [2]	**1526** [9T]	40.6	85.5	1.20	31.9	4.7
DP 444 BG/RR	1574 [4]	1509 [20T]	**1589** [10T]	1434 [19]	**1526** [9T]	42.6	86.1	1.18	31.0	4.2
DP 393	1520 [11]	1538 [18]	1554 [17]	**1453** [15]	**1516** [12T]	40.6	86.1	1.22	32.3	4.9
ST5242BR	**1629** [2]	1447 [27]	**1604** [8]	1385 [23]	**1516** [12T]	41.2	84.8	1.13	28.9	4.4
GA2002167	1534 [8]	**1653** [12]	1411 [27]	**1449** [17]	**1512** [13]	41.9	84.7	1.19	34.1	4.7
PHY370WR	1258 [37]	**1648** [13]	**1669** [4]	**1451** [16]	**1507** [14]	41.7	85.5	1.17	31.5	4.8
DP 432 RR	1524 [10]	1393 [31]	**1558** [16]	**1524** [8]	**1499** [16]	40.0	85.6	1.18	31.3	4.6
PHY310R	1327 [29]	1452 [25]	**1640** [5]	**1514** [10T]	**1483** [17]	42.2	85.5	1.18	32.2	4.9
PHY440W	1509 [12]	1422 [29]	1445 [25]	**1511** [11]	**1472** [18]	39.6	85.6	1.21	30.6	4.5
FM960BR	1393 [23]	1354 [36]	**1589** [10T]	**1498** [13]	1459 [20]	39.2	85.0	1.17	34.1	4.3
DPLX03X179R	1474 [15]	1557 [16]	1255 [37]	**1518** [9]	1451 [21]	42.4	86.3	1.22	33.5	4.8
FM958LL	1527 [9]	1509 [20T]	1401 [29T]	1347 [28]	1446 [23T]	40.1	85.7	1.25	34.0	4.3
DP 434 RR	1356 [27]	**1761** [5]	1406 [28]	1234 [37]	1439 [25]	41.6	86.1	1.24	28.7	4.2
FM960B2R	1472 [16]	1360 [35]	1530 [19]	1265 [35]	1407 [27T]	39.1	85.5	1.23	35.4	4.5
GA2002212	1365 [26T]	**1746** [6]	1294 [35]	1128 [39]	1383 [28]	43.5	85.5	1.20	33.5	4.8
FM960R	1386 [24]	1448 [26]	1327 [32]	1352 [27]	1378 [29]	40.4	85.6	1.22	36.4	4.0
Tamcot 22	1253 [39]	**1672** [10]	1186 [41]	1329 [30]	1360 [32]	41.9	84.7	1.20	29.9	4.5
GA2002207	1325 [30]	**1661** [11]	1348 [31]	1090 [41]	1356 [33]	42.1	85.5	1.21	32.0	4.8
UGA161	1284 [32]	1388 [32]	1289 [36]	1442 [18T]	1351 [34]	38.6	86.1	1.24	33.6	4.7
Deltapearl	1245 [40]	1273 [42]	1321 [33]	1339 [29]	1295 [36]	39.0	85.4	1.22	32.6	4.7
GA2002211	1158 [42]	1413 [30]	1401 [29T]	1155 [38]	1282 [37]	40.3	85.3	1.19	33.9	5.0
DP 424 BII/R	1105 [43]	1326 [38]	1249 [38]	1401 [22]	1270 [38]	37.1	85.4	1.17	29.4	4.7
FM966LL	1353 [28]	1324 [39]	1220 [39]	1126 [40]	1256 [39]	38.6	85.4	1.18	36.3	4.3
GA200035	1409 [22]	1278 [41]	1205 [40]	994 [42]	1222 [40]	39.6	85.8	1.21	33.6	4.6
Group Average	*1429*	*1498*	*1447*	*1384*	*1440*	*40.8*	*85.5*	*1.20*	*32.3*	*4.6*

Table 1. Yield Summary for Dryland Earlier Maturity Cotton Varieties, 2005 (Cont'd)

	Lint Yield[a]									
Entry	Athens	Midville	Plains	Tifton	4-Loc.	Lint	Unif.	Length	Strength	Mic.
	---------------------------- lb/acre ----------------------------					%	%	in	g/tex	units
RRFlex Varieties										
ST 4554B2RF	1565 [6]	**1763** [4]	**1707** [3]	**1467** [14]	**1625** [1]	41.9	85.6	1.18	29.8	5.0
CG4020B2RF	1455 [18]	**1742** [7]	**1595** [9]	**1549** [6]	**1585** [3]	41.3	85.6	1.23	29.7	4.5
DP 108 RF	1459 [17]	**1851** [1]	1449 [23]	1402 [21]	**1540** [7]	40.8	85.2	1.18	32.0	4.2
DynaGro 2100BRF	1384 [25]	**1783** [2]	**1564** [15]	1366 [26]	**1524** [10]	39.7	85.2	1.17	29.4	4.2
DP 113 B2RF	1450 [19]	1437 [28]	**1609** [7]	**1594** [4]	**1522** [11]	39.9	85.4	1.21	35.2	4.3
ST 4664RF	1428 [21]	1486 [21]	1497 [21]	**1596** [3]	**1502** [15]	41.4	85.3	1.17	30.0	4.9
DP 117 B2RF	1275 [34]	1528 [19]	**1634** [6]	1421 [20]	1464 [19]	41.3	85.2	1.19	35.3	4.7
DynaGro 2520BRF	1238 [41]	1482 [23]	**1755** [1]	1319 [31]	1449 [22]	41.0	86.1	1.23	29.5	4.3
PHY485WRF	1482 [14]	1280 [40]	1486 [22]	**1535** [7]	1446 [23T]	41.0	86.0	1.18	32.3	4.9
PHY425RF	1317 [31]	**1764** [3]	1305 [34]	1373 [25]	1440 [24]	39.7	86.1	1.19	32.4	4.9
PHY475WRF	1282 [33]	1542 [17]	**1573** [14]	1307 [33]	1426 [26]	40.1	85.8	1.17	31.2	4.5
DP 110 RF	1256 [38]	1483 [22]	1448 [24]	1442 [18T]	1407 [27T]	40.9	86.1	1.22	34.9	4.7
CG3520B2RF	1448 [20]	1233 [43]	1543 [18]	1235 [36]	1365 [30]	39.6	86.1	1.23	28.9	4.4
CG3020B2RF	1263 [36]	1365 [34]	1507 [20]	1316 [32]	1363 [31]	39.3	85.7	1.18	29.1	4.2
PHY415RF	1265 [35]	1472 [24]	1371 [30]	1290 [34]	1350 [35]	40.5	84.9	1.16	29.7	4.7
Group Average	*1371*	*1547*	*1536*	*1414*	*1467*	*40.6*	*85.6*	*1.20*	*31.3*	*4.6*
Overall Average	1409	1515	1477	1394	1449	40.7	85.5	1.20	31.9	4.6
LSD 0.10	239	227	197	196	157	1.0	0.5	0.02	1.3	0.2
CV %	14.5	12.8	11.4	12.0	12.7	2.4	0.7	1.61	4.3	4.5

[a] Superscripts indicate ranking at that location.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 2. Two-Year Summary for Dryland Earlier Maturity Cotton Varieties at Four Locations[a], 2004-2005

Variety	Lint Yield[b]	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
DP 455 BG/RR	**1335** [1]	43.0	84.1	1.16	33.2	4.4
FM960BR	**1292** [2]	40.2	84.6	1.14	35.2	4.6
DP 445 BG/RR	**1280** [3]	41.6	85.4	1.16	31.0	4.8
DP 444 BG/RR	1247 [4]	42.9	85.3	1.15	30.4	4.4
DP 393	1221 [5]	41.1	85.6	1.18	32.6	5.0
DP 434 RR	1219 [6]	42.1	85.8	1.20	29.0	4.5
DP 432 RR	1216 [7]	40.8	85.2	1.15	31.8	4.8
GA2002167	1205 [8]	42.7	84.5	1.17	34.6	4.9
GA2002212	1203 [9]	43.6	85.2	1.18	34.3	5.0
FM960B2R	1172 [10T]	39.7	85.1	1.19	34.8	4.7
FM960R	1172 [10T]	41.0	85.0	1.18	35.8	4.3
FM958LL	1169 [11]	40.7	85.1	1.19	34.2	4.6
GA2002211	1107 [12]	41.4	85.0	1.16	34.2	5.1
Deltapearl	1101 [13]	39.6	85.1	1.19	32.8	4.9
DP 424 BII/R	1079 [14]	37.1	85.1	1.15	29.4	4.8
GA200035	1070 [15]	40.8	85.3	1.18	34.2	4.8
FM966LL	1039 [16]	39.1	84.9	1.15	36.9	4.6
Average	1184	41.0	85.1	1.17	33.2	4.7
LSD 0.10	65	0.4	0.4	0.01	0.9	0.1
CV %	13.4	2.2	0.8	1.94	4.6	4.4

[a] Athens, Midville, Plains, and Tifton.
[b] Superscripts indicate ranking.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 3. Yield Summary for Earlier Maturity Cotton Varieties, 2005, Irrigated

	Lint Yield[a]									
Entry	Bainbridge	Midville	Plains	Tifton	4-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	---------------------------- lb/acre ----------------------------					%	%	in	g/tex	units
DP 455 BG/RR	973 [13]	**2339** [1]	**1678** [7]	**1582** [8]	**1643** [1]	42.7	84.6	1.19	33.1	4.3
DP 445 BG/RR	1085 [6]	2003 [7]	**1745** [5]	**1590** [7]	**1606** [2]	41.8	85.4	1.18	31.7	4.7
DP 444 BG/RR	1062 [9]	2011 [6]	**1744** [6]	**1497** [16]	**1578** [3]	43.0	85.7	1.19	30.5	4.3
DPLX04Y170BR	1068 [8]	1852 [22]	**1772** [4]	**1616** [3]	**1577** [4]	41.9	85.3	1.18	31.4	4.7
DP 393	**1301** [1]	1886 [17]	1536 [17]	1454 [23]	**1544** [5]	41.5	86.5	1.22	32.6	4.9
ST4575BR	**1108** [4]	1702 [35]	**1798** [2]	**1536** [12]	**1536** [7T]	40.9	85.6	1.18	29.7	4.8
DP 454 BG/RR	**1131** [2]	2048 [3]	**1825** [1]	1139 [42]	**1536** [7T]	41.7	85.3	1.16	30.9	4.1
DP 432 RR	937 [16]	2031 [5]	1502 [21]	**1649** [1]	**1530** [8]	40.6	86.1	1.20	30.7	4.8
PHY370WR	788 [26]	1878 [19]	**1781** [3]	**1602** [5]	**1512** [9]	40.7	85.9	1.19	30.9	4.7
PHY310R	1090 [5]	1917 [14]	1538 [15]	1455 [22]	**1500** [10]	41.8	85.3	1.17	32.5	4.7
UGA161	**1129** [3]	1726 [31]	1519 [18]	**1474** [18]	1462 [13]	38.6	85.9	1.24	33.1	4.7
ST5242BR	998 [12]	1819 [26]	1589 [12]	1405 [29]	1453 [14]	40.6	84.9	1.15	29.0	4.5
DPLX03X179R	1025 [10]	2039 [4]	1379 [29]	1359 [31]	1450 [15]	42.5	86.2	1.22	34.6	4.5
PHY440W	768 [31]	1875 [20]	1612 [11]	**1508** [14]	1441 [16]	40.6	85.8	1.21	30.2	4.4
DP 424 BII/R	1075 [7]	1814 [27]	1487 [24]	1357 [32]	1433 [17]	37.2	85.6	1.17	29.9	4.7
FM960BR	972 [14T]	1606 [41]	1629 [9]	1448 [24]	1414 [19]	39.1	85.1	1.17	35.3	4.4
DP 434 RR	672 [37]	1909 [15]	1488 [23]	**1489** [17]	1390 [23]	41.7	85.7	1.24	29.1	4.1
ST4686R	883 [21]	1724 [32]	1510 [19]	1437 [27]	1388 [24]	41.1	85.6	1.19	30.8	4.7
GA2002167	897 [19]	1973 [9]	1350 [31T]	1200 [37]	1355 [27]	41.4	84.8	1.19	32.2	4.8
FM960B2R	743 [35]	1691 [36]	1627 [10]	1178 [38]	1310 [32]	39.4	85.6	1.22	33.8	4.7
FM958LL	960 [15]	1658 [39]	1352 [30]	1214 [36]	1296 [33]	39.6	85.6	1.22	33.7	4.7
GA200035	924 [17]	1873 [21]	1229 [38]	1126 [43]	1288 [34]	39.7	85.6	1.21	33.9	4.6
GA2002211	669 [38]	1833 [24]	1181 [40]	1363 [30]	1261 [35]	40.8	86.2	1.21	34.0	5.0
Tamcot 22	657 [42]	1634 [40]	1446 [26]	1276 [34]	1253 [37]	41.2	85.1	1.20	29.3	4.6
Deltapearl	661 [40]	1712 [33]	1268 [36]	1263 [35]	1226 [38]	39.4	85.5	1.23	31.8	4.7
FM966LL	826 [22]	1710 [34]	1204 [39]	1153 [41]	1223 [39]	39.1	85.3	1.18	35.9	4.2
FM960R	668 [39]	1735 [30]	1305 [35]	1166 [39]	1218 [40]	40.0	85.3	1.21	34.6	4.1
GA2002207	818 [24]	1676 [38]	1142 [42]	1165 [40]	1200 [41]	41.0	85.5	1.21	32.5	4.8
GA2002212	766 [32]	1569 [43]	1350 [31T]	1088 [44]	1193 [42]	42.9	85.9	1.20	34.3	5.1
Group Average	*919*	*1836*	*1503*	*1372*	*1407*	*40.8*	*85.6*	*1.2*	*32.1*	*4.6*

Table 3. Yield Summary for Earlier Maturity Cotton Varieties, 2005, Irrigated (Cont'd)

	Lint Yield[a]									
Entry	Bainbridge	Midville	Plains	Tifton	Average	Lint	Index	Length	Strength	Mic.
	lb/acre					%	%	in	g/tex	units
RRFlex Varieties										
DP 117 B2RF	972 [14T]	1947 [11]	**1644** [8]	**1603** [4]	**1541** [6]	41.0	85.4	1.20	35.0	4.8
ST 4554B2RF	913 [18]	1924 [12T]	1541 [14]	**1595** [6]	**1493** [11]	40.6	85.3	1.20	30.9	4.9
DP 113 B2RF	812 [25]	1967 [10]	1546 [13]	**1578** [9]	1476 [12T]	39.4	85.4	1.21	35.8	4.2
PHY485WRF	1017 [11]	1774 [28]	1537 [16]	**1576** [10]	1476 [12T]	40.1	86.5	1.21	32.5	4.9
PHY415RF	786 [27]	**2103** [2]	1350 [31T]	**1463** [20]	1425 [18]	40.4	85.4	1.18	30.4	4.7
ST 4664RF	782 [28]	1922 [13]	1325 [33]	**1618** [2]	1412 [20]	41.1	85.8	1.20	30.5	4.8
DynaGro 2520B2RF	744 [34]	1924 [12T]	1504 [20]	**1462** [21]	1408 [21]	39.7	86.2	1.25	29.3	4.1
CG4020B2RF	754 [33]	1884 [18]	1496 [22]	**1465** [19]	1400 [22]	39.8	86.4	1.26	29.1	4.2
CG3520B2RF	821 [23]	1826 [25]	1343 [32]	**1504** [15]	1374 [25]	39.1	86.6	1.24	28.2	4.4
DP 110 RF	707 [36]	1984 [8]	1177 [41]	**1558** [11]	1357 [26]	40.3	86.1	1.21	35.3	4.7
PHY425RF	887 [20]	1677 [37]	1317 [34]	**1530** [13]	1353 [28]	40.1	86.0	1.21	31.2	4.8
PHY475WRF	777 [29]	1763 [29]	1427 [27]	1439 [26]	1352 [29]	40.1	86.0	1.19	31.2	4.6
CG3020B2RF	658 [41]	1846 [23]	1418 [28]	1447 [25]	1342 [30]	39.0	85.5	1.19	28.9	4.2
DynaGro 2100B2RF	613 [43]	1892 [16]	1464 [25]	1300 [33]	1317 [31]	38.3	85.8	1.18	28.9	4.2
DP 108 RF	777 [30]	1581 [42]	1236 [37]	1422 [28]	1254 [36]	40.3	85.4	1.19	32.5	4.3
Group Average	*801*	*1868*	*1422*	*1504*	*1399*	*40.0*	*85.5*	*1.21*	*31.3*	*4.5*
Overall Average	879	1847	1475	1417	1404	40.5	85.6	1.20	31.8	4.6
LSD 0.10	194	260	189	189	157	0.9	0.6	0.02	1.2	0.2
CV %	18.9	12.0	10.9	11.4	12.8	2.0	0.8	1.78	4.4	5.2

[a] Superscripts indicate ranking at that location.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 4. Two-Year Summary for Earlier Maturity Cotton Varieties at Four Locations[a], 2004-2005, Irrigated

Variety	Lint Yield[b]	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
DP 455 BG/RR	**1624** [1]	43.3	84.5	1.19	33.3	4.3
DP 432 RR	**1548** [2]	41.1	85.5	1.18	31.0	4.8
DP 445 BG/RR	**1533** [3]	41.7	85.2	1.17	31.1	4.6
DP 393	**1530** [4]	41.3	86.2	1.21	32.6	4.8
FM960BR	**1507** [5]	40.1	84.9	1.16	36.2	4.5
DP 444 BG/RR	**1460** [6]	42.8	85.4	1.18	30.4	4.3
DP 434 RR	**1449** [7]	42.1	85.7	1.22	28.5	4.3
GA2002167	**1417** [8]	42.7	84.8	1.18	32.8	4.8
GA2002211	**1415** [9]	41.8	85.6	1.19	34.4	4.9
DP 424 BII/R	**1406** [10]	37.8	85.6	1.17	29.2	4.7
GA200035	**1389** [11]	41.1	85.3	1.19	34.0	4.7
FM958LL	**1377** [12]	40.3	85.3	1.20	34.3	4.7
FM960B2R	**1374** [13]	39.9	85.3	1.21	34.2	4.7
Deltapearl	**1372** [14]	40.5	85.7	1.22	32.5	4.7
GA2002212	**1364** [15]	43.4	85.7	1.20	34.4	5.0
FM960R	**1352** [16]	40.6	85.4	1.19	34.7	4.2
FM966LL	**1327** [17]	39.2	85.1	1.17	37.0	4.3
Average	1438	41.2	85.4	1.19	33.0	4.6
LSD 0.10	N.S.[c]	0.4	0.4	0.01	0.9	0.1
CV %	11.8	2.3	0.8	1.67	4.9	5.2

[a] Bainbridge, Midville, Plains, and Tifton.

[b] Superscripts indicate ranking.

[c] The F-test indicated no statistical differences at the alpha = 0.10 probability level; therefore a LSD value was not calculated.

Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 5. Yield Summary for Dryland Later Maturity Cotton Varieties, 2005

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	**1698** [1]	1624 [10]	**1932** [1]	**1312** [10]	**1642** [1]	42.5	85.2	1.16	30.1	4.4
DPLX04Y170BR	1455 [7]	1606 [13T]	1651 [2]	**1468** [1]	**1545** [2]	42.0	84.8	1.17	31.7	4.8
ST6636BR	**1517** [3]	1664 [7]	1616 [4]	1274 [15]	**1518** [3]	39.7	85.3	1.19	32.8	5.0
ST 5599BR	**1498** [5]	1589 [14]	1618 [3]	**1362** [2]	**1517** [4]	40.5	84.4	1.18	32.4	4.8
DP 455 BG/RR	1409 [10]	**1928** [2]	1464 [11]	1254 [16]	**1514** [5]	43.3	84.3	1.19	32.1	4.3
DP 494 RR	1462 [6]	**1832** [4]	1376 [17]	**1298** [12]	**1492** [6]	41.7	85.8	1.21	34.4	5.0
DP 445 BG/RR	**1535** [2]	1525 [21]	1506 [8]	**1357** [3]	1481 [7]	42.3	85.6	1.18	32.3	4.9
DPLX03X179R	1360 [12]	**1993** [1]	1206 [32]	**1328** [7]	1472 [8]	43.0	86.0	1.21	34.8	4.9
DP 449 BG/RR	1361 [11]	1619 [11]	1511 [7]	**1351** [5]	1461 [9]	40.2	84.7	1.16	34.2	4.8
DP 555 BG/RR	1257 [17]	1371 [37]	1599 [5]	**1346** [6]	1393 [11]	42.0	84.1	1.17	32.4	4.7
GA2003178	1426 [9]	1572 [16]	1346 [20]	1127 [23]	1368 [13]	39.9	84.9	1.16	35.8	5.1
FM991BR	1430 [8]	1476 [27]	1568 [6]	982 [36]	1364 [15]	40.8	84.8	1.18	35.3	5.1
DP 491	1142 [26]	**1867** [3]	1327 [21]	1092 [30]	1357 [16]	42.2	86.0	1.25	34.3	4.7
GA2001078	1206 [22]	1516 [24]	1314 [23]	**1297** [13]	1333 [19]	42.1	85.9	1.21	33.0	4.7
GA2003118	1264 [15]	1581 [15]	1247 [30]	1212 [20]	1326 [20]	40.1	86.7	1.24	34.1	4.9
DP 543 BGII/R	1047 [32]	1548 [17]	1382 [16]	**1314** [8]	1323 [21]	39.2	84.6	1.18	32.1	4.7
DP 488 BG/RR	1228 [20]	1436 [32]	1498 [10]	1054 [32]	1304 [22]	39.8	86.2	1.23	33.5	4.7
Deltapearl	1064 [31]	1649 [8]	1323 [22]	1135 [22]	1293 [23]	40.4	85.3	1.22	32.4	4.9
DP 493	1044 [33]	1606 [13T]	1390 [15]	1101 [28]	1285 [24]	42.4	84.6	1.17	32.9	5.1
ST6848R	1192 [23]	1509 [25]	1282 [26]	1120 [25]	1276 [27]	39.0	86.2	1.20	35.8	4.9
GA2003137	1244 [19]	1543 [18]	1268 [29]	1043 [34]	1274 [28]	42.1	85.9	1.21	32.7	4.8
ST 5303R	1113 [29]	1413 [35]	1284 [24]	1191 [21]	1250 [30]	39.5	85.7	1.15	34.8	4.6
FM991B2R	954 [35]	1434 [33]	1272 [27]	**1306** [11]	1241 [31T]	38.6	85.4	1.21	35.5	4.6
DPLX05X648DR	936 [37]	1440 [31]	1500 [9]	1089 [31]	1241 [31T]	41.4	84.0	1.17	30.3	5.0
FM991R	1094 [30]	1681 [6]	1134 [37]	929 [39]	1210 [34]	39.1	85.7	1.21	33.6	4.9
GA2003165	1128 [27]	1524 [22]	1143 [36]	1028 [35]	1206 [35]	38.9	85.2	1.19	32.9	4.6
PHY510RR	1144 [25]	1407 [36]	1155 [34]	1051 [33]	1189 [38]	39.2	84.9	1.19	34.0	4.9
Group Average	*1267*	*1591*	*1404*	*1201*	*1366*	*40.8*	*85.3*	*1.19*	*33.3*	*4.8*

Table 5. Yield Summary for Dryland Later Maturity Cotton Varieties, 2005 (Cont'd)

	Lint Yield[a]									
Entry	Athens	Midville	Plains	Tifton	4-Loc.	Lint	Unif.	Length	Strength	Mic.
	lb/acre					%	%	in	g/tex	units
RRFlex Varieties										
ST 6611B2RF	1246 [18]	1648 [9]	1402 [14]	**1355** [4]	1413 [10]	39.2	84.8	1.19	32.3	4.8
ST 4357B2RF	1318 [13T]	1475 [28]	1416 [13]	**1313** [9]	1380 [12]	40.7	86.0	1.23	29.0	4.5
STX 0414B2RF	1301 [14T]	1535 [19]	1350 [19]	1282 [14]	1367 [14]	38.6	85.7	1.21	32.5	4.6
DP 143 B2RF	1318 [13T]	1468 [29]	1356 [18]	1250 [17]	1348 [17]	38.7	85.7	1.28	29.6	4.6
ST 6622RF	**1505** [4]	1612 [12]	1127 [38]	1111 [26]	1339 [18]	40.5	85.7	1.20	32.7	4.8
STX5885B2RF	953 [36]	1521 [23]	1420 [12]	1235 [19]	1282 [25]	38.7	85.3	1.20	31.5	5.0
DP 147 RF	1301 [14T]	1686 [5]	1156 [33]	981 [37]	1281 [26]	40.7	85.4	1.25	32.5	4.5
DP 164 B2RF	1124 [28]	1423 [34]	1271 [28]	1237 [18]	1264 [29]	39.6	85.0	1.22	31.8	4.8
DP 156 B2RF	1160 [24]	1533 [20]	1152 [35]	1100 [29]	1236 [32]	38.7	85.0	1.21	30.0	4.5
ST 5007B2RF	1217 [21]	1332 [38]	1283 [25]	1102 [27]	1233 [33]	37.0	86.2	1.25	29.9	4.3
DP 152 RF	1009 [34]	1467 [30]	1220 [31]	1125 [24]	1205 [36]	39.5	84.9	1.20	30.9	4.4
DP 167 RF	1259 [16]	1485 [26]	1053 [39]	978 [38]	1194 [37]	39.6	86.1	1.25	32.6	4.6
Group Average	*1226*	*1515*	*1267*	*1172*	*1295*	*39.3*	*85.5*	*1.22*	*31.3*	*4.6*
Overall Average	1254	1568	1362	1192	1344	40.3	85.3	1.20	32.7	4.7
LSD 0.10	202	241	203	180	156	0.9	1.7	0.02	1.3	0.2
CV %	13.7	13.1	12.7	12.9	13.2	1.8	0.8	1.76	4.5	4.7

[a] Superscripts indicate ranking at that location.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 6. Two-Year Summary for Dryland Later Maturity Cotton Varieties at Four Locations[a], 2004-2005

Variety	Lint Yield[b]	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
ST 5599BR	**1316** [1]	41.3	83.9	1.13	32.1	5.0
DP 455 BG/RR	**1301** [2]	43.7	84.0	1.16	32.9	4.5
DP 449 BG/RR	**1262** [3]	40.2	84.3	1.12	34.4	4.9
DP 494 RR	**1257** [4]	41.4	85.2	1.18	33.7	5.0
DP 555 BG/RR	**1255** [5]	42.7	83.8	1.14	31.7	4.9
DP 445 BG/RR	1230 [6]	42.1	85.0	1.15	31.9	4.9
FM991BR	1205 [7]	40.0	84.6	1.15	36.0	5.0
DP 491	1193 [8]	42.6	85.4	1.21	34.3	4.9
DP 488 BG/RR	1183 [9]	41.1	85.2	1.19	32.8	4.8
GA2003137	1182 [10]	42.9	84.6	1.16	33.1	5.0
GA2001078	1160 [11]	41.8	85.2	1.17	33.1	4.9
Deltapearl	1159 [12]	40.6	84.8	1.19	32.5	5.0
DP 493	1154 [13]	42.9	84.1	1.14	32.9	5.2
DP 543 BGII/RR	1143 [14]	40.1	84.1	1.14	31.6	5.0
GA2003165	1126 [15]	39.6	84.7	1.17	33.0	4.8
ST 5303R	1101 [16]	39.7	85.0	1.11	35.7	4.8
FM991B2R	1072 [17]	38.8	84.9	1.18	34.5	4.7
FM991R	1050 [18]	38.9	85.0	1.17	33.8	4.9
PHY510RR	1048 [19]	39.4	84.5	1.16	33.9	4.9
Average	1179	41.0	84.6	1.16	33.4	4.9
LSD 0.10	70	0.3	0.4	0.01	1.0	0.1
CV %	13.8	1.7	0.7	1.74	4.7	4.4

[a] Athens, Midville, Plains, and Tifton.
[b] Superscripts indicate ranking.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 7. Yield Summary for Later Maturity Cotton Varieties, 2005, Irrigated

	Lint Yield[a]									
Entry	Bainbridge	Midville	Plains	Tifton	4-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	lb/acre					%	%	in	g/tex	units
DPLX04Y170BR	**1251** [4]	**2234** [3]	**1941** [1]	**1701** [1]	**1782** [1]	41.2	85.8	1.21	32.0	4.7
ST6636BR	**1340** [2]	**2230** [4]	**1674** [4]	**1589** [4]	**1708** [2]	39.0	86.1	1.23	33.6	4.6
DP 445 BG/RR	**1343** [1]	**2130** [11]	**1734** [2]	**1593** [3]	**1700** [3]	41.4	86.2	1.22	32.0	4.7
DP 449 BG/RR	1147 [7]	**2283** [1]	**1691** [3]	1529 [7]	**1662** [4]	39.6	85.7	1.19	34.2	4.8
DP 454 BG/RR	**1188** [5]	**2171** [6]	1634 [7]	**1605** [2]	**1649** [5]	41.9	85.6	1.18	30.7	4.1
DP 555 BG/RR	**1278** [3]	2034 [18]	**1665** [6]	1476 [9]	1613 [6]	42.5	85.0	1.19	31.3	4.6
DP 455 BG/RR	966 [19]	**2250** [2]	1570 [11]	1371 [22]	1540 [7]	41.9	85.3	1.21	33.2	4.1
DP 493	1097 [9]	**2168** [7]	**1673** [5]	1220 [37]	1539 [8]	42.7	85.0	1.20	32.7	4.8
DPLX05X648DR	984 [14]	**2115** [13]	1628 [9]	1424 [16]	1538 [9]	41.2	84.4	1.19	31.1	4.9
GA2001078	955 [20]	**2164** [8]	1507 [12]	1442 [14]	1517 [11T]	41.9	85.8	1.21	33.2	4.8
ST 5599BR	1143 [8]	1997 [21]	1583 [10]	1344 [24]	1517 [11T]	39.5	85.3	1.21	32.8	4.6
DPLX03X179R	892 [26]	**2137** [9]	1342 [24]	**1580** [5]	1488 [13]	41.8	86.0	1.22	35.3	4.6
DP 488 BG/RR	908 [24]	**2086** [14]	1483 [14]	1382 [20]	1464 [14]	39.8	86.0	1.24	32.7	4.6
ST6848R	864 [31]	**2205** [5]	1464 [15]	1299 [28]	1458 [15]	38.8	86.2	1.22	35.6	4.7
GA2003137	875 [29]	1908 [29]	1633 [8]	1374 [21]	1448 [16]	42.2	86.1	1.22	33.4	4.6
DP 543 BGII/R	982 [16]	1880 [33]	1386 [22]	1386 [18]	1408 [21]	38.7	85.2	1.21	32.9	4.7
GA2003118	977 [17]	**2128** [12]	1203 [31]	1307 [27]	1404 [22]	39.2	86.0	1.23	33.5	4.6
DP 494 RR	1006 [12]	**2135** [10]	1246 [27]	1189 [38]	1394 [23]	40.7	86.1	1.23	35.2	4.8
GA2003178	975 [18]	1906 [30]	1207 [29]	1425 [15]	1379 [25]	38.4	85.3	1.19	36.5	4.9
FM991BR	888 [28]	1954 [24]	1171 [32]	1397 [17]	1352 [26]	39.2	85.3	1.20	37.3	4.8
Deltapearl	631 [39]	2076 [15]	1438 [17]	1250 [35]	1349 [27]	38.4	85.6	1.24	32.3	4.6
ST 5303R	892 [27]	1981 [22]	1158 [34T]	1237 [36]	1317 [30]	38.6	86.3	1.18	36.7	4.3
DP 491	837 [34]	2011 [19]	1025 [37]	1342 [25]	1304 [31]	41.5	86.4	1.27	33.7	4.5
GA2003165	1017 [11]	1816 [36]	1096 [35]	1252 [34]	1295 [32]	38.3	86.0	1.23	33.8	4.4
PHY510RR	870 [30]	1909 [28]	989 [38]	1352 [23]	1280 [33]	38.7	85.2	1.20	34.8	4.7
FM991R	855 [32]	1945 [26]	1206 [30]	1057 [39]	1266 [35]	39.0	85.3	1.22	35.0	4.7
FM991B2R	815 [36]	1631 [39]	1297 [26]	1293 [29]	1259 [36]	37.8	85.5	1.23	36.1	4.4
Group Average	*999*	*2055*	*1431*	*1386*	*1468*	*40.1*	*85.6*	*1.21*	*33.8*	*4.6*

Table 7. Yield Summary for Later Maturity Cotton Varieties, 2005, Irrigated (Cont'd)

	Lint Yield[a]									
Entry	Bainbridge	Midville	Plains	Tifton	4-Loc.	Lint	Unif.	Length	Strength	Mic.
	---------- lb/acre ----------					%	%	in	g/tex	units
RRFlex Varieties										
STX 0414B2RF	**1179** [6]	1978 [23]	1437 [18]	1537 [6]	1533 [10]	38.2	85.9	1.23	33.2	4.6
ST 4357B2RF	1032 [10]	2054 [16]	1493 [13]	1458 [12]	1509 [12]	39.9	86.9	1.27	29.8	4.2
ST 6611B2RF	987 [13]	1889 [32]	1415 [20]	1473 [10]	1441 [17]	38.2	85.3	1.22	32.8	4.6
DP 164 B2RF	941 [21]	1847 [34]	1444 [16]	1469 [11]	1425 [18]	39.3	86.3	1.25	32.1	4.8
DP 143 B2RF	983 [15]	2009 [20]	1350 [23]	1325 [26]	1417 [19]	38.6	86.1	1.29	30.2	4.4
ST 6622RF	927 [23]	1910 [27]	1309 [25]	1490 [8]	1409 [20]	39.8	86.1	1.23	32.5	4.5
DP 156 B2RF	840 [33]	1897 [31]	1431 [19]	1383 [19]	1387 [24]	38.4	85.2	1.23	30.3	4.5
DP 147 RF	824 [35]	1952 [25]	1170 [33]	1446 [13]	1348 [28]	39.9	86.2	1.27	32.8	4.4
ST 5007B2RF	899 [25]	1737 [38]	1396 [21]	1277 [31]	1327 [29T]	36.6	87.2	1.28	30.4	4.0
DP 167 RF	929 [22]	2053 [17]	1065 [36]	1262 [33]	1327 [29T]	38.6	86.4	1.27	33.0	4.5
STX5885B2RF	762 [37]	1829 [35]	1224 [28]	1269 [32]	1271 [34]	36.6	85.6	1.23	32.0	4.7
DP 152 RF	742 [38]	1812 [37]	1158 [34T]	1279 [30]	1248 [37]	38.5	85.0	1.23	31.4	4.2
Group Average	*920*	*1914*	*1324*	*1389*	*1387*	*38.6*	*86.0*	*1.25*	*31.7*	*4.4*
Overall Average	975	2012	1398	1387	1443	39.7	85.8	1.22	33.1	4.6
LSD 0.10	196	198	283	149	134	0.9	0.6	0.02	1.4	0.2
CV %	17.2	8.4	12.0	9.2	10.8	1.8	0.9	1.58	4.3	4.5

[a] Superscripts indicate ranking at that location.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 8. Two-Year Summary for Later Maturity Cotton Varieties at Four Locations[a], 2004-2005, Irrigated

Variety	Lint Yield[b]	Lint	Uniformity Index	Length	Strength	Micronaire
	lb/acre	%	%	inches	g/tex	units
DP 555 BG/RR	**1650** [1]	43.1	84.6	1.18	31.5	4.6
DP 445 BG/RR	**1648** [2]	41.8	85.8	1.19	31.7	4.7
DP 455 BG/RR	**1590** [3]	42.8	85.1	1.19	32.8	4.2
DP 488 BG/RR	1580 [4]	40.8	86.2	1.23	32.5	4.7
DP 449 BG/RR	1577 [5]	40.4	85.2	1.16	34.0	4.7
GA2001078	1568 [6]	42.2	85.7	1.19	33.2	4.7
GA2003137	1541 [7]	42.9	85.7	1.20	33.7	4.7
ST 5599BR	1538 [8]	40.9	85.1	1.18	32.6	4.8
DP 493	1537 [9]	43.4	84.9	1.18	33.2	4.8
DP 494 RR	1527 [10]	41.8	85.9	1.21	34.5	4.7
DP 543 BGII/RR	1473 [11]	39.8	85.2	1.19	32.2	4.8
Deltapearl	1445 [12]	40.4	85.4	1.22	32.3	4.7
FM991BR	1440 [13]	39.6	85.2	1.18	37.1	4.8
DP 491	1437 [14]	42.3	86.2	1.25	34.0	4.5
GA2003165	1432 [15]	39.1	85.9	1.22	34.8	4.6
ST 5303R	1410 [16]	39.7	85.6	1.15	36.5	4.5
FM991R	1358 [17]	39.5	84.9	1.20	34.8	4.7
FM991B2R	1349 [18]	38.3	85.4	1.21	35.9	4.4
PHY510RR	1341 [19]	39.5	84.9	1.19	34.0	4.8
Average	1497	40.9	85.4	1.20	33.7	4.6
LSD 0.10	67	0.4	0.4	0.01	0.8	0.1
CV %	10.0	2.1	0.8	1.57	4.0	4.7

[a] Bainbridge, Midville, Plains, and Tifton.
[b] Superscripts indicate ranking.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 9. Yield Summary for Earlier Maturity Cotton Strains, 2005, Irrigated

	Lint Yield[a]								
Variety	Midville	Plains	Tifton	3-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	---------------------- lb/acre			----------------------	%	%	inches	g/tex	units
DX25105N	1923 [10]	**1672** [3]	**1471** [3]	**1689** [3]	41.7	85.9	1.24	31.4	5.1
Deltapearl	1864 [11]	**1624** [5]	1307 [15]	1598 [9]	40.4	86.0	1.23	33.3	4.8
DX24101-20	1833 [12]	1473 [15]	**1481** [2]	1596 [10T]	40.2	86.4	1.23	33.2	4.5
GA2003156	**2046** [2]	1499 [14]	1240 [18]	1595 [11]	40.5	86.2	1.24	35.1	4.7
GA2002209	**1945** [7]	1397 [18]	**1399** [9]	1580 [12]	41.6	86.0	1.22	33.8	4.9
FMx96-5044B2L	1792 [14]	1532 [12]	1262 [17]	1529 [14]	38.0	86.1	1.28	33.8	4.6
FMx9166B2LL	1785 [15]	1535 [11]	1196 [20]	1506 [15]	39.0	85.2	1.20	36.1	4.4
DX24706	1607 [19]	1441 [16]	**1460** [4]	1503 [16]	40.0	85.9	1.19	30.6	5.0
Tam 00 WA-104	1552 [22]	1511 [13]	**1379** [11]	1481 [17]	38.4	86.0	1.21	32.5	4.5
FM966LL	1696 [18]	1207 [22]	1212 [19]	1372 [18]	38.3	85.7	1.20	36.2	4.4
Tam 99 WJ-9	1473 [23]	1348 [19]	1276 [16]	1366 [19]	37.0	86.6	1.26	34.7	4.6
GA2002113	1601 [20]	1269 [21]	1185 [21]	1352 [20]	40.8	86.1	1.27	33.0	4.5
Tam 98 WW-3	1750 [17]	1150 [25]	1144 [23T]	1348 [21]	37.4	85.8	1.24	30.4	4.5
GA2002199	1353 [25]	1158 [23]	832 [24]	1114 [24]	41.1	85.7	1.19	35.7	5.5
Group Average	*1730*	*1415*	*1274*	*1474*	*39.6*	*86.0*	*1.23*	*33.6*	*4.7*
<u>RRFlex Varieties</u>									
xBCG-9124-F	**2173** [1]	**1671** [4]	**1448** [6]	**1764** [1]	40.2	87.3	1.27	28.9	4.3
xBCG-1004-F	**2016** [3]	**1735** [1]	**1459** [5]	**1737** [2]	39.3	87.1	1.25	29.4	4.5
CX621-F	1934 [8]	**1613** [7]	**1484** [1]	**1677** [4]	39.4	86.9	1.28	28.9	4.3
xBCG-4630-F	**1960** [5]	**1618** [6]	**1427** [7]	**1668** [8]	39.9	87.0	1.27	29.5	4.3
xBCG-4575-F	**2006** [4]	**1588** [8]	**1397** [10]	**1664** [6]	39.0	86.0	1.20	29.9	4.2
xBCG-3255-F	**1950** [6]	**1577** [9]	**1418** [8]	**1648** [7]	39.2	86.1	1.19	29.8	4.2
xBCG-4153-F	1928 [9]	**1539** [10]	**1362** [13]	1610 [8]	39.0	86.0	1.23	28.7	4.3
xBCG-8391-F	1783 [16]	**1674** [2]	**1330** [14]	1596 [10T]	36.9	87.4	1.28	30.0	4.2
CX601-F	1806 [13]	1426 [17]	**1365** [12]	1532 [13]	39.5	85.6	1.20	29.4	4.3
xBCG-1505-F	1451 [24]	1282 [20]	1157 [22]	1296 [22]	37.5	86.0	1.21	33.9	4.3
xBCG-0105-F	1565 [21]	1155 [24]	1144 [23T]	1288 [23]	36.0	85.9	1.27	32.8	3.8
Group Average	*1870*	*1534*	*1363*	*1589*	*38.7*	*86.5*	*1.24*	*30.1*	*4.2*
Overall Average	1792	1468	1313	1524	39.2	86.2	1.23	32.0	4.5
LSD 0.10	229	196	170	138	1.0	0.6	0.02	1.2	0.2
CV %	10.9	11.4	11.0	11.1	2.2	0.7	1.59	3.8	4.8

[a] Superscripts indicate ranking at that location.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

Table 10. Yield Summary for Later Maturity Cotton Strains, 2005, Irrigated

	Lint Yield[a]								
Variety	Midville	Plains	Tifton	3-Loc. Average	Lint	Unif. Index	Length	Strength	Mic.
	---------------------- lb/acre ----------------------				%	%	inches	g/tex	units
CS37	**1900** [2]	**1316** [6]	**1478** [1]	**1565** [1]	39.6	85.8	1.24	31.2	4.6
Deltapearl	**1831** [5]	**1435** [2]	1307 [3]	**1525** [2]	39.5	85.0	1.24	33.2	4.8
FMx9166B2LL	**1781** [8]	**1514** [1]	1246 [8]	**1514** [3]	39.0	85.0	1.21	35.9	4.6
CS44	**1889** [3]	**1383** [3]	1264 [5]	**1512** [4]	40.0	85.6	1.25	31.8	4.7
GA2003138	**1834** [4T]	**1324** [5]	1221 [9]	**1460** [5]	39.8	85.5	1.21	31.0	4.4
GA2002125	**1993** [1]	1110 [13]	1263 [6]	**1455** [6]	41.5	86.1	1.25	34.5	4.7
GA2003131	1660 [11]	**1276** [7]	**1381** [2]	**1439** [7]	38.6	86.3	1.28	32.9	4.3
GA2002118	**1829** [6]	**1273** [8]	1131 [13]	**1411** [8]	39.9	86.3	1.23	35.2	4.9
FM966LL	1670 [10]	**1353** [4]	1186 [11]	1403 [9]	38.0	85.7	1.19	36.7	4.2
CE21	**1834** [4T]	1101 [14]	1177 [12]	1371 [10]	38.6	84.6	1.18	31.3	4.8
CS42	1698 [9]	1081 [15]	1268 [4]	1349 [11]	38.9	86.1	1.27	32.0	4.1
FMx96-5044B2L	1631 [12]	1169 [10]	1211 [10]	1337 [12]	36.7	85.7	1.29	34.3	4.4
CE33	**1816** [7]	1059 [16]	1121 [14]	1332 [13]	36.8	85.2	1.24	34.3	4.5
CS41	1541 [14]	1137 [11]	1075 [16]	1251 [14]	38.7	86.2	1.27	31.1	4.4
CS43	1606 [13]	957 [17]	1105 [15]	1223 [15]	35.4	86.5	1.27	32.2	4.4
CS38	1532 [15]	880 [18]	1254 [7]	1222 [16]	38.1	86.4	1.26	32.5	4.4
CE25	1455 [16]	**1210** [9]	948 [18]	1205 [17]	39.2	84.6	1.17	34.1	4.5
GA2002199	1382 [17]	1125 [12]	988 [17]	1165 [18]	41.3	86.4	1.20	35.8	5.2
Average	1716	1206	1201	1374	38.9	85.7	1.23	33.3	4.5
LSD 0.10	263	306	153	162	1.0	0.6	0.02	1.1	0.2
CV %	13.0	21.4	10.8	15.3	2.1	0.8	1.64	3.1	4.8

[a] Superscripts indicate ranking at that location.
Bolding indicates entries not significantly different from highest yielding entry based on Fisher's protected LSD (P = 0.10).

COTTON PLANT DENSITY: IMPACTS ON FIBER QUALITY

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Introduction

Cotton plant density has been studied quite intensively in the past and continues to receive attention. The vast majority of this work examines yield, and it is well understood that respectable yields can be obtained from a large range of plant densities. Cotton is unique among many crop plants in that it can exhibit compensatory growth. This characteristic allows for similar yields at plant densities ranging from 1 to 6 plants per foot of row. In addition, yields are also similar between cotton planted in conventional row widths and ultra-narrow rows. What has not been examined so intensively is the impact of these varying plant densities on fiber quality.

As plant density is altered, yields are maintained via alterations in the fruiting pattern of the cotton plant. At higher plant densities fewer bolls per plant will be produced. Plants growing in these higher plant densities also tend to begin fruiting later on higher nodes, and will not produce as many fruiting branches as plants grown in lower plant densities. The potential loss in yield due to less production per plant is overcome by the increased number of plants.

In lower plant densities each individual plant will produce more bolls. Cotton plants grown under these conditions also tend to begin fruiting earlier on lower nodes, produce more fruiting branches, and develop bolls at more distal fruiting positions. All of these factors also lead to a longer fruiting period for plants grown in lower plant densities.

Similar to yield, the quality of the fiber produced by a cotton plant is influenced by many factors such as variety, fertility, insect management, water stress, and temperature. Another factor that potentially influences fiber quality more than yield is weathering of the opened boll.

While growing cotton in lower plant densities may not have an observable impact on yield it may influence quality parameters. Plants grown in lower plant densities produce fruit and develop fiber over a longer period of time, potentially introducing greater variability in developmental conditions for earlier and later set bolls. In addition, plants grown in these lower plant densities will have open bolls exposed to weathering for a longer period of time than will plants produced in higher plant densities. The fiber quality of a boll is at its premium the day it opens, and only deteriorates after that.

A multitude of production practices have changed since the introduction of transgenic cotton varieties, including seeding rates. Cotton seed costs and technology fees associated with seed purchase have steadily increased in recent years. To help offset the rise of seed cost and technology fees producers have reduced seeding rates. The question is whether the reduction seeding rates and plant density has impacted fiber quality.

The objective of this research was to examine the impact of seeding rate on fiber quality.

Materials and Methods

Large plot trials were established across Georgia in growers' fields on cotton variety DP 555 BGRR. Locations included Evans Co., Appling Co., Jefferson Co., Laurens Co. and Pierce Co. Varying plant populations were established by modifying seeding rates on the planter. Low, medium, and high seeding rates consisted of approximately 1.7, 3 and 4 seeds per foot of row, respectively.

Yields were determined by machine harvesting the 4 or 6 center rows of each plot and weighing on a boll buggy equipped with scales at the Appling, Evans, Laurens, and Pierce Co. locations.

Quality was documented in two ways. First a 30 lb subsample of machine picked cotton was collected from each plot. This cotton was ginned at the UGA Microgin in Tifton. HVI data was obtained via the International Textile Center in Lubbock, TX. Secondly, all individual plots from each seeding rate were combined into a module in the Jefferson, Laurens, and Evans Co. locations. These modules were ginned on local commercial gins and all bales were classed with HVI equipment at the Macon classing office.

Results and Discussion

Due to differences in plant emergence there was a significant interaction across locations for final plant stand. Therefore, all yield and quality data generated via the UGA Microgin are presented separately by location in tables 1 through 5.

The variation in stands between the low and high seeding was highly affected by location. In Jefferson Co. the range was only 1.14 to 1.94 plants per foot for the low and high seeding rates, respectively (Table 3). While in Pierce Co. the range was 1.32 to 3.48 plants per foot. Regardless of location or range in final plant stand yield and turnout was unaffected. This further substantiates previous research and grower experience. Thus, there continues to be no yield sacrifice by reducing seeding rates in order to save on seed costs.

Fiber quality as measured from samples ginned at the UGA Microgin and classed at the International Textile Center in Lubbock, TX indicated no consistent trends in HVI parameters as affected by seeding rates.

In Evans, Laurens, and Jefferson Co. cotton from the individual plots were moduled so that separate modules could be built from the varying seeding rates. The fiber quality parameters micronaire, length and strength indicated similar trends to the cotton ginned at the UGA Microgin (data not shown). However, some interesting trends were noted for uniformity. In all three of these locations as the number of plants per foot of row increased, uniformity increased also.

While this discrepancy between data generated at the UGA Microgin and a commercial gin is concerning the magnitude of the change in uniformity with increasing plant density is of little consequence in economic terms. Under the current market structure, the potential economic benefit of increasing uniformity will in no way offset the costs of increased seeding rates.

Conclusions

Collectively these data do not suggest consistent yield or quality benefit with varying seeding rates at the rates tested. It still remains UGA Extension recommendations to utilize seeding rates of 2.5 to 3 seed per foot to maximize the chances of obtaining an adequate and uniform plant stand. The potential change in uniformity does justify further studies into the effect of final plant stand on this parameter.

Table 1. Final plant stand, lint yield, turnout, and fiber quality from 3 planting densities, Appling Co., 2005.

Seeding Rate	Final Stand Plants/foot	Yield Lbs Lint/A	Turnout %	Micronaire	Length inches	Uniformity%	Strength g/tex
Low	1.53 c	965 a	40.1 a	4.4 a	1.095 b	81.2 a	29.9 a
Medium	2.36 b	907 a	40.3 a	4.4 a	1.103 a	80.8 a	29.8 a
High	3.24 a	966 a	40.1 a	4.4 a	1.091 b	81.1 a	29.4 a
Pr>f	*0.0003*	*0.7025*	*0.9253*	*0.7624*	*0.0193*	*0.0593*	*0.7471*
CV	5.8	9.9	1.6	1.7	1.4	0.9	2.2

Table 2. Final plant stand, lint yield, turnout, and fiber quality from 3 planting densities, Evans Co., 2005.

Seeding Rate	Final Stand Plants/foot	Yield Lbs Lint/A	Turnout %	Micronaire	Length inches	Uniformity%	Strength g/tex
Low	1.69 c	920 a	42.9 a	4.6 a	1.083 a	80.6 a	28.9 a
Medium	2.15 b	965 a	41.9 a	4.5 a	1.083 a	80.7 a	28.5 a
High	3.32 a	966 a	41.9 a	4.4 a	1.088 a	80.7 a	28.8 a
Pr>f	*0.0003*	*0.5239*	*0.0747*	*0.2992*	*0.3086*	*0.9826*	*0.2004*
CV	5.5	5.5	1.0	1.4	1.0	0.9	2.4

Table 3. Final plant stand, lint yield, turnout, and fiber quality from 3 planting densities, Jefferson Co., 2005.

Seeding Rate	Final Stand Plants/foot	Yield Lbs Lint/A	Turnout %	Micronaire	Length inches	Uniformity%	Strength g/tex
Low	1.14 c	802	40.0 a	4.2 a	1.101 a	81.9 a	30.5 a
Medium	1.52 b	846	39.4 a	4.0 a	1.096 a	81.4 a	30.2 a
High	1.94 a	850	39.7 a	4.1 a	1.102 a	81.4 a	30.0 a
Pr>f	*0.0007*	-	*0.7246*	*0.1814*	*0.2081*	*0.4681*	*0.0716*
CV	5.1	-	2.3	2.3	1.3	0.8	2.5

*Yields were determined from final module weights, individual plot data was not available thus, statistical analysis of yield was not possible.

Table 4. Final plant stand, lint yield, turnout, and fiber quality from 3 planting densities, Laurens Co., 2005.

Seeding Rate	Final Stand Plants/foot	Yield Lbs Lint/A	Turnout %	Micronaire	Length inches	Uniformity%	Strength g/tex
Low	1.13 c	937 a	40.4 a	4.4 a	1.083 a	80.8 a	28.5 a
Medium	1.81 b	942 a	39.9 a	4.4 a	1.084 a	80.7 a	28.9 a
High	2.73 a	1046 a	40.9 a	4.5 a	1.084 a	81.0 a	28.7 a
Pr>f	*0.0001*	*0.5195*	*0.5290*	*0.7656*	*0.9070*	*0.7346*	*0.6428*
CV	10.0	12.4	2.5	1.5	1.2	0.6	2.9

Table 5. Final plant stand, lint yield, turnout, and fiber quality from 3 planting densities, Pierce Co., 2005.

Seeding Rate	Final Stand Plants/foot	Yield Lbs Lint/A	Turnout %	Micronaire	Length inches	Uniformity%	Strength g/tex
Low	1.32 c	798 a	41.8 a	4.6 a	1.101 a	82.1 a	29.7 a
Medium	2.48 b	835 a	42.2 a	4.6 a	1.117 a	81.7 a	29.8 a
High	3.48 a	809 a	41.1 a	4.5 a	1.108 a	81.9 a	29.5 a
Pr>f	*0.0001*	*0.3635*	*0.5939*	*0.5017*	*0.0525*	*0.6024*	*0.2100*
CV	2.6	3.6	3.2	0.9	1.5	0.8	2.3

Table 6. Uniformity as determined by commercial ginning moduled cotton from 3 planting densities, Evans, Laurens, and Jefferson Co., 2005.

	Evans	Laurens	Jefferson
Seeding Rate	Uniformity %		
Low	79.40	79.51	79.32
Medium	79.78	80.27	79.44
High	79.83	80.32	79.60

COTTON PLANT GROWTH REGULATORS AND YIELD ENHANCERS

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Introduction

There is no shortage of products that are marketed as plant growth regulators or yield enhancers. Undoubtedly, the most successful and consistent of these products has been Mepiquat chloride which is sold under various trade names, but is most synonymous with Pix. Despite the success and wide use of this product, yield responses have been erratic at best.

Mepiquat chloride has proved to be most useful as a crop management tool, with any observed yield increases almost being secondary in nature. When use correctly this product will reduce plant height and leaf area, promote earlier boll set, and increase ease of harvesting. Reduction in plant height and leaf area allows for easier penetration of insecticide sprays and harvest-aids and may potentially reduce boll rot since airflow will not be as restricted throughout the canopy. While currently not perceived to be of a real benefit in Georgia, earlier boll set and more rapid crop maturity is advantageous in many parts of the cotton belt, and may lead to yield increases by allowing for earlier harvest prior to fall rains.

Usage of mepiquat chloride has been on the forefront of many Georgia producers minds subsequent to the rapid adoption of DP 555 BGRR. This variety as the potential to be very growthy and management with mepiquat chloride is almost mandatory. However, the issue becomes muddled with the now vast array of mepiquat-type products available.

Products now on the market place include the original mepiquat chloride, and other formulations which include yield enhancers such as *Bacillus cereus* and kinetin. To further confuse the issue another product consists of mepiquat pentaborate which is supposedly more effective. Another material has also been developed which consists of mepiquat chloride with twice the amount of active ingredient as other materials and contains cyclanilide as an added active ingredient. This product, Stance, is unique in that it is being marketed at a single use rate of 3 oz/A. The more traditional mepiquat containing materials have varying rates depending on crop size and growth conditions.

The objective of this study was to determine if any differences exist in vegetative growth control, yield, or quality of cotton treated with various PGR products.

Materials and Methods

Large plot trials were established across Georgia in growers' fields on cotton variety DP 555 BGRR. Locations included Evans Co., Colquitt Co., and Jefferson Co. Rate for rate comparisons were made with the various plant growth regulating products, with the exception of Stance which was applied at 3 oz/A at all times. Specific rates of application at each location are listed in Table 1. Treatments were replicated 3 or 4 times and arranged in a randomized complete block design. All treatments were applied with commercial equipment. Timing of application was based on growth stage and crop needs according to UGA Extension recommendations.

Data collected included plant height at harvest, yield and quality. Quality was documented in two ways. First a 30 lb subsample of machine picked cotton was collected from each plot. This cotton was ginned at the UGA Microgin in Tifton. HVI data was obtained via the International Textile Center in Lubbock, TX. Secondly, all individual plots from each treatment were combined into a module in the Colquitt and Jefferson Co. locations. These modules were ginned on local commercial gins and all bales were classed with HVI equipment at the Macon classing office.

Results and Discussion

Vegetative Growth

There were no significant interactions for plant height or total nodes of cotton treated with the individual products across locations. At harvest no differences between the products were observed (Table 2).

Yield

There were no significant interactions for yield with the individual products across location. No differences in cotton yield were observed between the products (Table 2).

Fiber Quality

Microgin Samples

There were no significant interactions for any fiber quality parameter for cotton treated with the individual products across locations. Furthermore, micronaire, uniformity and strength were not different between any of the treatments (Table 3). Fiber length, however was significantly greater in the cotton treated with Stance. On average fiber length was increased by .016 inches which is equivalent to 0.5 staple.

Moduled Cotton

Similar trends were noted for the fiber quality parameters in the moduled cotton as were observed with the subsamples ginned at the UGA microgin. Micronaire, uniformity and strength appear to be unaffected by the individual treatments. Staple tended to be greater with the Stance treatment.

CONCLUSIONS

These data suggest that in terms of vegetative growth control, yield and the majority of fiber quality parameters there is no difference in the performance of the plant growth regulators evaluated. These observations are consistent with previous research conducted and validate the recommendation that choice of plant growth regulator product should be made on price alone. The issue of Stance increasing fiber length will need to be examined further. As a word of caution, this is the first year that Stance has been widely evaluated across Georgia.

Table 1. Rate and Timing of plant growth regulator application, 2005.

	Colquitt Co.				Evans Co.			Jefferson Co.		
	6/6	6/22	7/6	7/26	7/6	7/25	8/10	7/8	7/25	8/17
	Oz/A									
Mepichlor	8	10	10	14	8	12	16	8	16	16
Mepex Ginout	8	8	10	14	8	12	16	8	16	16
Pentia	8	8	10	14	8	12	16	8	16	16
Stance	3	3	3	3	3	3	3	3	3	3

Table 2. Vegetative growth, turnout, and yield as influenced by 4 mepiquat containing plant growth regulators. Data combined over 3 locations Evans Co., Colquitt Co., and Jefferson Co., 2005.

	Height Inches/plant	Nodes #/plant	Turnout %	Seed Cotton	Lint
				Lbs/A	
Mepichlor	48.5 a	25.7 a	41.4 a	3061 a	1240 a
Mepex Ginout	48.3 a	25.7 a	40.5 a	3141 a	1272 a
Pentia	48.9 a	26.6 a	40.6 a	3111 a	1263 a
Stance	47.3 a	25.6 a	40.1 a	3094 a	1245 a
Pr>f	*0.7394*	*0.4232*	*0.2343*	*0.3442*	*0.2348*
CV	5.5	6.0	1.5	4.3	4.4

Table 3. HVI data as influenced by 4 mepiquat containing plant growth regulators. Data generated via ginning 30 lb samples from each plot at the UGA microgin and classed at the International Textile Center in Lubbock, TX. Data combined over 3 locations Evans Co., Colquitt Co., and Jefferson Co., 2005.

	Micronaire	Length Inches	Uniformity %	Strength g/tex
Mepichlor	4.3 a	1.098 b	81.3 a	29.6 a
Mepex Ginout	4.3 a	1.094 b	81.4 a	29.9 a
Pentia	4.3 a	1.100 b	81.3 a	29.9 a
Stance	4.3 a	1.113 a	81.6 a	30.0 a
Pr>f	*0.7005*	*0.0011*	*0.2915*	*0.1619*
CV	2.5	1.2	0.8	2.6

Table 4. HVI data as influenced by 4 mepiquat containing plant growth regulators. Data generated via combining cotton from all replications for each treatment into separate modules. Cotton was classed at the Macon classing office. Data combined over 2 locations Colquitt Co. and Jefferson Co., 2005.

	Micronaire		Staple		Uniformity		Strength	
			——32nds——		——%——		——g/tex——	
	Jeff.	Col.	Jeff.	Col.	Jeff.	Col.	Jeff.	Col.
Mepichlor	4.5	4.7	33.9	34.6	80.0	79.5	28.7	29.5
Mepex Ginout	4.5	4.7	34.4	34.4	80.1	79.8	29.0	29.6
Pentia	4.5	4.7	34.3	34.7	80.4	80.3	30.5	29.4
Stance	4.5	4.8	34.4	34.9	80.4	79.4	29.1	29.6

REPLANTING SKIPPY STANDS

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Introduction

Whether or not to replant cotton when faced with a less than optimal stand continues to be a difficult decision. Ultimately the choice to replant or leave the original stand is often made based on past experience. Once the decision has been made a producer often spends the remainder of the season wondering if the decision was correct or not. Currently a majority of season-long production costs are incurred once planting has been accomplished. Thus stand establishment is critical.

The objective of this research was to evaluate the yields of less than optimal stands in relation to the yield of an optimal stand planted later (replanted). Furthermore the objective was to mathematically describe a skippy stand.

Materials and Methods

Skippy stands were established in 4-row plots 40 feet long replicated four times in both South Louisiana and East Georgia in 2004 and 2005. Skippy stands were obtained by planting varying ratios of a Liberty Link (Ignite herbicide tolerant) cotton variety with a non-Liberty Link variety during the first week of May at both locations. Ratios consisted of 100% LL, 80% LL, 60% LL, 40% LL, and 20% LL. Often times a skippy stand in the field is the result of mechanical impedance to plant emergence as opposed to poor germination, resulting in a stand that is not only skippy but also stressed. Thus, each of the varying ratios of LL to non-LL seeds was planted at both an optimal depth and 2 inches deep in an effort to impose a stress. Replant plots were seeded the first week of June. To establish skips all plots planted the first week of May were treated with Ignite at 32 oz/A once seedlings had reached the 1-true leaf stage to remove all non-LL plants. This same process was repeated in 2005 with a LL variety and a full-season RR variety (DPL 555 BGRR) and non-RR variety, where skips were established by treating plots with glyphosate at 1 lb ai/A.

Data collection consisted of machine picked plot yields taken from the two center rows of each plot. The yields of all plots were expressed as a percentage of replanted plot yields within a replication. Skip length and frequency within a plot was documented by measuring all skips within the two center rows of each plot that were greater than 12 inches. This number is referred to as cumulative skip length per 80 foot of row. Cumulative skip lengths were determined for the following categories: greater than 1 ft, 1.5 ft, 2 ft, 2.5 ft. 3 ft, 3.5 ft and 4 ft. The standard deviation of skips in each of these categories was also determined.

Regression analysis was performed on all data. Initial independent variable selection was made via PROC STEPWISE in SAS. Independent variables consisted of cumulative skip lengths, standard deviations of skip lengths, location, stress, variety and all interactions.

Results and Discussion

Stepwise variable selection indicated that skip lengths greater than 3 feet was the significant independent variable (Table 1). Since variety and stress were shown to minimal effects on final yield in comparison to skip length these data were pooled across skip lengths. In addition, to make the model more user friendly skips were converted to a numbering system. A skip of 3 feet was given a value of 1, a skip of 9 feet was given a value of 3. Thus in field evaluation skips greater than 3 feet are summed and divided by 3. The resulting number is inserted into the model.

Table 1. Analysis of variance and parameter estimates for modeling skippy stand yields in relation to replant yields

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F value	Pr>f
Model	4	4.66071	1.16518	47.56	<0.0001
Error	69	1.69041	0.02450		
Corrected Total	73	6.35112			
	R^2	0.7338			
	R^2_{adj}	0.7184			
	C.V.	14.812			

Parameter Estimates

Variable	DF	Estimate	Standard Error	T Value	Pr>|t|
Intercept	1	1.2401	0.04734	26.2	<.0001
LA_05	1	-0.18044	0.06067	-2.97	0.004
GA_04	1	0.3495	0.052	6.72	<.0001
GA_05	1	-0.08301	0.05275	-1.57	0.1202
# 3ft skips/80ft	1	-0.01934	0.00242	-8	<.0001

It is important to note that the independent variables LA_05, GA_04, and GA_05 are “dummy” variables thus there are in effect four models, one for each location in each year, as indicated in Table 2.

Table 2. Depiction of models by location relating skippy stand yields to replant yields

Parameter Estimates

	Louisiana		Georgia	
	2004	2005	2004	2005
Variable	Estimate			
Intercept	1.24	1.59	1.06	1.16
# 3ft skips/80ft	-0.01934	-0.01934	-0.01934	-0.01934

While the intercept of the models vary between LA and GA in 2004 and 2005 the influence of the number of 3 foot skips is consistent across locations and years. The intercept values for the LA data are significantly greater than the values obtained for GA. The proper interpretation of this is that the replant performed poorly in LA relative to GA. This is a key point since the LA data was generated from a dryland study, where the GA study was irrigated. Thus these data support the idea that replanting in a non-irrigated situation is more risky than replanting where irrigation is available.

While two years of data at two locations does not lend itself to producing a model to explain all potential replant situations, the model developed does begin to lay some ground work. Figures 1 and 2 graphically depict the performance of a skippy initial stand in relation to a replanted stand in LA and GA in 2004 and 2005. How this data will be used will vary by location and field. What is left to question is what level of performance for a skippy initial stand is acceptable. For instance if the calculated performance of the initial stand relative to a replant is 1, then intuitively the stand should be kept since a replant is not predicted to perform any better. However, should replanting occur if the predicted performance value of the initial stand is 0.95, 0.9, 0.85, or 0.8? This decision will ultimately be influenced by the average production history of a given field. For example if a field has an average production history of 700 lbs lint/A for later planting dates a 10% reduction would equate to 70 lbs. Another field may have an average production history of 1000 lbs lint/A for later planting dates in which a 10% yield reduction would equate to 100 lbs. Replanting the former field may not be justified, in the latter replanting may be of benefit.

The final step for this model will be to develop an index explaining current soil and environmental conditions which can be related to the intercept of the model. This is especially important in dryland situations. The intercepts of the models generated in Louisiana vary significantly, in 2004 the replanted plots performed better than in 2005. This difference was primarily due to extremely dry conditions at the time of replanting in 2005.

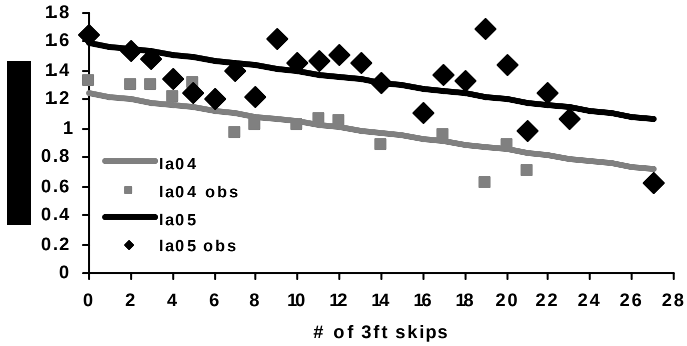

Figure 1. Predicted versus observed yields of skippy stands shown as a percentage of replant yields, Louisiana, 2004 and 2005.

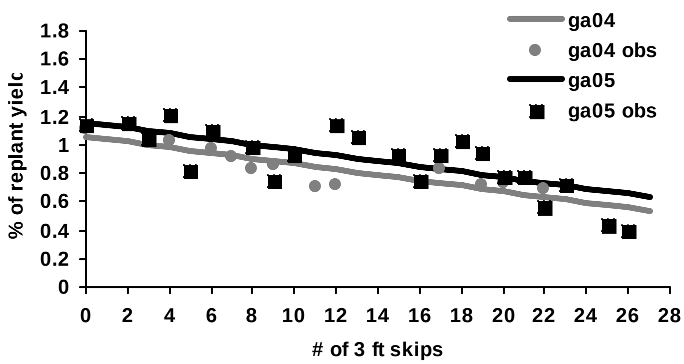

Figure 2. Predicted versus observed yields of skippy stands shown as a percentage of replant yields, Georgia, 2004 and 2005.

UNIFORM LARGE PLOT VARIETY TRIALS

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Introduction

In the past county agents would often establish variety trials in cooperation with seed companies or with specialists, however no effort was made to assure these trials were conducted in a uniform matter and data dissemination was limited.

The goal of this research was to establish a uniform variety trial conducted in multiple locations under varying production practices. These are to serve as a supplement to the Statewide Variety Testing Program.

Materials and Methods

In 2005 a series of 11 large plot variety trials were conducted across Georgia in cooperation with county agents. All of these trials contained the same core set of 10 varieties representing the most widely planted variety (DP 555 BGRR) and 9 newly released varieties. Agents were allowed to plant additional varieties if desired. All plots were at least 0.2 acres in size. DP451BR was utilized as a running check in 10 of the 11 trials. This variety was planted in every 4th or 5th plot in an effort to quantify variability within the field.

Plots were established under irrigated, dryland, conventional till and strip till conditions. At harvest samples from each plot were ginned at the UGA microgin and HVI quality data was obtained via the International Textile Center in Lubbock, TX.

Results and Discussion

A combined analysis of yield and quality are listed in Tables 1 through 4. Due to unforeseen production problems in certain locations only 9 varieties were able to be evaluated consistently in 8 locations.

Collectively these data indicate that there are several varieties that competed very well with DP 555 BGRR. These include DP 445 BGRR, DP 454 BGRR, and ST 5242BR. Availability of these varieties in 2006 may be limited, however.

Conclusions

These trials proved to be a success in 2005 and will continue in 2006. These trials allow agents and growers a "real world" look at not only the yield of newer varieties but also allow an examination of the growth habit of these varieties. In 2006 data collection will be expanded to a quantification of growth differences between varieties.

Table 1. Nine varieties evaluated at 10 locations

	lbs lint/A*	turnout %*	seed cotton/A**	Micronaire	Length	Uniformity	Strength
DP445BR	1255.3 a	0.3896 c	3312.1 a	4.26 ab	1.13 b	83.18 a	30.15 c
DP555BR	1206.0 a	0.4055 a	3069.5 b	4.35 a	1.10 c	81.15 e	29.53 d
DP454BR	1203.7 ab	0.3956 bc	3084.7 b	3.93 c	1.10 c	82.62 b	29.50 d
DP488BR	1133.0 bc	0.3766 d	2941.3 b	4.22 ab	1.15 a	82.19 c	30.79 b
DP455BR	1124.8 c	0.3982 b	3018.8 b	3.96 c	1.12 b	81.56 d	30.52 bc
FM960B2R	1119.9 c	0.3697 e	3065.8 b	4.31 a	1.14 a	82.22 c	32.39 a
DP543B2R	1116.1 c	0.3700 e	3067.2 b	4.30 a	1.13 b	81.61 d	30.65 b
FM960BR	1077.6 c	0.3687 e	3047.2 b	4.16 b	1.10 c	82.73 b	32.72 a
PHY470WR	1077.4 c	0.3667 e	2985.1 b	4.29 ab	1.11 c	83.26 a	29.12 d
Pr>f	*0.0006*	*0.0001*	*0.0320*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
C.V.	7.4	1.9	7.1	2.0	1.2	0.7	2.5

* Lbs lint/A and turnout% were evaluated at 8 of the locations Appling, Burke, Colquitt, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.
**Seed cotton yeilds were evaluated at 10 locations Appling, Bleckley, Bulloch, Burke, Colquitt, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.

Table 2. Ten varieties evaluated at 9 locations

	lbs lint/A*	turnout %*	seed cotton/A**	Micronaire	Length	Uniformity	Strength
DP445BR	1226.1 a	0.3885 c	3272.0 a	4.16 b	1.13 b	83.28 ab	30.32 b
DP454BR	1189.6 a	0.3958 b	3060.4 bc	3.82 c	1.11 cd	82.92 bc	29.63 c
DP555BR	1184.9 ab	0.4048 a	3043.8 bc	4.20 ab	1.10 c	81.42 g	29.50 c
FM960B2R	1112.3 bc	0.3706 de	3046.8 bc	4.17 b	1.15 a	82.43 de	32.37 a
DP488BR	1112.1 bc	0.3766 d	2977.3 bc	4.10 b	1.15 a	82.38 de	30.80 b
DP543B2R	1108.5 bc	0.3714 de	3047.3 bc	4.20 ab	1.13 b	81.65 fg	30.64 b
DP455BR	1087.1 c	0.3978 b	2883.4 c	3.87 c	1.12 bc	81.98 df	30.55 b
FM991BR	1075.6 c	0.3632 f	3094.0 b	4.35 a	1.13 b	82.74 cd	32.80 a
PHY470WR	1057.9 c	0.3667 ef	2948.8 bc	4.22 ab	1.11 cd	83.52 a	29.22 c
FM960BR	1052.7 c	0.3687 ef	3006.9 bc	4.10 b	1.10 c	83.02 bc	32.87 a
Pr>f	*0.0026*	*0.0001*	*0.0725*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
C.V.	7.7	1.9	7.4	1.8	1.2	0.7	2.3

* Lbs lint/A and turnout% were evaluated at 7 of the locations Appling, Burke, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.
**Seed cotton yeilds were evaluated at 9 locations Appling, Bleckley, Bulloch, Burke, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.

Table 3. Eleven varieties evaluated at 8 locations							
	lbs lint/A*	turnout %*	seed cotton/A**	Micronaire	Length	Uniformity	Strength
DP445BR	1264.3 a	0.3893 c	3356.0 a	4.11 bc	1.13 cd	83.18 ab	30.11 cd
DP454BR	1231.2 ab	0.3978 b	3136.9 bcde	3.80 d	1.11 ef	82.98 bc	29.58 de
DP555BR	1225.0 abc	0.4059 a	3128.2 bcde	4.16 abc	1.11 ef	81.49 e	29.36 e
DP543B2R	1173.5 bcd	0.3723 def	3182.6 abcd	4.16 abc	1.13 bc	81.73 e	30.52 bc
ST6636BR	1150.3 bcd	0.3662 ef	3292.3 ab	4.34 a	1.13 cd	83.33 ab	31.11 b
FM960B2R	1141.0 cd	0.3733 de	3096.4 cde	4.13 bc	1.15 ab	82.47 d	32.18 a
DP488BR	1139.3 cd	0.3793 d	3020.4 de	4.06 c	1.16 a	82.37 d	30.70 bc
FM991BR	1135.8 d	0.3652 d	3226.7 abc	4.26 ab	1.13 c	82.57 cd	32.68 a
DP455BR	1132.3 d	0.3992 ab	2981.8 e	3.81 d	1.12 cde	81.86 e	30.53 bc
FM960BR	1104.2 d	0.3725 de	3114.2 bcde	4.03 c	1.10 f	83.03 ab	32.71 a
PHY470WR	1099.2 d	0.3670 ef	3040.0 cde	4.18 abc	1.11 def	83.46 a	29.01 e
Pr>f	*0.0436*	*0.0001*	*0.0455*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
C.V.	7.9	2.0	7.3	1.8	1.2	0.7	2.4

* Lbs lint/A and turnout% were evaluated at 6 of the locations Burke, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.
**Seed cotton yeilds were evaluated at 8 locations Bleckley, Bulloch, Burke, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.

Table 4. Twelve varieties evaluated at 7 locations							
	lbs lint/A*	turnout %*	seed cotton/A**	Micronaire	Length	Uniformity	Strength
ST5242BR	1313.5 a	0.3866 c	3400.6 a	4.22 abc	1.09 g	82.99 bc	28.56 f
DP445BR	1264.3 ab	0.3893 c	3317.9 ab	4.11 bc	1.13 cd	83.18 ab	30.11 cd
DP454BR	1231.2 abc	0.3978 b	3208.5 abcd	3.80 d	1.11 ef	82.98 bc	29.58 de
DP555BR	1225.0 abcd	0.4059 a	3063.6 cde	4.16 abc	1.11 efg	81.49 e	29.36 e
DP543B2R	1173.5 bcde	0.3723 def	3187.3 bcd	4.16 abc	1.13 bc	81.73 e	30.52 bc
ST6636BR	1150.3 cde	0.3662 f	3266.6 abc	4.34 a	1.13 cd	83.33 ab	31.11 b
FM960B2R	1141.0 cde	0.3733 de	3109.1 cde	4.13 bc	1.15 ab	82.47 d	32.18 a
DP488BR	1139.3 cde	0.3793 d	3047.7 de	4.06 c	1.16 a	82.37 d	30.70 bc
FM991BR	1135.8 de	0.3652 f	3224.5 abcd	4.26 ab	1.13 c	82.57 cd	32.68 a
DP455BR	1132.3 de	0.3992 ab	2949.2 e	3.81 d	1.12 cde	81.86 e	30.53 bc
FM960BR	1104.2 e	0.3725 de	3087.6 cde	4.03 c	1.10 fg	83.03 ab	32.71 a
PHY470WR	1099.2 e	0.3670 ef	3050.1 de	4.18 abc	1.11 def	83.46 a	29.01 ef
Pr>f	*0.0048*	*0.0001*	*0.0315*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
C.V.	8.3	2.0	7.5	1.9	1.2	0.7	2.4

* Lbs lint/A and turnout% were evaluated at 6 of the locations Burke, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.
**Seed cotton yeilds were evaluated at 7 locations Bleckley, Burke, Effingham, Irwin, Jeff Davis, Jefferson, and Terrell Counties.

All turnout data generated at UGA Microgin - Tifton, GA

NOTE - Seed cotton yield multiplied by turnout may not equal lint/A values reported due to turnout data not being available at all locations.

Minimum plot size was 0.2 acres

Results from individual trials are listed by location in the following Tables.

APPLING CO - Dryland							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
ST5242BR	1065.8	0.3675	2900.6	4.37	1.11	83.23	29.53
DP445BR	997.2	0.3835	2600.4	4.47	1.14	83.87	31.63
DP488BR	948.7	0.3604	2632.4	4.37	1.14	82.40	31.43
DP555BR	944.3	0.3986	2368.9	4.50	1.09	81.03	30.33
DP454BR	939.9	0.3838	2448.7	3.97	1.10	82.60	29.90
FM960B2R	939.7	0.3547	2649.4	4.40	1.15	82.20	33.47
DP451BR	840.2	0.3420	2456.6	4.75	1.13	83.47	28.83
DP455BR	815.9	0.3892	2096.3	4.23	1.12	82.67	30.67
PHY470WR	810.3	0.3652	2218.7	4.50	1.10	83.90	30.53
FM960BR	743.9	0.3462	2148.6	4.47	1.11	82.97	33.83
DP543B2R	718.4	0.3657	1964.5	4.47	1.10	81.13	31.37
FM991BR	714.2	0.3515	2031.9	4.87	1.10	83.77	33.57
Agent	James Clark						
Grower	Southeastern Gin						
Planted	26-May-05						
Harvested	18-Nov-05						

BLECKLEY CO - Irrigated			
	Lint/A	turnout%	seed cotton/A
ST6636BR			4012.8
FM991BR			3906.9
DP454BR			3881.9
FM960BR			3785.8
DP445BR			3783.6
DP451BR			3724.5
DP455BR			3600.1
ST5242BR			3423.6
FM960B2R			3397.9
PHY470WR			3366.1
DP543B2R			3350.9
DP555BR			3320.6
DP488BR			3304.4
Agent	Gordon Lee		
Grower	Mike Lucas		
Planted	6-May-05		
Harvested	5-Oct-05		

BULLOCH CO - Dryland			
	Lint/A*	turnout%*	seed cotton/A
DP449BR	1638.4	0.4009	4086.9
DP555BR	1510.4	0.4169	3580.1
DP445BR	1541.2	0.4305	3622.9
DP455BR	1294.7	0.3729	3210.5
FM960BR	1313.6	0.3980	3300.6
ST6636BR	1259.1	0.3883	3471.9
FM991BR	1359.0	0.4233	3242.6
DPX170BR	1241.1	0.3940	2994.1
DP543B2R	1215.2	0.4040	3150.1
FM960B2R	1268.0	0.4235	3007.9
PHY470WR	1181.9	0.3980	2969.5
DPX648DR	1149.7	0.3939	2918.8
DP488BR	1144.5	0.4045	2829.4
DP454BR	1109.0	0.4208	2635.4
Agent	Wes Harris and Patt Todd		
Grower	Greg Sikes		
Planted	26-Apr-05		
Harvested	21-Sep-05		** DPL Gin Data*

BURKE CO - Irrigated							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
DP445BR	1246.8	0.4138	3013.1	4.37	1.12	83.87	29.53
ST6636BR	1143.7	0.3779	3026.3	4.20	1.14	82.77	27.97
ST5599BR	1140.4	0.3979	2865.8	3.90	1.10	83.40	29.40
DP555BR	1092.6	0.4162	2625.2	3.77	1.11	82.07	30.53
ST5242BR	1086.4	0.3977	2731.9	4.17	1.15	82.53	30.40
DP451BR	1071.2	0.3651	2933.9	4.23	1.11	81.57	30.43
FM960B2R	1066.6	0.3795	2810.8	4.13	1.10	81.83	29.23
DP454BR	1033.7	0.4067	2541.5	4.07	1.14	83.10	32.00
FM991BR	1031.6	0.3766	2739.1	3.83	1.09	83.30	32.50
DP455BR	1027.7	0.4159	2470.8	4.50	1.11	82.93	32.47
DP488BR	1021.4	0.3847	2654.6	4.10	1.12	83.20	28.83
DP543B2R	990.3	0.3833	2583.9	4.40	1.08	83.70	27.93
PHY470WR	964.8	0.3737	2581.4	4.23	1.13	82.67	31.10
FM960BR	941.2	0.3830	2457.4	4.50	1.13	83.80	31.60
Agent	Will Duffie and Richard McDaniel						
Grower	Cleve Mobley						
Planted	16-May-05						
Harvested	27-Oct-05						

EFFINGHAM CO - Dryland							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
DPX170BR	1174.0	0.3843	3055.0	4.40	1.15	83.33	29.80
ST5242BR	1160.4	0.3611	3213.4	4.33	1.12	83.13	29.60
DPX648DR	1129.7	0.4049	2789.9	4.43	1.12	82.00	29.00
DP451BR	1104.7	0.3465	3187.9	4.60	1.16	83.03	28.97
DP543B2R	1096.1	0.3532	3103.6	4.13	1.16	82.70	30.43
DP445BR	1081.9	0.3771	2868.5	4.40	1.17	84.27	31.00
DP455BR	1074.2	0.3869	2776.4	4.13	1.17	82.70	31.07
ST6636BR	1050.2	0.3594	2922.4	4.63	1.16	83.77	32.30
FM991B2R	1024.3	0.3498	2928.0	4.40	1.15	84.20	33.00
DP555BR	1005.1	0.4044	2485.2	4.47	1.11	81.83	28.67
FM991BR	1002.9	0.3565	2812.8	4.37	1.16	82.70	32.33
DP488BR	987.7	0.3690	2676.6	4.23	1.17	82.13	31.23
FM960BR	981.1	0.3567	2750.5	4.20	1.13	84.10	32.23
DP454BR	935.6	0.3785	2471.8	3.93	1.13	83.67	29.70
FM960B2R	896.1	0.3487	2569.7	4.23	1.18	83.10	32.07
PHY470WR	895.6	0.3495	2562.7	4.70	1.15	83.73	29.60
Agent	Bill Tyson						
Grower	Larry Redmond						
Planted	16-May-05						
Harvested	7-Nov-05						

IRWIN CO - Dryland							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
DP555BR	1634.0	0.4027	4057.8	4.60	1.11	81.67	30.53
DP454BR	1632.1	0.3889	4196.5	4.27	1.13	83.13	30.13
DP543B2R	1478.4	0.3641	4060.6	4.83	1.12	81.47	31.03
DP445BR	1476.9	0.3805	3881.3	4.53	1.15	83.50	30.50
FM960B2R	1420.5	0.3685	3855.3	4.63	1.15	82.47	33.77
ST5242BR	1418.2	0.3730	3802.0	4.53	1.09	82.73	27.93
DP488BR	1400.2	0.3694	3790.2	4.63	1.16	82.43	32.00
FM991BR	1391.5	0.3551	3918.5	4.67	1.15	82.70	34.43
DP451BR	1386.6	0.3461	4006.2	4.57	1.14	82.90	28.67
FM960BR	1382.1	0.3618	3819.8	4.47	1.10	82.83	33.73
ST6636BR	1378.4	0.3510	3926.7	4.97	1.13	83.83	31.43
DP455BR	1352.5	0.3904	3464.8	4.30	1.13	82.13	31.97
PHY470WR	1273.0	0.3551	3585.4	4.37	1.11	83.43	28.87
Agent	Phillip Edwards						
Grower	Tommy Wilson						
Planted	13-May-05						
Harvested	25-Oct-05						

JEFF DAVIS CO - Dryland							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
ST5242BR	1470.7	0.3962	3711.9	4.07	1.09	82.77	27.33
DP451BR	1228.4	0.3630	3384.0	3.60	1.09	82.30	28.80
DP454BR	1226.2	0.4136	2964.6	3.53	1.09	80.43	28.87
DP424B2R	1187.0	0.3614	3283.9	3.63	1.11	82.53	29.27
ST6636BR	1177.2	0.3749	3140.2	3.80	1.11	82.57	29.47
DP445BR	1123.9	0.3980	2824.1	3.70	1.13	82.53	28.43
DPX648DR	1119.4	0.4080	2743.4	4.07	1.10	81.57	29.60
DP543B2R	1108.0	0.3852	2876.5	4.07	1.09	81.37	27.53
PHY470WR	1077.2	0.3820	2819.8	3.90	1.10	82.57	28.20
DP555BR	1072.2	0.4051	2646.8	3.97	1.10	82.07	28.77
DPX170BR	1071.8	0.3925	2730.8	4.33	1.08	80.97	28.00
FM991BR	1061.2	0.3720	2852.9	4.07	1.09	83.00	28.23
FM960B2R	1002.3	0.3922	2555.3	3.80	1.07	82.20	31.57
DP488BR	984.1	0.3806	2585.3	4.07	1.11	80.77	28.63
FM960BR	972.2	0.3805	2554.6	4.07	1.12	81.77	30.87
DP455BR	945.4	0.4084	2315.2	3.43	1.13	81.57	28.63
Agent	Tim Varnedore						
Grower	Delvin Williams						
Planted	27-May-05						
Harvested	9-Nov-05						

JEFFERSON CO - Irrigated							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
DP445BR	1625.9	0.4118	3948.0	4.40	1.14	83.50	30.90
ST5242BR	1505.3	0.4109	3663.7	4.20	1.09	83.17	29.13
DP451BR	1370.5	0.3753	3651.6	4.13	1.16	83.77	28.77
DP454BR	1347.3	0.4095	3290.1	3.70	1.10	83.43	30.57
DP555BR	1343.5	0.4066	3304.5	4.00	1.11	81.70	30.50
FM991BR	1343.2	0.3793	3541.2	4.33	1.15	83.03	33.97
DP455BR	1323.0	0.4181	3164.5	3.77	1.13	82.43	31.27
DP488BR	1314.8	0.3923	3351.7	4.13	1.16	83.27	31.37
ST6636BR	1221.6	0.3944	3097.5	4.57	1.13	83.50	31.90
FM960B2R	1221.0	0.3940	3099.2	4.13	1.15	82.67	33.13
FM960BR	1186.4	0.3900	3042.2	4.07	1.13	82.93	33.77
PHY470WR	1185.4	0.3788	3129.3	4.17	1.11	83.97	30.20
DP543B2R	1184.7	0.3861	3068.6	4.20	1.15	82.60	32.03
FM991B2R	1018.0	0.3725	2733.0	4.03	1.20	83.80	34.43
Agent	Jim Crawford						
Grower	Robbie Brett						
Planted	13-May-05						
Harvested	21-Oct-05						

TERRELL CO - Irrigated							
	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
ST5242BR	1239.9	0.3806	3257.7	3.93	1.08	82.67	28.53
FM960B2R	1239.6	0.3567	3475.4	3.67	1.17	81.93	32.53
DPX648DR	1233.4	0.3874	3183.5	3.73	1.12	80.50	29.70
PHY480WR	1232.9	0.3535	3487.6	3.80	1.16	83.83	28.93
DP454BR	1212.4	0.3894	3113.0	3.40	1.12	81.93	28.90
DP555BR	1202.7	0.4002	3005.3	3.67	1.12	80.53	29.67
PHY470WR	1199.1	0.3627	3306.1	3.67	1.11	83.40	28.30
DP543B2R	1183.2	0.3622	3266.7	3.50	1.15	81.30	30.53
FM960BR	1161.9	0.3628	3202.5	3.83	1.10	82.80	32.43
DP488BR	1127.6	0.3795	2970.9	3.73	1.16	82.30	30.57
DP455BR	1070.9	0.3754	2852.5	3.33	1.12	81.40	29.50
ST4646B2	1067.5	0.3567	2992.5	3.73	1.08	81.93	27.90
DP424B2R	1050.9	0.3247	3236.9	3.50	1.09	82.30	26.50
DP449BR	1043.3	0.3669	2843.1	3.80	1.11	82.00	28.90
DP445BR	1030.3	0.3545	2906.4	3.33	1.08	81.43	29.43
FM991BR	984.4	0.3516	2800.0	3.63	1.11	82.30	32.00
ST6636BR	930.5	0.3395	2740.4	3.57	1.11	82.53	29.93
Agent	Will Duffie						
Grower	Peavey Bros. Farms						
Planted	19-May-05						
Harvested	10-Nov-05						

BENHILL Co. - Dryland	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
DP455BR	477.9	0.3969	1204.1	4.17	1.10	82.63	28.60
ST5242BR	461.6	0.4002	1153.4	4.30	1.06	83.80	26.30
PHY470WR	449.7	0.3785	1188.0	4.43	1.08	84.53	28.43
DP555BR	446.4	0.4206	1061.4	4.27	1.06	81.30	27.37
ST6636BR	424.4	0.3528	1202.7	4.40	1.11	83.33	29.93
DP451BR	379.8	0.3512	1080.3	4.42	1.08	82.98	26.64
DP543B2R	366.1	0.3816	959.5	4.07	1.10	82.70	28.53
FM960BR	359.9	0.3820	942.0	4.03	1.09	83.30	33.53
DP454BR	351.8	0.4124	853.0	3.77	1.06	82.23	28.33
FM991BR	351.2	0.3653	961.3	4.53	1.09	82.87	32.03
DP488BR	334.7	0.3765	888.8	4.53	1.11	82.33	29.67
Agent	Scott Carlson						
Grower	Kyle and Kent Phillips						
Planted	2-Jun-05						
Harvested	2-Dec-05						

COLQUITT CO - Irrigated*	Lint/A	turnout%	seed cotton/A	Micronaire	Length	Uniformity	Strength
DP445BR	1459.7 a	0.3978 bc	3672.3 a	4.50 c	1.13 b	82.94 a	29.73 cde
DP454BR	1302.7 bcde	0.3944 c	3303.0 a	4.17 e	1.09 d	81.92 b	29.20 e
DP455BR	1389.0 ab	0.4013 b	3462.3 a	4.17 e	1.11 c	80.60 c	30.46 bcd
DP488BR	1279.5 bcdef	0.3771 d	3392.0 a	4.50 c	1.15 a	81.77 b	30.76 bc
DP543B2R	1169.6 f	0.3605 f	3246.7 a	4.53 c	1.12 bc	81.52 b	30.68 bc
DP555BR	1353.6 abc	0.4100 a	3300.7 a	4.69 ab	1.09 d	80.50 c	29.60 de
FM960B2R	1173.4 ef	0.3632 ef	3237.0 a	4.64 b	1.13 b	81.73 b	32.43 a
FM960BR	1252.2 cdef	0.3682 e	3410.0 a	4.31 d	1.09 d	82.06 b	32.37 a
PHY470WR	1213.9 def	0.3665 ef	3312.0 a	4.44 c	1.10 d	82.64 a	28.89 e
ST6636BR	1342.2 abcd	0.3687 e	3640.3 a	4.77 a	1.13 b	82.87 a	31.10 b
Agent	Scott Brown and Glenn Beard						
Grower	Ronald Baker	*Trial replicated 3 times*					
Planted	29-Apr-05						
Harvested	28-Sep-05						

DEVELOPMENT OF TISSUE CULTURE AND TRANSFORMATION SYSTEMS FOR AN ELITE GEORGIA COTTON LINE (GOSSYPIUM HIRSUTUM L.)

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Peggy Ozias-Akins[2] and Peng W. Chee[1]
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Introduction

In cotton, the ability to produce embryogenic cells is genotype dependent with only a few genotypes known to be capable of regenerating plants from cell culture. Because of this limitation, most transgenic cultivars are produced by inserting the transgene into the highly embryogenic but obsolete cultivar and then introduced into the desired cultivars through backcrossing (Wilkins et al. 2000). Efficient cotton regeneration/transformation, particularly of commercially important cultivars, remains a major obstacle to cotton cultivar improvement by genetic transformation. The green fluorescent protein (GFP) from the jellyfish *Aequorea victoria* has been proven to be a convenient and powerful vital marker in transgenic plants studies. GFP visual selection system seems to hold the most promise for commercially important genotypes (cultivars and breeding materials), which tissue culture/transformation system that are inefficient or no system exist. The purpose of the present work was to investigate the regeneration ability in elite Georgia cottons and the suitability of GFP as a visual selecting system in particle bombardment transformation of these cotton lines.

Material and Methods

The eight elite Georgia germplasm lines tested were those developed by S. Baker, retired Univ. of Georgia cotton breeder, and lines bred by O.L. May (GA 161, GA 94894, GA 96199, GA 96211, GA 9654, GA 98015, GA 98033, and GA 98084). The seven Pee Dee lines (PD 97006, PD 97019, PD 97021, PD 97047, PD 97072, PD 97100, and PD 97101) from the USDA/ARS, Florence, SC, were bred by O.L. May in the late 1990s. Seeds of Coker 312, the standard cultivar for somatic embryogenesis, were obtained from Dr. K. Rajasekaran, USDA/ARS, New Orleans, LA, and included in the study as a positive control.

Seeds were surface sterilized and germinated on MS0 solid medium. Hypocotyl explants 5~7 mm in length were excised from 7 to 10 day-old seedling and grow in a callus induction medium (CIM). Four weeks later, friable callus was transferred into 125 ml jars containing embryo induction medium (liquid) (EIML), and shaken at 130 rpm under a 16/8 h light/day cycle at 28C for a period of 4 to 6 weeks. After 4 to 6 weeks, cell suspension cultures containing white embryogenic cells were placed on embryo development medium (EDM). Mature embryos and embryogenic callus formed in EDM after about one month culture. Vigorously growing, friable, loose and light yellow embryogenic calluses in EDM were transferred to CIM medium and pre-culture for two days before bombardment transformation.

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). Plasmid DNA was coated onto 1.0-μm gold particles (Bio-Rad) using the procedure of Sanford et al. (1990). Ten microliters of the suspension was loaded onto a macrocarrier for bombardment. Calluses were bombarded with the PDS-1000He Particle Delivery System (Bio-Rad) using 1,100/1350 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. The calluses were selected under the GFP light on the basis of fluorescence and transferred to fresh CIM medium every five days following bombardment, until homogenously fluorescing calluses were obtained. Plantlets were rooted, acclimatized and transferred to green house. Transgenic confirmation was based on visual GFP expression/selection under GFP light and PCR based molecular biological confirmation. PCR primers 5′-AAG GGC GAG GAG CTG TTC AC-3′ and 5′-TTC TGC TGG TAG TGG TCG GC-3′were designed according to GFP coding sequence, a 548-bp fragment from the open reading frame was expected to be amplified.

Results and Discussion

All genotypes tested produced callus on CIM medium within 2 to 4 weeks. The hypocotyl explants formed callus more readily than cotyledons. Not all seeds in an embryogenic line produce somatic embryos; specific individuals within a cultivar may be more embryogenic than others. In this experiment, Coker 312 showed a high frequency of embryogenesis and among the fifteen Georgia and Pee Dee lines, four of the genotypes PD 97019, PD 97021, PD 97100, and GA 98033 were found to be embryogenic (Sakhanokno et al. 2004). Seed-to-seed variability in embryogenic capability was observed and these could have originated during the cultivar development process where different F4 or F5 plants were bulked. The embryogenic cell lines from GA98033 were subcultured/selected for 6 months, and highly embryogenic cell lines have been selected. Regenerated plants were grown in green house to produce seeds for next generation.

Visual selection was performed 2 days after bombardment. Small pieces of callus with green fluorescence dots were selected and transferred to fresh CIM medium for callus proliferation. Early selection helps transformed cells to proliferate without disturbance by non-transformed surrounding cells. Second selection begins 5 days after first selection when there has been a considerable increase in the mass of the transformed callus. At this stage, it was relatively easy to excise green-fluorescing cells from the non-transformed calluses mass. Repeated selection to remove the green-fluorescing cells from the non-fluorescing ones was carried out at five-day intervals. Each round of selection produced a larger, more homogeneous mass of rapidly growing, fluorescing cells. Calli exhibiting homogeneous green fluorescence were obtained after approximately two months of repeated selection. The homogeneous fluorescing calli were transferred to embryo development medium (EDM) for somatic embryo formation. Fluorescent somatic embryos were regenerated from the selected fluorescent calluses in EDM after 30 days. Different development stages of embryos emitted different GFP intensity. GFP transgenic cells exhibit green color at early developmental stage. During the callus stage there is little difference in fluorescence in selected putatively transformed callus. When developed to globe-stage, the embryos have more fluorescence than calli nearby, while those from non-transformed calluses exhibit red color. The transformed calli express strong fluorescence even though the fluorescence of the germinated somatic embryos was less. As the regenerated plantlets grew over the next 2 months, they were potted to soil in the greenhouse. PCR amplification of selected GFP positive plants confirmed integration of the *gfp* gene in those plants that were regenerated from calluses transformed with the p254EGFP construct and selected by GFP fluorescence. All plant lines that showed green fluorescence were positive for GFP but those of the non-transformed lines were negative. A mean of 3.3/plate transgenic cell lines was recovered by using present method.

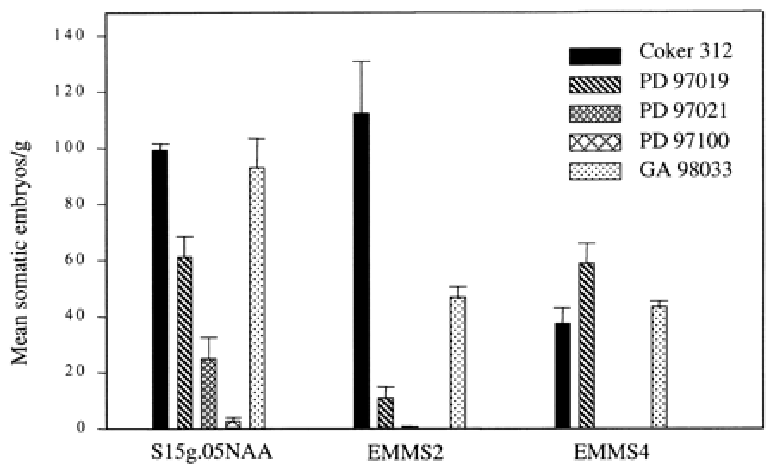

Figure1. Number of somatic embryos induced from calli of five cotton genotypes

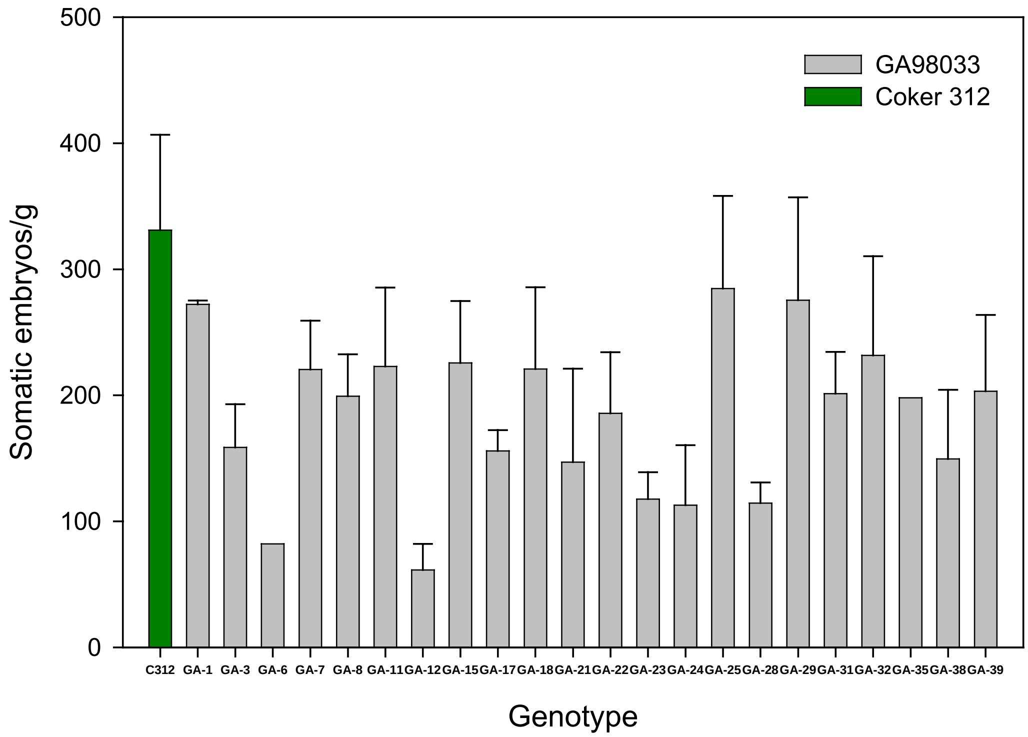

Figure 2. Improvement of somatic embryogenesis in GA98033

Table 1. Transformed cotton lines obtained from GFP visual selection

Experiment No.	No. of plates bombarded	GFP transient expression (2days)	GFP stable expression (7days)	Transformed line obtained
1	3	433.3±30.55	136±14.11	2.67±0.58
2	3	502.3±26.76	165.7±66.71	4±0
3	3	490±26.46	137±11.14	3.33±0.58

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PROGRESS TOWARD THE DEVELOPMENT OF TRANSGENIC COTTON CULTIVARS ADAPTED TO GEORGIA ENVIRONMENTS

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Material and Methods

Fifteen cultivars/germplasm lines were tested; eight elite Georgia germplasm cultivar/lines (GA 161, GA 94894, GA 96199, GA 96211, GA 9654, GA 98015, GA 98033, and GA 98084, developed by Shelby Baker or Lloyd May with the University of Georgia Cotton Breeding Program) and seven Pee Dee lines (PD 97006, PD 97019, PD 97021, PD 97047, PD 97072, PD 97100, and PD 97101 developed by Lloyd May while with the USDA/ARS in Florence, SC). Coker 312, the standard cultivar for somatic embryogenesis (seeds were obtained from Dr. K. Rajasekaran, USDA/ARS, New Orleans, LA) was included as a positive control.

Seeds were surface sterilized and germinated on MS0 solid medium. Hypocotyl explants 5~7 mm in length were excised from 7 to 10 day-old seedling and grown in a callus induction medium (CIM). Four weeks later, friable calli were transferred into 125 ml jars containing embryo induction medium (liquid), and shaken at 130 rpm under a 16/8 h light/day cycle at 28C for a period of 4 to 6 weeks. After 4 to 6 weeks, cell suspension cultures containing white embryogenic cells were placed on embryo development medium (EDM) (Sakhanokho et al., 2004). Mature embryos and embryogenic calli formed in EDM after about one month culture. Vigorously growing, friable, loose and light yellow embryogenic calli in EDM were transferred to medium and pre-cultured for two days before transformation by bombardment.

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All genotypes tested produced callus on CIM medium within 2 to 4 weeks. The hypocotyl explants formed callus more readily than cotyledons. Not all seeds in an embryogenic line produce somatic embryos; specific individuals within a cultivar may be more embryogenic than others. In this experiment, Coker 312 showed a high frequency of embryogenesis and, among the fifteen Georgia and Pee Dee lines, four of the genotypes; PD 97019, PD 97021, PD 97100, and GA 98033; were found to be embryogenic (Figure 1). Seed-to-seed variability in embryogenic capability was observed and these could have originated during the cultivar development process where different F4 or F5 plants were bulked. The embryogenic cell lines from GA98033 were subcultured/selected for 6 months and highly embryogenic cell lines were been selected (Figure 2). Regenerated plants were grown in a greenhouse to produce seeds for next generation.

Highly embryogenic cell lines from the above study were used as explants for GFP gene transfer via bombardment. GFP visual selection was performed 2 days after bombardment. Small pieces of callus with green fluorescence dots were selected and transferred to fresh CIM medium for callus proliferation. Early selection helps transformed cells to proliferate without disturbance by non-transformed surrounding cells. The second selection began 5 days after first selection to allow a desired, substantial increase in the mass of the transformed callus. At this stage, it was relatively easy to excise green-fluorescing cells from the non-transformed calluses mass. Repeated selection to remove the green-fluorescing cells from the non-fluorescing ones was carried out at five-day intervals. Each round of selection produced a larger, more homogeneous mass of rapidly growing, fluorescing cells. Calli exhibiting homogeneous green fluorescence were obtained after approximately two months of repeated selection. The homogeneous fluorescing calli were transferred to EDM for somatic embryo formation.

Fluorescent somatic embryos were regenerated from the selected fluorescent calli in EDM after 30 days. Different development stages of embryos emitted different GFP intensity. During the early stage, GFP transgenic cells exhibit green color. During the callus stage there is little difference in fluorescence in selected putatively transformed callus. When embryogenic cell developed to globe-stage, the embryos show a stronger fluorescence than nearby calli, while those from non-transformed calluses exhibit a red color. The transformed calli expressed a stronger fluorescence than the germinated somatic embryos did. As the regenerated plantlets grew over the next 2 months, they were potted in soil in the greenhouse. PCR amplification of selected GFP positive plants confirmed the presence of the *gfp* gene in those plants that were regenerated from calluses transformed with the p254EGFP construct and selected by GFP fluorescence. All plant lines that showed green fluorescence were positive for GFP but those of the non-transformed lines were negative. A mean of 3.3/plate transgenic cell lines was recovered (Table 1).

Future work will focus on continuing to increase the regeneration efficiency of GA98033 and transferring agronomically/economically important genes to GA98033.

Acknowledgements

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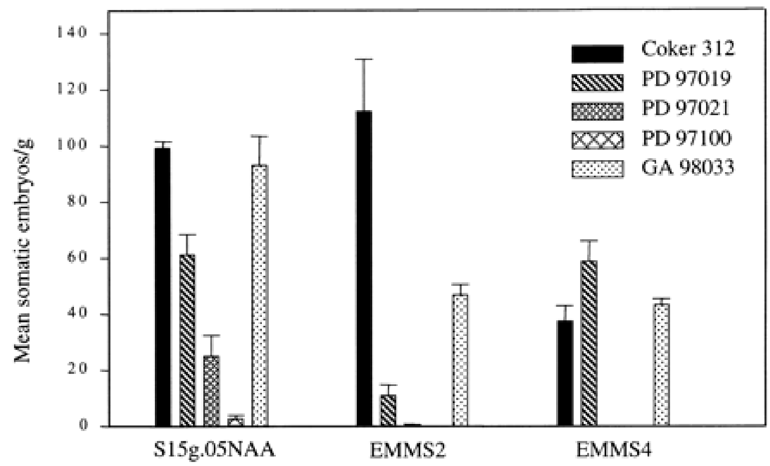

Figure1. Number of somatic embryos induced from calli of five cotton genotypes .

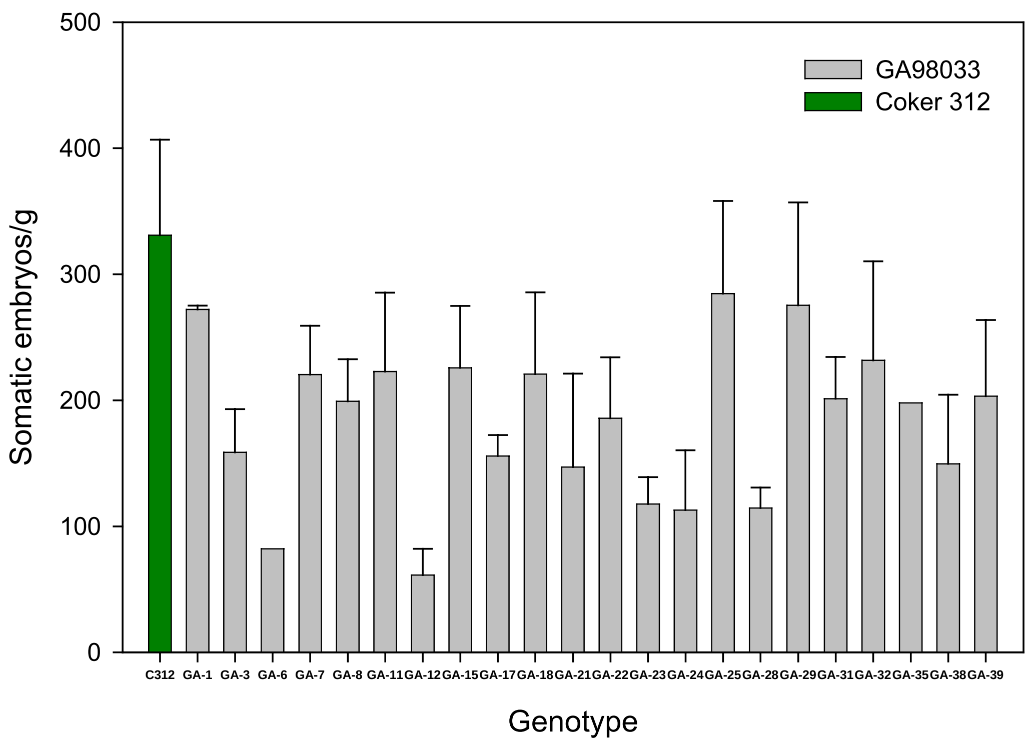

Figure 2. Improvement of somatic embryogenesis in GA98033

Table 1. Transformed cotton lines obtained from GFP visual selection

Experiment No.	No. of plates bombarded	GFP transient expression (2 days)	GFP stable expression (7 days)	Transformed lines obtained
1	3	433.3±30.55	136±14.11	2.67±0.58
2	3	502.3±26.76	165.7±66.71	4±0
3	3	490±26.46	137±11.14	3.33±0.58

BREEDING CULTIVARS AND GERMPLASM WITH ENHANCED YIELD AND QUALITY, 2004

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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 by Dr. Lloyd May toward meeting these goals during his last season (2004) leading the program. Dr. Peng Chee has been named the lead researcher of the Cotton Improvement Program with Dr. Ed Lubbers as Associate Cotton Breeder (Research Professional). Stephen Walker was retained as Senior Field Technician from Dr. May's personnel.

Materials and Methods

The general cotton breeding generation advance is as follows. Each year 50-60 F1 crosses are made and the seed sent to the USDA-ARS Cotton Winter Nursery in Mexico for selfing to the F2 generation. The annual crossing effort involves mating elite University of Georgia breeding lines with promising non-transgenic commercial cultivars and germplasm to produce sets of half-sib families. In 2004, 20 F2-bulk populations from such F1 crosses were evaluated for lint yield in 2-replicate, randomized complete block designs, with each set of half-sib F2 families and a check cultivar, DeltaPEARL, constituting a trial. Poor germination of the seed sent to the Cotton Winter Nursery precluded the evaluation of the full number of F2-bulk populations. Of the 50 F2-bulk populations we evaluated in 2003, 15 were advanced to F3 in 2004 for single plant selection. About 1300 single plants were selected in the 2004 F3 populations. F3 plants with lint fractions less than 39% are discarded and then further selected on the basis of HVI fiber properties. Some 1000 F3 plants selected in 2003 were advanced to F4 progeny rows in 2004 for evaluation in an un-replicated grid design, with every 5th row in the trial assigned to DP 491. The trial was machine harvested and the seed-cotton yield of each F4 progeny row was compared with the seed-cotton yield of the nearest row of DP 491. Based on the yield comparisons, about 435 F4 progenies were promoted for testing in the upcoming F5 preliminary yield trials. A separate, late-planted seed increase plot allows selection for plant type and hand harvest of seed-cotton to maintain genetic purity of each F5 generation experimental line. Replicated testing of the F5 breeding material was conducted at the William Gibbs Research Farm, near Tifton, GA (Preliminary Trials 1-6) and Southwest Georgia Branch Experiment Station, near Plains, GA (Preliminary Trials 7-19). The F6 material (Advanced Trials 1 & 2) were grown in both Tifton and Plains. The F7 material (Elite Trial) was grown in Tifton and Clarkdale, AR. These trials consisted of 20-25 experimental entries and two checks planted in three replicate, randomized complete block designs. The later generation material was also compared to DP 555 BG/RR; but this cannot be considered a check because it has a transgenic advantage that will confound the identification of any genetic improvement. Realistically however, it would be considered encouraging for any GA line that was not be significantly different from it. Prior to machine harvest of all trials except the F2 and F4 generations, 25 unweathered, open bolls from the middle of the fruiting zone was harvested from each plot, and were subsequently ginned on a 10-saw laboratory model gin to determine lint fraction. Fiber samples were submitted to the Cotton Incorporated Textile Services Laboratory for HVI analysis, while Official Variety Trial fiber was subjected to HVI analysis at a commercial testing laboratory.

Some advanced generation (F6 or later) germplasm lines with high potential were also tested in the 2004 University of Georgia Official Variety Trials (Day et al., 2004)

Results and Discussion

The 2004 Preliminary (F5) yield trials revealed a number of lines with lint yields exceeding those of the best check, DeltaPEARL with FiberMax FM 966 or FiberMax FM 958 (Tables 1-10). Of the lines with yields significantly exceeding the checks, several also had desirable fiber lengths, strengths, and micronaire readings: GA2004010 and GA2004020 (Table 1); GA2004055 (Table 3); GA2004089 (Table 4); GA2004108 (Table 5); GA2004142 and GA2004155 (Table 7); GA2004168 (Table 8); GA2004192, GA2004196, GA2004201, and GA2004206 (Table 9); GA2004232 and A2004236 (Table 11); GA2004284 and GA2004290 (Table 13); GA2004303 (Table 14); GA2004331 and GA2004340 (Table 15); GA2004352, GA2004353, GA2004356, and GA2004358 (Table 16); GA2004371 (Table 17); and GA2004416 and GA2004430 (Table 19). These lines will be advanced to the Advanced (F6) yield trials with additional high performers to fill 2 tests.

Results of the 2004 Advanced (F6 generation) yield trials of the 2003 series lines was tested in both Plains and Tifton, revealed genotype by environment interaction thus confounding clear selection of the best lines to be tested in the following year. A Bt transgenic cultivar, DP 555 BG/RR, was grown with the other, conventional lines but cannot be used as a comparison since the Bt character could be a major reason for its top yielding performance. Even with this advantage, six lines were found to be not significantly different in one or the other test location; GA2003006, GA2003018, GA2003071, GA2003117, GA2003123, and GA2003209 (Tables 11 and 12). None of the lines performed in the top echelon at both locations. Additional testing at different field sites will be required to properly select the lines with both performance and stability.

Unlike 2003, we conducted an Elite (F7 generation) yield trial in 2004 in Tifton, GA and Clarkdale, AR. We again saw evidence of genotype by environment interaction effects, but GA2002199 and GA2002027 were not significantly different in either location from DP 555 BG/RR with the transgenic advantage. These lines will be tested further.

GA2002211 and GA2002212 were the best performers overall of the GA lines in the Dryland and Irrigated Earlier Maturity Variety Trials (Day et al., 2004). The consistent performance over several years and high fiber quality of GA200035 and GA200036 will be further assessed in consideration for release as germplasm.

The up-dated citations for the two germplasm lines released last year, GA96-211 (May and Davis, 2004) and GA98028 (May, 2004), are provided. As expected (May et al, 2004a), GA98033 has also been released as a germplasm line (May et al., 2004b). As described in the Cotton Research and Extension Report 2003, GA98033 has a yield potential and fiber quality as good as or better than certain popular transgenic cultivars combined with an excellent capability of being regenerated from tissue culture. This embryogenic capability was discovered in the Cotton Molecular Breeding Laboratory under the leadership of Dr. Peng Chee.

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Table 1. Results of 2004 Preliminary (F5) Trials 1 and 2.

2004 PT-1 TIFTON							**2004 PT-2 TIFTON**						
ENTRY	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**	**ENTRY**	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004020	44.0	**1507**	1.15	85.0	32.6	4.9	GA2004040	43.7	**1356**	1.14	84.8	35.8	5.1
GA2004010	44.7	**1497**	1.17	85.1	31.6	4.8	GA2004030	41.0	**1337**	1.16	84.6	34.3	5.3
GA2004022	42.4	**1389**	1.16	85.3	33.9	5.3	GA2004046	44.3	**1331**	1.12	83.5	35.7	5.6
GA2004014	43.0	**1366**	1.06	83.5	36.2	5.1	FM966	41.7	**1322**	1.13	83.1	37.6	5.1
GA2004013	42.8	**1359**	1.16	84.8	32.5	5.0	DeltaPEARL	42.2	**1288**	1.17	84.8	35.3	5.3
GA2004016	43.9	**1337**	1.19	84.8	31.5	4.5	GA2004044	44.2	**1269**	1.13	84.5	34.6	4.9
GA2004023	41.9	**1327**	1.16	85.2	38.9	5.1	GA2004029	42.4	**1268**	1.13	85.0	34.1	5.1
GA2004019	43.4	**1308**	1.11	84.4	35.9	5.4	GA2004024	42.3	**1239**	1.10	83.7	35.1	5.1
GA2004021	43.8	**1308**	1.11	84.0	35.1	5.1	GA2004033	41.6	**1206**	1.15	83.6	35.3	5.2
GA2004018	44.3	1249	1.15	85.1	32.2	5.0	GA2004031	41.4	**1170**	1.11	84.1	36.5	5.1
GA2004004	43.7	1237	1.17	85.7	33.2	4.6	GA2004028	43.5	1133	1.12	84.3	36.0	5.2
DeltaPEARL	41.3	1210	1.14	83.5	35.7	5.2	GA2004043	44.3	1130	1.12	83.6	34.8	4.9
GA2004006	41.6	1206	1.14	85.0	35.3	5.1	GA2004045	40.1	1128	1.11	84.1	33.1	5.4
GA2004001	40.5	1180	1.19	85.6	33.6	4.7	GA2004038	42.5	1125	1.17	85.3	35.6	5.0
GA2004005	43.4	1168	1.16	84.6	35.9	4.8	GA2004026	40.3	1102	1.15	84.8	32.8	5.0
GA2004017	43.2	1103	1.11	84.0	33.3	5.3	GA2004036	41.6	1099	1.12	84.0	36.4	5.2
FM966	41.1	1102	1.12	84.3	38.8	4.9	GA2004034	41.5	1085	1.07	83.6	36.4	5.3
GA2004011	41.8	1098	1.13	84.5	37.2	5.2	GA2004037	40.2	1052	1.16	84.9	33.8	4.8
GA2004015	43.1	1091	1.12	84.4	37.5	5.2	GA2004025	39.5	1040	1.14	84.6	37.5	4.8
GA2004002	41.5	1076	1.09	83.2	38.2	5.1	GA2004027	40.9	1032	1.13	85.5	34.1	4.8
GA2004009	40.9	1042	1.15	84.7	33.9	5.0	GA2004035	42.1	1030	1.13	84.9	37.3	5.1
GA2004003	44.6	1019	1.15	84.3	36.3	5.1	GA2004039	41.1	1026	1.18	85.9	34.3	5.2
GA2004007	42.9	1010	1.10	84.1	34.3	5.2	GA2004041	42.4	1013	1.15	84.8	34.7	4.9
GA2004012	41.4	973	1.17	84.2	36.1	4.9	GA2004032	42.2	963	1.11	84.4	35.9	5.1
GA2004008	41.1	900	1.12	84.3	36.3	5.1	GA2004042	42.1	929	1.15	84.3	37.1	5.4
LSD0.10	**1.7**	**235**	**0.05**	**NS**	**2.7**	**0.2**	**LSD0.10**	**1.8**	**188**	**0.03**	**0.8**	**1.6**	**0.2**
TRIAL MEAN		1202					TRIAL MEAN		1147				

DeltaPEARL and FiberMax FM 966 are check varieties for comparison purposes.

Table 2. Results of 2004 Preliminary (F5) Trials 3 and 4.

2004 PT-3 TIFTON							**2004 PT-4 TIFTON**						
ENTRY	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**	**ENTRY**	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004055	43.4	**1442**	1.14	84.3	38.6	5.2	GA2004089	44.7	**1580**	1.20	85.4	34.3	4.8
GA2004059	44.3	**1415**	1.13	84.0	33.2	5.2	GA2004076	45.2	**1535**	1.14	84.1	33.3	5.3
GA2004054	41.5	**1346**	1.20	84.7	33.4	4.9	GA2004091	43.2	**1512**	1.09	83.2	35.5	5.5
DeltaPEARL	41.4	1306	1.15	84.5	36.4	5.2	GA2004079	42.7	**1501**	1.21	85.1	33.1	4.8
GA2004069	40.7	1279	1.22	85.2	37.3	5.0	GA2004084	42.5	**1496**	1.14	84.1	32.5	4.8
GA2004064	41.5	1238	1.18	84.6	37.9	4.8	GA2004085	44.9	**1494**	1.14	84.1	31.8	5.2
GA2004056	44.2	1231	1.14	84.6	35.5	5.1	GA2004083	44.4	**1488**	1.16	84.8	34.3	5.0
GA2004053	42.8	1227	1.18	84.8	35.6	4.8	GA2004088	44.0	**1470**	1.19	85.6	33.1	4.7
GA2004050	43.5	1226	1.14	84.0	37.6	5.1	DeltaPEARL	42.3	1454	1.16	84.5	34.0	5.0
GA2004067	42.1	1226	1.15	85.2	32.6	5.3	GA2004077	44.1	1454	1.16	85.5	34.3	5.3
GA2004051	41.6	1218	1.17	84.6	35.4	5.1	GA2004092	43.4	1408	1.13	84.2	36.4	5.1
GA2004052	41.7	1207	1.17	84.9	34.5	4.9	GA2004082	45.3	1396	1.12	84.0	34.0	5.3
GA2004049	41.8	1176	1.17	84.4	33.6	4.7	GA2004074	44.4	1394	1.18	84.7	33.5	4.8
FM966	42.4	1175	1.11	83.4	36.7	5.0	GA2004070	43.6	1393	1.16	84.4	35.5	4.9
GA2004066	42.0	1173	1.14	84.2	32.3	5.2	GA2004081	42.3	1383	1.18	85.4	34.0	4.8
GA2004048	42.4	1170	1.20	85.3	32.3	4.9	GA2004072	42.7	1368	1.16	84.6	34.5	4.9
GA2004057	41.8	1156	1.15	84.2	36.8	5.4	GA2004086	44.7	1355	1.13	83.7	37.8	5.1
GA2004047	42.8	1132	1.21	85.6	32.4	5.2	GA2004075	43.5	1341	1.12	84.4	35.7	4.8
GA2004065	42.3	1130	1.14	84.2	35.1	5.3	GA2004087	43.0	1332	1.16	84.6	33.4	4.8
GA2004058	41.7	1042	1.12	84.0	32.7	5.3	GA2004078	42.3	1324	1.15	84.8	36.5	5.0
GA2004061	41.0	1034	1.17	84.2	35.5	4.8	GA2004080	43.3	1295	1.16	84.6	29.9	4.7
GA2004060	40.5	1020	1.15	84.3	36.0	5.1	GA2004073	43.5	1209	1.16	84.7	33.6	5.1
GA2004068	43.4	995	1.12	83.6	36.0	5.3	GA2004071	41.0	1176	1.14	84.7	35.3	4.9
GA2004062	40.4	947	1.16	84.6	41.5	4.8	FM966	40.4	1023	1.12	84.1	37.5	4.9
GA2004063	39.6	943	1.09	83.4	35.4	5.2	GA2004090	39.7	878	1.21	85.9	35.7	4.9
LSD0.10	**1.5**	**112**	**0.05**	**NS**	**2.1**	**0.3**	**LSD0.10**	**1.1**	**125**	**0.04**	**NS**	**2.3**	**0.4**
TRIAL MEAN		1178					TRIAL MEAN		1370				

DeltaPEARL and FiberMax FM 966 are check varieties for comparison purposes.

Table 3. Results of 2004 Preliminary (F5) Trials 5 and 6.

2004 PT-5 TIFTON							2004 PT-6 TIFTON						
ENTRY	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC	ENTRY	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
GA2004108	44.8	**1630**	1.15	84.1	34.1	4.9	GA2004122	45.2	**1605**	1.18	83.3	30.5	4.8
GA2004109	45.2	**1549**	1.16	83.4	36.0	5.1	GA2004137	44.8	**1519**	1.16	83.9	32.8	4.9
GA2004100	43.5	1521	1.14	84.2	31.4	5.0	GA2004131	43.9	**1494**	1.16	83.7	30.9	4.7
GA2004106	44.4	1511	1.14	83.4	31.2	4.9	DeltaPEARL	42.5	**1492**	1.16	84.0	32.0	5.0
DeltaPEARL	42.4	1506	1.15	84.2	34.2	5.1	GA2004121	42.2	**1463**	1.19	85.4	32.8	4.8
GA2004094	42.7	1502	1.12	84.5	32.6	5.2	GA2004128	43.1	**1452**	1.15	83.9	33.0	5.1
GA2004110	44.8	1492	1.09	82.7	34.1	5.4	GA2004135	40.9	1386	1.21	85.5	33.3	5.1
GA2004113	44.2	1479	1.11	83.8	34.7	5.1	GA2004138	45.6	1382	1.16	84.1	31.2	5.3
GA2004093	44.7	1467	1.15	83.8	34.5	5.0	GA2004117	42.9	1365	1.18	85.5	31.3	4.8
GA2004104	45.3	1465	1.10	83.6	32.7	5.3	GA2004134	40.1	1339	1.19	84.7	29.7	4.8
GA2004111	43.9	1450	1.16	84.3	32.9	4.9	GA2004120	40.6	1339	1.18	84.7	31.5	5.1
GA2004105	43.9	1425	1.11	83.9	35.4	5.2	GA2004127	41.7	1320	1.11	84.1	33.5	5.1
GA2004096	44.7	1410	1.15	84.6	30.4	5.0	GA2004129	39.1	1316	1.17	85.7	31.8	4.9
GA2004103	42.9	1392	1.14	83.4	33.9	4.9	GA2004125	42.7	1297	1.16	84.3	33.7	4.9
GA2004095	44.7	1349	1.13	84.3	34.2	4.9	GA2004136	41.8	1292	1.15	85.2	31.2	5.2
GA2004098	43.1	1301	1.16	84.5	30.8	5.1	GA2004118	44.1	1282	1.20	85.7	33.4	4.8
GA2004114	42.2	1297	1.11	83.7	37.0	5.3	GA2004133	40.8	1242	1.12	83.7	32.9	4.7
FM966	43.5	1295	1.10	83.3	37.2	5.1	GA2004130	40.8	1191	1.15	84.6	32.0	4.9
GA2004115	42.5	1250	1.19	84.3	31.2	4.9	GA2004132	42.2	1188	1.18	84.7	36.6	4.8
GA2004101	42.6	1247	1.13	83.9	31.0	5.2	GA2004123	43.0	1178	1.15	84.7	30.7	5.3
GA2004099	44.0	1235	1.15	84.0	32.7	4.9	GA2004116	41.7	1176	1.16	84.1	31.5	4.7
GA2004102	42.6	1207	1.10	83.6	33.8	5.0	GA2004124	38.6	1101	1.14	85.2	32.0	4.5
GA2004107	44.7	1141	1.12	82.9	32.0	5.1	FM966	39.7	1099	1.16	84.7	35.6	5.0
GA2004097	44.1	1114	1.08	83.0	33.5	4.9	GA2004119	40.0	987	1.19	85.2	33.7	4.7
GA2004112	43.6	1051	1.13	84.1	31.5	5.1	GA2004126	42.5	755	1.16	83.7	31.1	5.1
LSD0.10	**1.6**	**99**	**0.04**	**NS**	**2.9**	**NS**	**LSD0.10**	**1.7**	**198**	**0.03**	**1.1**	**2.9**	**0.3**
TRIAL MEAN		1371					TRIAL MEAN		1290				

DeltaPEARL and FiberMax FM 966 are check varieties for comparison purposes.

Table 4. Results of 2004 Preliminary (F5) Trials 7 and 8.

2004 PT-7 PLAINS							**2004 PT-8 PLAINS**						
ENTRY	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**	**NAME**	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004142	43.9	**1406**	1.25	86.5	33.0	4.4	GA2004168	41.4	**1320**	1.24	85.3	31.8	4.5
GA2004155	44.0	**1331**	1.17	84.2	31.2	4.5	GA2004174	43.6	**1266**	1.21	84.9	33.7	4.7
GA2004160	41.0	1300	1.26	86.1	34.0	4.7	GA2004175	44.5	**1244**	1.20	84.3	31.9	4.6
GA2004143	42.8	1293	1.24	86.6	35.4	4.3	GA2004184	41.5	**1228**	1.23	85.1	34.1	4.6
GA2004153	42.4	1276	1.22	85.3	32.8	4.4	GA2004181	43.6	**1220**	1.21	84.6	31.6	4.8
GA2004147	41.5	1258	1.22	84.8	33.0	4.4	GA2004166	42.7	**1208**	1.20	85.1	34.2	4.6
GA2004152	41.3	1255	1.29	86.9	32.1	3.9	GA2004165	40.6	1186	1.21	85.1	35.1	4.2
GA2004156	44.1	1247	1.20	84.6	33.3	4.7	GA2004177	44.4	1177	1.19	84.6	33.6	4.4
GA2004145	41.4	1242	1.23	84.9	32.3	4.9	GA2004176	42.8	1173	1.24	85.0	33.3	4.3
GA2004139	43.5	1234	1.24	85.7	29.5	4.8	DeltaPEARL	40.7	1172	1.20	84.1	34.6	4.4
GA2004159	42.4	1222	1.22	85.4	34.9	4.6	GA2004162	41.5	1171	1.23	85.4	32.3	4.2
GA2004144	41.8	1221	1.22	84.2	32.6	4.3	FM958	40.9	1162	1.19	84.2	34.7	4.7
GA2004151	41.3	1207	1.18	84.2	31.9	4.4	GA2004180	42.6	1158	1.22	85.2	34.8	4.6
GA2004161	40.7	1202	1.27	86.1	31.3	4.3	GA2004179	42.9	1148	1.20	84.5	34.2	4.4
GA2004148	40.0	1172	1.24	85.4	32.8	4.7	GA2004167	42.6	1144	1.22	85.3	34.3	4.9
GA2004140	42.1	1159	1.26	85.5	32.7	4.2	GA2004163	42.0	1140	1.15	83.6	32.6	4.9
FM958	38.9	1147	1.20	84.9	36.1	4.4	GA2004169	43.3	1120	1.18	84.2	34.2	4.5
GA2004150	43.6	1141	1.21	84.7	30.3	4.2	GA2004178	42.0	1107	1.26	86.5	34.8	4.4
GA2004146	39.6	1120	1.23	84.7	32.8	4.8	GA2004171	42.1	1094	1.25	85.7	32.6	4.8
GA2004154	42.4	1088	1.23	85.6	33.9	4.5	GA2004182	41.5	1083	1.20	84.9	33.2	4.5
GA2004141	41.6	1055	1.22	84.9	31.2	4.9	GA2004164	40.2	1077	1.22	83.4	37.5	4.5
DeltaPEARL	38.3	1034	1.24	85.5	31.7	4.3	GA2004172	41.2	1072	1.23	84.7	32.0	4.5
GA2004157	43.2	1025	1.24	84.5	33.0	4.6	GA2004173	42.2	1048	1.19	84.3	34.2	4.7
GA2004149	41.7	1013	1.25	85.7	32.5	4.1	GA2004170	41.4	971	1.25	85.2	34.2	4.4
GA2004158	40.0	846	1.24	85.6	33.2	4.5	GA2004183	42.3	970	1.24	85.0	35.3	4.6
LSD0.10	**1.6**	**88**	**0.04**	**1.3**	**2.4**	**0.3**	**LSD0.10**	**2.0**	**115**	**0.03**	**NS**	**2.3**	**NS**
TRIAL MEAN		1180					TRIAL MEAN		1146				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 5. Results of 2004 Preliminary (F5) Trials 9 and 10.

2004 PT-9 PLAINS

NAME	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
GA2004196	41.0	**1211**	1.24	86	34.2	4.4
GA2004201	43.6	**1178**	1.21	85	36.2	4.7
GA2004192	43.0	**1172**	1.21	85	34.8	4.8
GA2004206	42.7	**1170**	1.24	85	33.1	4.6
GA2004207	41.6	**1129**	1.23	85	32.3	4.3
GA2004187	41.8	**1106**	1.25	85	32.7	4.3
GA2004205	40.9	**1097**	1.24	86	32.9	4.6
GA2004204	43.9	1086	1.20	85	33.5	4.6
GA2004199	40.5	1085	1.25	86	32.5	4.7
GA2004186	42.3	1053	1.26	86	30.9	4.3
GA2004190	41.5	1039	1.24	85	30.8	4.2
GA2004202	41.9	1039	1.24	86	32.3	4.0
FM958	40.5	1033	1.24	85	36.1	4.3
GA2004185	39.9	1013	1.29	86	32.0	4.2
GA2004193	41.8	1005	1.23	85	32.6	4.8
GA2004197	40.3	975	1.26	86	30.5	4.1
GA2004200	43.6	973	1.22	85	32.4	4.3
GA2004203	40.2	973	1.27	86	34.5	4.3
GA2004198	42.3	951	1.27	86	32.8	4.1
DeltaPEARL	38.5	947	1.25	85	32.4	4.2
GA2004195	39.7	940	1.27	87	34.9	4.5
GA2004188	40.6	913	1.26	86	34.0	4.3
GA2004189	40.4	892	1.24	85	32.6	4.0
GA2004191	41.0	846	1.26	86	30.7	3.9
GA2004194	39.1	780	1.24	86	30.6	4.1
LSD0.10	**1.6**	**120**	0.03	**NS**	**2.1**	**NS**
TRIAL MEAN		1024				

2004 PT-10 PLAINS

NAME	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
GA2004230	40.4	**1267**	1.28	86.9	34.2	4.3
GA2004217	42.0	**1218**	1.23	85.4	34.8	4.7
DeltaPEARL	39.6	1125	1.22	85.2	34.3	4.5
GA2004214	41.0	1107	1.27	85.7	32.7	4.5
GA2004216	39.8	1074	1.26	85.4	34.5	4.4
GA2004220	40.9	1058	1.28	86.3	33.9	4.5
GA2004219	40.9	1049	1.26	85.7	31.5	4.3
GA2004218	42.8	1047	1.23	84.8	32.8	4.5
GA2004223	39.7	1036	1.21	84.4	31.9	4.3
GA2004227	40.7	1030	1.24	85.0	32.6	4.2
FM958	39.6	1027	1.20	84.8	37.1	4.7
GA2004208	40.0	1012	1.28	86.9	36.4	4.6
GA2004225	40.6	1010	1.23	85.3	33.7	4.5
GA2004210	38.7	974	1.26	85.9	34.5	4.4
GA2004211	39.1	970	1.23	85.4	32.2	4.1
GA2004226	43.6	965	1.22	85.2	32.3	4.4
GA2004228	41.2	963	1.21	84.3	31.8	4.7
GA2004209	42.4	952	1.25	85.7	33.9	4.7
GA2004221	38.6	939	1.31	87.2	35.0	4.1
GA2004213	39.7	938	1.28	85.9	33.9	4.5
GA2004224	38.8	930	1.28	86.4	31.5	4.4
GA2004229	41.3	906	1.27	86.3	33.2	4.7
GA2004215	40.6	888	1.25	85.6	33.0	4.3
GA2004212	41.6	814	1.25	85.4	31.4	4.2
GA2004222	38.1	767	1.30	87.0	32.6	4.4
LSD0.10	**1.6**	**115**	**0.04**	**1.3**	**2.2**	**NS**
TRIAL MEAN		1003				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 6. Results of 2004 Preliminary (F5) Trials 11 and 12.

2004 PT-11 PLAINS							**2004 PT-12 PLAINS**						
NAME	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**	**NAME**	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004236	44.4	**1296**	1.19	84.1	31.1	4.6	GA2004263	44.2	**1330**	1.17	84.9	34.3	4.7
GA2004232	42.3	**1229**	1.19	84.6	34.6	4.6	GA2004268	42.0	**1309**	1.26	85.7	36.0	4.8
GA2004234	41.6	1175	1.24	85.8	34.8	4.6	GA2004269	40.5	**1277**	1.28	86.4	36.0	4.4
GA2004238	39.5	1149	1.22	85.3	32.7	4.7	GA2004256	43.2	**1265**	1.22	86.2	36.9	4.7
GA2004233	42.1	1126	1.20	85.1	33.8	4.7	FM958	40.8	**1242**	1.15	84.5	37.4	5.1
GA2004237	42.6	1120	1.14	84.0	34.0	5.2	DeltaPEARL	39.2	**1239**	1.22	85.0	34.1	4.7
FM958	40.5	1117	1.16	84.0	37.8	4.9	GA2004262	41.5	1223	1.28	86.7	35.9	4.2
GA2004251	41.4	1108	1.24	85.8	35.8	4.8	GA2004276	38.1	1222	1.16	84.6	36.6	5.0
GA2004250	41.2	1099	1.17	84.3	36.4	4.9	GA2004257	43.5	1214	1.21	85.2	34.5	4.8
GA2004231	41.9	1065	1.20	85.2	37.3	4.9	GA2004255	43.9	1214	1.21	85.7	34.0	4.2
PD94042	41.3	1062	1.17	84.6	33.8	4.8	GA2004272	40.8	1213	1.20	84.6	35.1	5.1
GA2004241	40.4	1044	1.26	86.5	34.3	4.6	GA2004254	38.9	1210	1.18	84.8	36.9	4.9
DeltaPEARL	39.5	1043	1.21	84.7	34.2	4.9	GA2004261	40.4	1199	1.19	84.9	35.8	4.7
GA2004244	40.9	1043	1.21	85.6	34.5	4.5	GA2004267	42.0	1192	1.18	84.9	35.8	4.8
GA2004247	41.6	1033	1.22	86.0	35.7	4.8	GA2004266	40.4	1172	1.28	86.7	36.6	4.5
GA2004235	43.0	1006	1.19	83.8	32.9	5.0	GA2004274	37.6	1169	1.18	85.3	35.7	5.5
GA2004242	43.0	1003	1.27	86.8	36.0	4.3	GA2004273	37.3	1161	1.20	85.6	36.0	4.8
GA2004252	39.9	999	1.19	85.4	35.7	4.8	GA2004275	38.9	1147	1.18	85.2	32.8	5.0
GA2004240	42.0	994	1.26	86.1	33.7	4.4	GA2004271	40.8	1144	1.18	84.6	32.5	4.8
GA2004246	38.9	987	1.20	85.4	33.2	5.0	GA2004260	40.3	1140	1.16	84.7	34.3	4.6
GA2004243	39.6	979	1.24	84.9	34.7	4.8	GA2004265	41.6	1134	1.23	85.1	34.9	4.6
GA2004245	41.0	975	1.20	85.4	35.5	4.4	GA2004258	40.7	1119	1.21	85.6	35.4	4.8
GA2004253	41.7	933	1.25	85.5	38.3	4.7	GA2004270	41.7	1095	1.29	86.5	35.8	4.3
GA2004239	40.8	859	1.21	85.3	34.6	4.6	GA2004259	39.7	1077	1.23	85.3	33.1	4.4
GA2004248	41.3	799	1.19	85.2	35.2	4.1	GA2004264	39.5	1071	1.21	85.3	36.0	4.5
LSD0.10	**1.2**	**91**	**0.04**	**1.1**	**1.6**	**0.4**	**LSD0.10**	**1.5**	**95**	**0.05**	**1.2**	**2.3**	**0.3**
TRIAL MEAN		1050					TRIAL MEAN		1191				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 7. Results of 2004 Preliminary (F5) Trials 13 and 14.

2004 PT-13 PLAINS							2004 PT-14 PLAINS						
NAME	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**	**NAME**	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004284	41.6	**1320**	1.20	84.9	32.6	4.7	GA2004303	42.3	**1385**	1.12	83.4	35.4	5.1
GA2004290	43.1	**1235**	1.17	84.5	33.9	5.1	GA2004313	40.1	1306	1.17	83.7	34.8	4.9
GA2004288	39.3	1209	1.14	84.7	34.8	5.4	GA2004314	37.7	1244	1.16	84.0	34.9	4.8
GA2004280	39.4	1182	1.19	85.5	36.7	5.4	GA2004317	38.5	1228	1.17	85.4	38.2	5.2
GA2004283	38.0	1176	1.16	85.1	34.0	5.1	GA2004305	38.9	1226	1.16	84.5	35.5	5.0
GA2004279	39.0	1175	1.18	84.8	33.6	4.5	GA2004315	40.3	1191	1.19	84.9	34.4	4.6
GA2004285	38.2	1173	1.18	85.5	34.6	4.8	GA2004316	38.0	1176	1.17	84.3	32.4	4.8
GA2004297	40.1	1157	1.23	85.5	34.8	4.3	DeltaPEARL	39.7	1173	1.21	85.2	33.3	4.7
GA2004298	39.4	1147	1.20	85.4	35.8	4.5	GA2004312	40.7	1155	1.20	85.5	33.9	4.4
GA2004294	38.2	1139	1.19	85.3	33.3	4.5	FM958	39.7	1154	1.18	85.2	36.0	4.9
GA2004292	40.3	1137	1.17	84.8	33.7	4.6	GA2004306	39.5	1138	1.18	83.9	34.5	4.7
GA2004281	37.8	1135	1.21	85.6	32.8	4.7	GA2004310	40.7	1136	1.13	83.2	33.5	5.2
GA2004299	37.7	1130	1.19	85.1	31.8	4.3	GA2004300	38.9	1134	1.16	84.8	33.5	4.7
GA2004296	39.2	1115	1.20	85.6	35.3	4.7	GA2004308	39.2	1123	1.19	83.8	34.2	4.6
GA2004289	37.9	1111	1.21	84.9	32.3	3.9	GA2004318	39.2	1116	1.16	83.8	33.8	4.9
GA2004291	40.3	1107	1.15	84.4	33.0	4.4	GA2004307	40.1	1114	1.14	84.3	33.6	4.7
GA2004295	39.7	1106	1.18	84.7	33.4	4.1	GA2004320	40.2	1097	1.12	83.1	35.7	4.8
GA2004278	38.8	1101	1.18	85.1	32.5	4.7	GA2004309	39.5	1093	1.19	84.3	35.7	4.8
GA2004286	39.2	1096	1.18	85.7	34.6	5.1	GA2004301	37.7	1088	1.21	84.1	33.8	5.0
DeltaPEARL	39.0	1069	1.21	85.5	34.1	4.4	GA2004302	39.6	1088	1.17	84.6	36.1	4.5
FM958	40.4	1057	1.22	85.6	34.3	4.1	GA2004304	38.7	1065	1.23	85.4	33.0	4.3
GA2004293	37.9	1002	1.18	83.6	31.5	4.2	GA2004322	37.9	1036	1.19	84.1	32.6	4.6
GA2004287	36.1	987	1.17	85.3	33.0	4.8	GA2004321	38.4	1027	1.15	84.0	32.5	4.5
GA2004282	39.9	986	1.19	85.5	34.0	5.2	GA2004319	39.5	1012	1.17	84.3	34.0	5.1
GA2004277	38.3	842	1.18	85.0	34.5	4.7	GA2004311	39.2	1003	1.16	84.0	36.5	4.7
LSD0.10	**2.0**	**100**	**0.03**	**0.8**	**1.3**	**0.4**	**LSD0.10**	**1.6**	**74**	**0.03**	**1.0**	**1.9**	**NS**
TRIAL MEAN		1116					TRIAL MEAN		1140				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 8. Results of 2004 Preliminary (F5) Trials 15 and 16.

2004 PT-15 PLAINS

NAME	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
GA2004331	43.4	**1453**	1.19	86.3	36.5	5.1
GA2004340	43.2	**1380**	1.18	84.5	33.6	4.7
GA2004329	41.1	1338	1.18	85.1	33.0	5.1
GA2004339	41.3	1338	1.17	85.0	32.8	5.0
GA2004334	41.3	1319	1.17	84.8	35.4	5.2
GA2004345	44.0	1311	1.19	84.7	34.0	4.8
GA2004338	42.0	1281	1.15	84.4	31.8	4.8
GA2004333	39.1	1266	1.18	85.0	35.2	5.2
GA2004341	40.7	1264	1.16	84.9	32.9	5.0
GA2004337	38.5	1251	1.15	84.8	35.7	5.6
DeltaPEARL	39.3	1218	1.22	85.4	34.0	4.5
GA2004342	41.2	1211	1.24	85.5	34.6	4.3
GA2004328	39.9	1210	1.17	85.3	34.1	5.2
GA2004327	42.1	1202	1.18	84.4	35.3	4.8
GA2004335	37.1	1201	1.20	86.0	33.9	4.5
GA2004326	40.9	1198	1.20	85.0	32.5	4.7
FM958	40.1	1194	1.20	84.4	35.8	4.5
GA2004324	41.3	1189	1.15	84.2	34.8	4.6
GA2004330	38.8	1130	1.17	85.8	35.7	5.2
GA2004325	37.9	1127	1.13	83.6	34.5	5.2
GA2004332	40.9	1121	1.16	84.2	34.9	4.5
GA2004343	38.0	1100	1.19	85.7	36.8	4.6
GA2004344	37.3	1092	1.22	85.5	33.7	4.6
GA2004336	39.9	1077	1.17	84.6	38.3	4.9
GA2004323	38.6	1042	1.16	85.0	34.6	4.6
LSD0.10	**1.0**	**79**	**0.03**	**1.0**	**2.2**	**0.4**
TRIAL MEAN		1220				

2004 PT-16 PLAINS

NAME	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
GA2004358	42.6	**1366**	1.24	85.8	34.1	4.4
GA2004352	42.4	**1329**	1.24	86.1	33.8	4.9
GA2004353	42.1	**1322**	1.21	85.8	33.5	4.7
GA2004356	41.9	**1298**	1.21	86.3	35.0	4.5
GA2004349	42.3	1278	1.26	86.6	32.0	4.5
GA2004357	41.6	1274	1.21	85.9	33.4	4.6
GA2004350	40.0	1264	1.21	85.4	33.7	4.6
GA2004366	39.0	1251	1.22	86.3	35.2	4.9
GA2004360	41.9	1248	1.15	84.6	33.1	5.0
GA2004351	40.9	1236	1.22	85.5	32.9	4.8
GA2004347	39.9	1219	1.18	85.0	34.9	4.5
GA2004363	41.1	1203	1.16	84.4	34.9	5.2
GA2004348	40.8	1202	1.19	85.9	35.3	4.7
GA2004355	37.6	1201	1.20	85.0	34.2	4.9
GA2004368	41.2	1168	1.21	85.5	34.1	4.7
GA2004361	41.6	1159	1.18	84.7	33.5	4.5
GA2004364	38.5	1158	1.20	85.5	32.5	4.8
GA2004362	41.1	1155	1.20	85.7	33.8	4.8
GA2004365	40.4	1155	1.19	85.4	33.4	5.5
GA2004346	39.4	1133	1.17	85.2	35.6	4.9
GA2004354	38.6	1105	1.21	85.4	34.5	4.8
DeltaPEARL	39.5	1087	1.23	85.1	33.3	4.3
FM958	39.7	1059	1.20	84.6	36.9	4.5
GA2004367	41.5	1043	1.20	84.4	33.3	4.7
GA2004359	37.8	1036	1.23	86.1	34.8	4.5
LSD0.10	**1.3**	**80**	**0.03**	**0.9**	**NS**	**0.4**
TRIAL MEAN		1198				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 9. Results of 2004 Preliminary (F5) Trials 17 and 18.

2004 PT-17							**2004 PT-18**						
NAME	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**	**NAME**	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004371	44.8	**1527**	1.20	85.3	30.3	4.6	GA2004413	40.0	**1198**	1.20	85.8	34.2	5.1
GA2004374	43.4	1406	1.20	85.9	32.4	4.6	GA2004392	39.0	**1180**	1.19	85.9	33.2	4.7
GA2004370	41.1	1259	1.23	86.4	32.6	4.3	DeltaPEARL	39.6	**1168**	1.22	85.7	34.9	4.6
GA2004389	40.6	1245	1.14	84.8	32.4	4.8	FM958	40.5	**1084**	1.17	85.1	37.7	4.8
GA2004373	42.7	1244	1.20	85.3	33.0	4.7	GA2004401	38.3	**1083**	1.17	84.8	35.8	5.0
GA2004369	43.4	1229	1.21	85.6	33.3	4.6	GA2004409	38.8	1066	1.18	85.5	37.0	4.6
GA2004376	38.2	1198	1.20	84.9	35.6	4.6	GA2004410	40.1	1043	1.19	85.4	36.6	5.3
GA2004384	38.0	1170	1.19	84.5	33.7	4.6	GA2004412	39.0	1039	1.17	84.3	32.6	5.0
GA2004390	39.7	1142	1.17	85.8	33.3	4.9	GA2004408	38.1	1033	1.23	86.2	35.5	5.0
GA2004391	39.4	1135	1.17	85.0	34.3	4.6	GA2004411	40.6	1032	1.21	86.0	37.7	4.9
FM958	40.3	1132	1.21	85.2	36.2	4.3	GA2004398	39.5	1022	1.19	85.0	35.2	4.2
GA2004386	37.4	1130	1.24	85.0	32.1	4.1	GA2004414	39.8	1016	1.17	84.7	34.7	4.9
GA2004382	37.6	1125	1.20	85.6	34.6	4.8	GA2004395	36.2	990	1.19	85.4	34.9	4.8
GA2004375	38.1	1118	1.19	85.0	32.0	4.5	GA2004396	37.0	988	1.23	85.9	35.4	4.5
GA2004377	39.0	1117	1.22	84.7	31.4	4.5	GA2004394	37.3	979	1.21	85.2	32.9	4.4
GA2004378	37.0	1115	1.21	85.5	34.3	4.6	GA2004402	38.3	978	1.18	84.7	34.7	4.8
GA2004372	42.5	1113	1.19	85.1	34.0	4.4	GA2004405	35.7	950	1.20	85.3	36.7	4.8
GA2004383	38.4	1107	1.22	85.9	32.0	4.6	GA2004400	37.7	949	1.22	86.2	34.2	4.4
GA2004387	39.1	1096	1.22	85.1	33.0	4.4	GA2004393	39.5	945	1.16	85.3	34.1	4.8
GA2004379	37.0	1077	1.21	85.6	36.7	4.9	GA2004397	37.6	935	1.20	85.6	34.6	4.7
GA2004380	38.9	1073	1.23	85.8	33.0	4.6	GA2004399	39.2	934	1.17	84.6	34.3	4.6
GA2004388	38.3	1060	1.18	85.4	37.2	4.8	GA2004403	39.0	923	1.23	86.6	34.8	4.8
GA2004381	38.1	1033	1.24	86.0	33.2	4.5	GA2004407	37.4	879	1.19	85.6	36.3	5.1
DeltaPEARL	39.8	1016	1.23	85.5	31.4	4.3	GA2004406	37.3	869	1.17	85.1	36.0	5.3
GA2004385	38.4	980	1.18	84.2	33.4	4.2	GA2004404	37.6	727	1.19	85.2	35.1	4.7
LSD0.10	**1.3**	**100**	**0.03**	**NS**	**2.3**	**0.2**	**LSD0.10**	**1.5**	**129**	**NS**	**NS**	**NS**	**0.4**
TRIAL MEAN		1154					TRIAL MEAN		1000				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 10. Results of 2004 Preliminary (F5) Trial 19.

2004 PT-19 PLAINS						
NAME	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2004416	39.8	**1413**	1.24	86.9	34.2	4.9
GA2004430	40.2	**1364**	1.21	86.0	32.9	4.6
GA2004419	39.1	1303	1.27	86.8	33.3	4.8
GA2004426	38.8	1273	1.25	86.9	36.4	4.7
GA2004425	38.8	1196	1.26	85.5	33.7	4.4
GA2004415	38.8	1195	1.28	87.0	36.1	4.6
GA2004421	38.9	1191	1.21	86.3	35.4	4.9
DeltaPEARL	39.0	1178	1.23	85.8	34.6	4.4
GA2004429	40.4	1166	1.23	85.6	34.5	4.5
GA2004420	38.2	1149	1.26	86.9	37.0	4.1
FM958	40.5	1095	1.21	85.3	35.7	4.7
GA2004427	38.2	1085	1.21	85.7	33.6	4.8
GA2004424	39.0	1078	1.26	86.6	33.3	4.4
GA2004423	38.0	1075	1.22	85.7	32.3	4.5
GA2004428	37.8	1057	1.25	87.3	38.1	4.9
GA2004434	42.1	1053	1.21	84.6	32.6	4.7
GA2004431	39.3	982	1.20	85.0	32.9	5.2
GA2004432	40.7	968	1.17	85.4	33.1	4.5
GA2004422	37.3	964	1.25	86.3	31.7	4.1
GA2004437	43.9	955	1.23	86.2	34.3	4.3
GA2004417	38.3	953	1.27	87.1	36.6	4.5
GA2004433	37.0	952	1.24	86.3	33.4	4.1
GA2004435	37.9	923	1.21	85.4	35.2	4.2
GA2004436	38.9	919	1.21	84.8	33.8	4.0
GA2004418	37.4	916	1.22	84.7	35.1	4.2
LSD0.10	**1.4**	**103**	**0.03**	**0.9**	**1.7**	**0.4**
TRIAL MEAN		1096				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 11. Results of 2004 Advanced (F6) Trial 1.

2004 AT-1 PLAINS							2004 AT-1 TIFTON						
ENTRY	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC	ENTRY	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
DP 555 BG/RR	41.1	**1229**	1.17	83.0	33.7	4.6	DP 555 BG/RR	45.7	**1649**	1.11	82.5	30.2	4.8
GA2003006	42.4	**1193**	1.18	84.9	36.5	5.0	GA2003018	43.6	**1599**	1.13	83.1	34.9	5.0
GA2003002	41.7	1101	1.21	85.3	35.6	4.7	GA2003071	42.1	**1587**	1.11	84.1	30.1	5.0
GA2003045	40.6	1100	1.16	84.5	35.3	4.6	GA2003047	42.3	1541	1.15	84.3	31.7	4.8
GA2003047	40.6	1093	1.18	84.2	34.7	4.8	GA2003030	45.0	1538	1.16	83.7	35.0	5.2
GA2003019	40.5	1069	1.22	85.4	35.8	4.6	GA2003064	44.4	1491	1.11	83.1	31.7	5.2
GA2003011	43.2	1064	1.21	85.1	35.6	5.0	GA2003009	43.7	1487	1.12	83.6	34.7	5.3
GA2003034	40.6	1062	1.20	85.7	38.8	4.8	GA2003002	43.2	1482	1.17	84.4	33.4	4.8
GA2003012	42.7	1050	1.19	84.0	33.8	4.5	GA2003006	44.4	1475	1.12	83.5	34.0	5.2
GA2003018	41.9	1044	1.19	84.8	35.7	4.6	DeltaPEARL	43.2	1474	1.15	82.6	31.4	4.9
FM 958	41.1	1039	1.17	84.6	37.4	4.9	GA2003020	42.8	1464	1.20	84.1	32.5	4.5
GA2003009	42.9	1037	1.18	85.2	39.0	4.9	GA2003044	43.3	1462	1.11	83.7	33.1	5.1
GA2003026	41.5	1019	1.20	85.5	38.1	4.5	GA2003053	43.6	1460	1.10	82.3	35.2	5.1
GA2003053	39.9	1004	1.16	83.6	36.8	4.5	GA2003019	42.3	1459	1.18	84.2	33.3	4.9
GA2003020	40.7	1003	1.22	85.7	37.1	4.6	GA2003026	45.2	1459	1.14	83.7	34.0	5.0
GA2003069	39.7	1003	1.18	85.1	34.7	4.7	GA2003011	45.4	1456	1.12	83.2	33.2	5.2
GA2003021	41.0	1001	1.20	84.4	35.1	4.6	GA2003034	42.9	1439	1.13	83.2	37.2	5.2
GA2003030	40.1	983	1.19	84.6	35.2	4.6	GA2003045	43.3	1436	1.10	83.2	32.3	4.9
GA2003005	40.4	980	1.25	86.0	35.1	4.7	GA2003004	44.1	1371	1.17	84.2	34.1	5.0
GA2003004	40.8	976	1.21	85.1	36.3	4.7	GA2003021	43.8	1366	1.13	83.5	32.7	4.9
GA2003044	40.4	974	1.17	84.8	36.9	4.8	GA2003012	44.2	1354	1.13	82.4	32.2	4.9
GA2003064	41.7	964	1.15	83.6	34.5	5.0	GA2003027	45.1	1344	1.15	84.0	35.3	4.8
DeltaPEARL	39.3	952	1.24	85.2	34.3	4.1	GA2003069	42.4	1339	1.12	83.3	31.9	4.9
GA2003036	38.8	947	1.16	84.4	33.1	4.6	GA2003036	41.9	1286	1.16	84.3	29.9	4.8
GA2003071	38.1	920	1.18	84.2	32.8	4.6	GA2003005	42.7	1256	1.18	83.9	31.7	4.8
GA2003027	42.0	892	1.18	84.7	37.7	4.6	FM 958	42.8	1185	1.14	84.0	36.5	5.0
LSD0.10	**1.4**	**122**	**0.04**	**1.2**	**2.4**	**NS**	**LSD0.10**	**1.6**	**101**	**0.04**	**0.7**	**1.4**	**0.2**
TRIAL MEAN		1027					TRIAL MEAN		1440				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 12. Results of 2004 Advanced (F6) Trial 2.

2004 AT-2 PLAINS							2004 AT-2 TIFTON						
ENTRY	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC	ENTRY	Lint %	Lint Yield	UHM IN	UI %	STR G/TEX	MIC
DP 555 BG/RR	40.7	**1301**	1.17	84.2	32.6	4.3	DP 555 BG/RR	44.4	**1588**	1.16	83.9	31.7	4.9
GA2003084	43.4	1140	1.19	85.2	36.7	5.2	GA2003123	45.0	**1501**	1.18	84.7	36.4	4.9
GA2003112	40.1	1133	1.27	87.1	38.0	5.0	GA2003209	43.6	**1491**	1.12	83.9	34.6	4.9
GA2003081	41.5	1110	1.20	85.5	33.7	4.8	GA2003117	43.7	**1479**	1.19	84.8	32.6	4.9
GA2003087	41.4	1105	1.15	84.6	32.1	4.8	GA2003126	42.4	1453	1.15	84.1	34.5	5.4
GA2003117	42.1	1084	1.24	86.1	35.3	4.7	GA2003105	42.6	1436	1.15	83.5	30.8	4.6
GA2003188	39.1	1082	1.14	83.7	37.5	4.5	GA2003087	45.0	1433	1.10	83.9	29.4	5.1
GA2003190	40.2	1080	1.18	85.4	39.1	4.9	GA2003100	42.3	1431	1.18	83.9	33.2	4.9
GA2003124	40.6	1067	1.24	85.8	35.3	4.6	GA2003112	42.5	1427	1.21	85.9	34.4	4.9
GA2003229	40.4	1044	1.19	85.2	39.6	4.3	GA2003084	45.5	1404	1.11	83.0	32.3	5.1
FM 958	40.4	1042	1.19	85.3	36.7	4.8	GA2003221	41.2	1389	1.22	85.5	37.2	4.8
NX2429	38.1	1042	1.17	85.3	35.8	4.9	GA2003127	44.3	1337	1.18	84.3	34.7	4.7
GA2003209	39.3	1035	1.18	84.4	36.1	4.4	GA2003135	42.6	1318	1.12	83.4	33.2	4.9
GA2003127	39.8	1033	1.23	85.7	38.0	4.6	GA2003081	41.9	1309	1.16	84.6	32.1	4.8
GA2003125	42.6	1023	1.20	84.8	35.9	4.6	GA2003211	41.7	1308	1.17	84.6	35.6	4.8
GA2003123	41.1	1019	1.24	86.0	35.2	4.8	GA2003227	41.6	1307	1.12	83.6	35.4	5.0
GA2003211	38.6	1011	1.20	85.0	40.5	4.6	NX2429	41.9	1300	1.13	84.0	32.1	5.0
GA2003100	39.8	986	1.23	86.4	37.0	4.8	GA2003219	41.6	1284	1.16	83.7	37.7	5.2
GA2003105	40.3	978	1.15	83.2	35.2	4.5	GA2003188	41.4	1282	1.14	84.2	35.7	4.9
GA2003219	40.8	976	1.22	85.2	39.4	4.4	GA2003190	42.1	1268	1.14	84.1	35.8	5.0
GA2003126	40.5	954	1.20	84.6	34.4	5.4	GA2003124	41.8	1265	1.22	85.2	33.0	4.6
GA2003176	38.7	935	1.26	86.1	34.8	4.3	GA2003229	43.2	1262	1.12	83.4	36.1	4.8
GA2003135	38.9	927	1.14	84.4	38.6	4.7	GA2003125	44.6	1248	1.16	84.5	34.6	5.0
DeltaPEARL	39.0	914	1.22	84.9	32.9	4.6	GA2003226	41.4	1233	1.16	83.9	34.8	4.8
GA2003226	39.0	907	1.21	84.8	38.9	4.7	GA2003176	41.2	1207	1.18	84.9	33.5	4.7
GA2003227	38.4	893	1.21	85.7	37.4	4.4	DeltaPEARL	41.9	1155	1.19	84.5	33.5	4.8
GA2003221	37.2	847	1.24	85.3	38.6	4.5	FM 958	42.3	1153	1.14	83.4	34.1	4.8
LSD0.10	**1.9**	**124**	**0.03**	**1.1**	**2.4**	**0.3**	**LSD0.10**	**2.0**	**117**	**0.04**	**1.1**	**2.8**	**0.3**
TRIAL MEAN		**1024**					**TRIAL MEAN**		**1343**				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 13. Results of 2004 Elite (F7) Trial.

2004 ELITE TRIAL - TIFTON						
ENTRY	**Lint %**	**Lint Yield**	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
DP 555 BG/RR	40	**966**	1.18	84.2	32.6	4.2
FM 966	37	**915**	1.23	85.7	37.1	4.5
GA2002207	42	**865**	1.22	85.5	32.6	4.5
GA2002199	41	**858**	1.18	84.7	35.4	4.9
GA2002125	40.0	854	1.23	85.3	34.8	4.5
GA2002118	39.0	852	1.22	84.9	35.5	4.5
DeltaPEARL	37.1	848	1.23	85.9	34.0	4.4
GA2002168	39.3	843	1.17	83.3	33.1	4.7
GA2002113	40.0	830	1.24	85.4	34.8	4.3
GA2002230	40	765	1.21	85.3	32.3	4.6
GA2002193	38	718	1.19	84.2	34.6	4.4
GA2002223	39	714	1.21	84.3	33.6	4.4
GA2002224	38	711	1.19	84.0	33.7	4.4
GA2002209	39	709	1.17	84.8	32.9	4.5
GA2002081	36	693	1.15	83.4	31.5	4.4
GA2002052	36	687	1.16	84.4	34.4	4.7
GA2002232	38	687	1.20	85.1	33.2	4.5
GA2002105	35	679	1.19	84.5	32.2	4.4
GA2002170	37	679	1.20	84.4	35.1	4.5
GA2002219	41	649	1.15	84.5	33.2	4.7
GA2002221	38	636	1.18	83.9	31.4	4.4
GA2002208	36	635	1.20	84.3	33.6	4.5
GA2002004	34	613	1.13	83.7	35.5	4.3
GA2002215	38	604	1.21	85.0	32.4	4.4
LSD0.10	**2.2**	**108**	**0.03**	**1.1**	**1.6**	**NS**
TRIAL MEAN		**750**				

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

Table 14. Results of 2004 Elite (F7) Trial.

2004 ELITE TRIAL - CLARKDALE, ARKANSAS														
ENTRY	**Lint Yield**	$r^{\dagger}$	**Lint %**	$r^{\dagger}$	**Ht cm**	$r^{\dagger}$	**Vert. %**	$r^{\dagger}$	**Open Bolls %**	$r^{\dagger}$	**UHM IN**	**UI %**	**STR G/TEX**	**MIC**
GA2002199	**1571**	1	44	5	98	9	42	13	63	5	1.15	86.2	33.8	4.7
GA2002209	**1568**	2	44	3	98	9	42	13	70	1	1.16	85.2	33.8	4.5
DP 555 BG/RR	**1557**	3	44	8	96	16	33	24	45	23	1.18	85.1	31.1	4.3
GA2002224	**1532**	4	42	17	103	3	45	7	60	9	1.16	84.5	31.9	4.6
GA2002207	**1526**	5	44	2	98	12	40	18	50	19	1.20	86.1	33.3	4.3
GA2002219	**1520**	6	44	4	105	2	52	3	67	4	1.13	84.6	33.7	4.5
GA2002223	**1518**	7	43	10	97	13	52	3	70	1	1.18	85.4	32.4	4.7
GA2002215	**1505**	8	43	12	102	6	47	5	58	11	1.16	85.0	32.0	4.5
GA2002125	**1480**	9	43	13	97	14	42	13	63	5	1.20	85.6	32.5	4.4
GA2002208	**1462**	10	44	6	94	19	45	7	60	9	1.22	86.3	33.2	4.9
GA2002193	**1441**	11	43	14	101	8	43	10	53	16	1.17	84.5	34.2	4.7
GA2002230	**1414**	12	43	11	94	18	40	18	58	11	1.20	85.5	31.0	4.8
GA2002232	1390	13	44	7	102	5	38	22	62	8	1.16	85.4	34.1	4.6
DeltaPEARL	1389	14	42	19	94	19	53	2	57	15	1.19	84.3	31.5	4.6
GA2002004	1371	15	39	24	109	1	47	5	53	16	1.19	85.5	33.7	4.4
GA2002118	1356	16	43	16	98	9	43	10	50	19	1.20	85.9	34.8	4.6
GA2002113	1323	17	43	15	96	15	40	18	58	11	1.23	86.1	33.9	4.3
GA2002052	1311	18	41	20	103	4	40	18	58	11	1.18	85.3	32.9	4.1
GA2002081	1292	19	40	22	89	24	42	13	53	16	1.22	86.3	34.5	4.4
GA2002168	1280	20	42	18	101	7	45	7	63	5	1.20	85.8	34.1	4.4
GA2002105	1252	21	41	21	93	22	43	10	50	19	1.22	86.2	35.0	4.3
GA2002170	1240	22	44	9	92	23	42	13	50	19	1.19	86.2	34.7	4.4
GA2002221	1179	23	44	1	96	16	60	1	68	3	1.19	85.9	31.7	4.3
FM 966	863	24	40	23	93	21	35	23	40	24	1.20	85.9	37.1	4.4
LSD0.10	**165**		**1.9**		**ns**		**ns**		**11**		**0.03**	**ns**	**2.2**	**ns**
TRIAL MEAN	**1389**		**42.6**		**98**		**44**		**58**		**1.18**	**85.5**	**33.3**	**4.5**
CV (%)	8.7		2.6		10.7		25.9		14.0		1.6	0.9	3.9	4.9

$r^{\dagger}$ - ranking of trait in the column to the immediate left.

DeltaPEARL and FiberMax FM 958 are check varieties for comparison purposes.

BREEDING CULTIVARS AND GERMPLASM WITH ENHANCED YIELD AND QUALITY, 2005

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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 2005 season.

Materials and Methods

The F6 material (Advanced Trials 1 & 2) were conducted at the William Gibbs Research Farm, near Tifton, GA. These trials consisted of 20-25 experimental entries and two checks planted in three replicate, randomized complete block designs. The F7 material and later material was grown as part of the 2005 University of Georgia Official Variety Trials (Day et al., this volume). Prior to machine harvest of all trials, 25 unweathered, open bolls from the middle of the fruiting zone was harvested from each plot, and were subsequently ginned on a 10-saw laboratory model gin to determine lint fraction. Fiber samples were submitted to the Cotton Incorporated Textile Services Laboratory for HVI analysis, while Official Variety Trial fiber was subjected to HVI analysis at a commercial testing laboratory.

Results and Discussion

The hand off of the classical breeding component from Dr. May to Dr. Chee in the Spring of 2005 occurred at an inopportune time to insure that the field research was fully covered. Only the field work with the F6 and later generations was continued because of the resource conflicts and time constraints.

Field emergence of the 2005 Advanced (F6) yield trials (ATs) were very poor for some of the lines that were tested so additional commercial lines were used to replant the blank plots. The standard checks, DeltaPEARL and FiberMax FM 958, were planted at the first planting. The ATs revealed a number of promising lines with lint yields exceeding those of the checks (Table 1). Fiber quality measures were not returned in time for this publication, however, previous testing indicated that the fiber quality measures were acceptable. AT 1 was extremely variable with a CV of 31% which decreases our ability to properly select the true winners in the test; a CV of around 10% is more desirable. None of the germplasm lines were significantly better than the best check and the trial will be repeated. AT 2 was a good test with a CV of 8% showing 6 germplasm lines that were significantly better than the best check; GA 2004232, GA 2004263, GA 2004303, GA 2004356, GA 2004371, and GA 2004392. These lines will be promoted to multi-location testing. In the 2004 preliminary yield trials (Lubbers et al., this volume), only 4 of these 6 winners in AT 2 performed significantly better than the checks. The other two (GA 2004263 and GA 2004392) did exceed the checks in 2004 but not significantly. They were simply selected as the best of their particular preliminary yield trial. Proper selection pressure during the breeding cycle needs to be considered so that the breeding program is efficient yet does not discard valuable lines.

GA2002209 and GA2003156 were consistently the best performers of the four GA lines in the Earlier Maturity Strains Trial (Day et al., this volume) and will be given additional testing for possible release as a germplasm line or cultivar. Further testing is needed for the five GA lines in the Later Maturity Strains Trial (Day et al., this volume) since their performance was inconsistent over the three testing locations (Midville, Plains, and Tifton).

GA2002167 was the most consistent performer overall of the GA lines in the Dryland and Irrigated Earlier Maturity Variety Trials (Day et al., this volume) with GA2003118 and GA2001078 leading the GA lines in the Dryland and Irrigated Later Maturity Variety Trials (Day et al., this volume). Of course, overall comparisons of the conventional GA lines with the transgenic commercial cultivars in the UGA Official Variety Trials should not be made since the relative performance is confounded by the presence of the Bt trait in most of the commercial cultivars.

Acknowledgments

The authors thank the Georgia Commodity Commission for Cotton for funding this research (Project Number 00-860GA CY 2003), Cotton Incorporated for providing HVI fiber analysis and seed production in Arizona under Core Funded Project 03-404, and Don Day, Larry Thompson, and staff for conducting the University of Georgia Official Variety Trials.

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Table 1. Results of 2005 Advanced (F6) Trials.

2005 AT 1 Tifton		
ENTRY	**Lint Yield**	**Lint Fraction**
FM 960 BR	**1065**	0.3675
DP 444 BR	**1061**	0.4060
GA 2004168	**1029**	0.4060
DP 555 BR	**961**	0.3875
GA 2004108	**958**	0.4245
GA 2004089	**957**	0.4175
FM 958	**945**	0.4015
GA 2004054	**933**	0.3715
DP 455 BR	**927**	0.4095
ST 4892 BR	**908**	0.4215
GA 2004155	**871**	0.4325
GA 2004088	**859**	0.4080
GA 2004142	**846**	0.4495
GA 2004055	**839**	0.4065
GA 2004174	**807**	0.4345
GA 2004030	713	0.3875
DP 491	711	0.3995
FM 958 LL	701	0.3800
GA 2004022	690	0.3920
ST 5599 BR	630	0.3760
GA 2004201	628	0.4340
GA 2004192	585	0.4355
GA 2004079	526	0.3650
DeltaPEARL	440	0.3975
LSD0.10	**345**	**0.0244**

2005 AT 2 Tifton		
ENTRY	**Lint Yield**	**Lint Fraction**
GA 2004263	**1764**	0.4615
GA 2004232	**1759**	0.4392
GA 2004303	**1727**	0.4254
GA 2004356	**1723**	0.4023
GA 2004392	**1643**	0.3975
GA 2004371	**1622**	0.4297
GA 2004284	1471	0.4350
GA 2004430	1463	0.4169
GA 2004413	1454	0.4246
GA 2004416	1389	0.4107
GA 2004230	1385	0.4194
GA 2004358	1379	0.4324
DeltaPEARL	1378	0.4195
DP 444 BR	1356	0.4127
GA 2004269	1250	0.4190
GA 2004268	1248	0.4209
FM 958	1244	0.4017
DP 455 BR	1220	0.4309
ST 4892 BR	1150	0.4020
DP 555 BR	1146	0.4082
ST 5599 BR	1091	0.3749
FM 960 BR	1089	0.3863
FM 958 LL	1045	0.3892
DP 491	907	0.4007
LSD0.10	**156**	**0.0152**

DeltaPEARL and FiberMax FM 958 are the chosen check varieties for comparison purposes.

PROGRESS TOWARD THE DEVELOPMENT OF AN UPLAND NEAR-ISOGENIC INTROGRESSION LINES CARRYING DIFFERENT PIMA CHROMOSOME SEGMENTS

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Introduction

Genetic diversity is required for breeding. One cannot select without traits or markers that differ. Continued breeding as well as the initial domestication inherently decreases available genetic diversity. Obviously we need to replace genetic diversity, but we need favorable diversity, not just any type of diversity. Mother Nature has given us a lot of alternate forms of genes but we have had centuries of selection that have eliminated most of them. We are now looking at an apparent yield and fiber quality plateau (W. Meredith, 2006) which some believe is caused by lack of diversity. We are also finding improved fiber quality necessary for the United States producer in the competitive, global cotton market.

To have the required diversity, we need to introduce new germplasm. Germplasm can be described as coming from gene pools depending generally on sexual compatibility and recombination. The primary gene pool for Upland cotton obviously includes the races of *Gossypium hirsutum*. *Gossypium barbadense, G. darwinii, G. mustelinum, and G. tomentosum* are also included here even though there are additional hindrances to introgression. The secondary gene pool includes the Gossypium diploids that can recombine once the sexual incompatibility is overcome and then those diploids that have reduced chromosome homology are in the tertiary gene pool.

The greatest hindrances in introgressing alleles from the related tetraploids are overwhelming allelic deluge and linkage drag. This is likely to be the greatest reason that breeders avoid using exotic germplasm. One method that has been suggested to overcome these problems is the AB-QTL (Advanced Backcross – Quantitative Trait Loci) analysis (Table 1). Using molecular markers to monitor QTLs may be a more effective technique to quickly remove the linkage drag as well as sifting out the desirable alleles despite the background noise caused by the environment.

Our objective is to develop a series of near-isogenic introgression lines (NIILs) by interspecific backcross of *G. barbadense* into Upland cotton using a modified AB-QTL. The intent is to cover the entire *G. barbadense* genome.

Materials and Methods

Our research uses Pima S-6, a *G. barbadense*, as the donor parent in an AB-QTL analysis. It is in the primary gene pool and is an excellent source of additional genetic diversity because it has high quality fiber and many available polymorphic markers. It is also domesticated, thereby giving some chance that there are fewer undesirable alleles. Direct use is inefficient because of hybrid breakdown, partial sterility, and later maturity than many Upland cultivars, but AB-QTL renders these specific difficulties less relevant.

We are using RFLPs (262 loci from a map with more than 2500 loci (Jiang et al., 2000)) to monitor the introgression of the Pima S-6 donor DNA into Tamcot 2111, the backcross parent. Three backcrosses were performed at which time the individual plants in the BC3F1 were genotyped and the BC3F2 families from those individuals were phenotyped (Fig. 1). Fiber quality phenotypes were measured in the first subset of this series to monitor the effects of the DNA segments (Chee et al., 2005a, b; Draye et al., 2005). QTL analyses via the analyses of variance is a secondary benefit in this research.

Results and Discussion

In the genotyping phase of the NIILs development (Fig. 2), we found three categories of NIILs: *group 1*) 37 lines were already NIILs, *group 2*) 491 lines, the bulk of the lines, are pre-NIILs that required further selfing and monitoring, and *group 3*) 68 lines that were required to be backcrossed again with further selfing and monitoring to provide at least 2 pre-NIILS each (for a total of more than 136 pre-NIILs). This totals to more than 664 NIILs from which we can select to cover the Pima S-6 genome. The NIILs in the field look very much like the recurrent parent, Tamcot 2111.

As we increased seed for the *group 1* NIILs, we took fiber quality data. With this data from three field plots grown in two years, a single factor ANOVA was performed with F-protected LSD mean separation. Micronaire (Mic) (Fig. 3), length as Upper Half Mean in inches (UHM) (Fig. 4), strength in grams/tex (STR) (Fig. 5), and % short fiber content (SFC%) (Fig. 6) all had significant differences between their respective fiber quality means. HVI Uniformity Index and HVI Elongation also followed this pattern (Figures not reported). The distribution of Mic and STR show the backcross parent, Tamcot 2111, in the center as would be expected (Figs. 3 and 5). Tamcot 2111 was found to be towards the shorter side of the distribution of length (Fig. 4) as we might expect since Pima S-6 is known for long staple. Tamcot 2111 was also found skewed toward greater SFC% (Fig. 6). Although this was not expected, it does show that we should easily be able to select for lint with less short fiber.

Our future work will include fine mapping of selected genomic regions that are associated with fiber quality traits as well as determining the performance of the QTLs of the NIILs under different genetic backgrounds along with stacking / pyramiding the QTLs to build better quality fiber.

All of the fiber quality traits showed genetic diversity that is available for introgression from these NIILs into elite cultivars. These NIILs are useful in that 1) they are a source of variation with less penalty of linkage drag, 2) they will have a more discrete segregation of the alleles within the genomic segment, and 3) they will allow fine mapping without the clutter of the original cross.

Acknowledgements

We acknowledge the financial support from the Georgia Agricultural Experiment Station, Cotton Incorporated, and USDA-IFAFS.

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Table 1. AB-QTL Analysis Summary (Tanksley & Nelson, 1996)

• Backcross to elite for BC1 and BC2 populations
– Can select at this stage against undesirable donor alleles using markers and/or phenotypes
• Molecular marker characterization at the BC2 or BC3 level.
• Generate BC3 or BC4 families
• Evaluate for agronomic performance and analyze for QTLs.
• Target valuable genomic regions
• Produce NILs with elite genetic background by employing MAS
• Evaluate the agronomic performance of the NILs and elite parent control in replicated environments

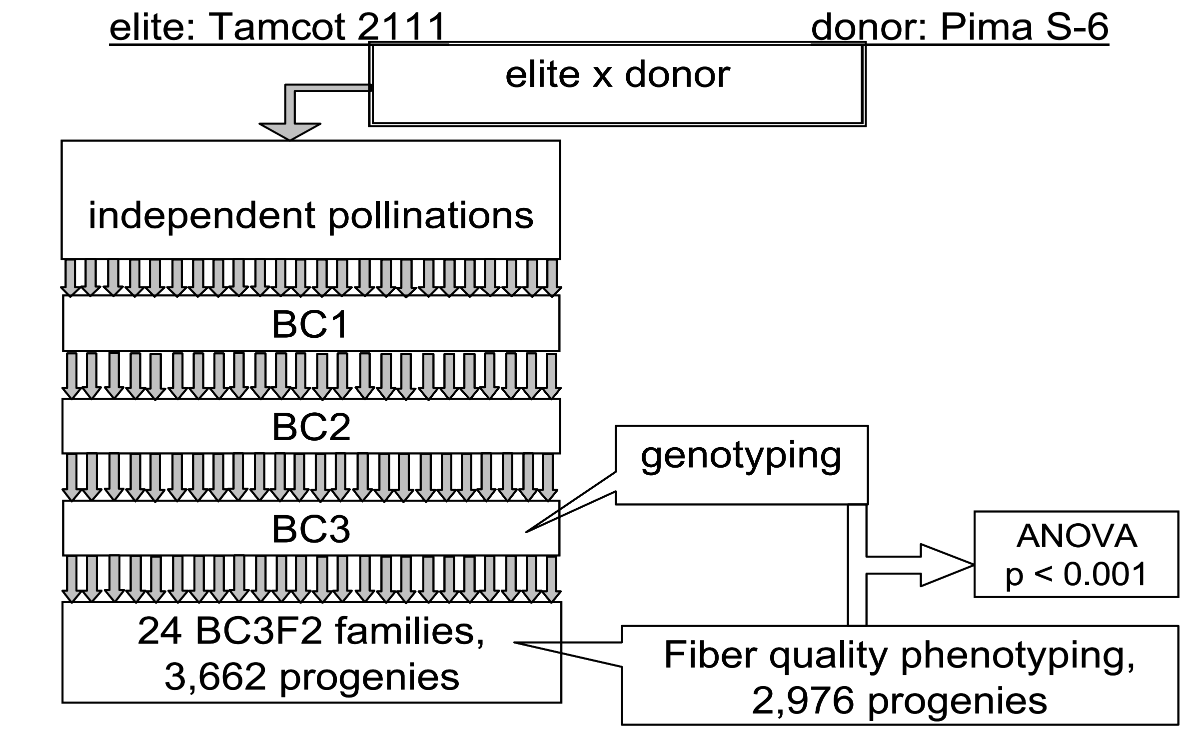

Fig. 1. The Methodology of the QTL Analysis

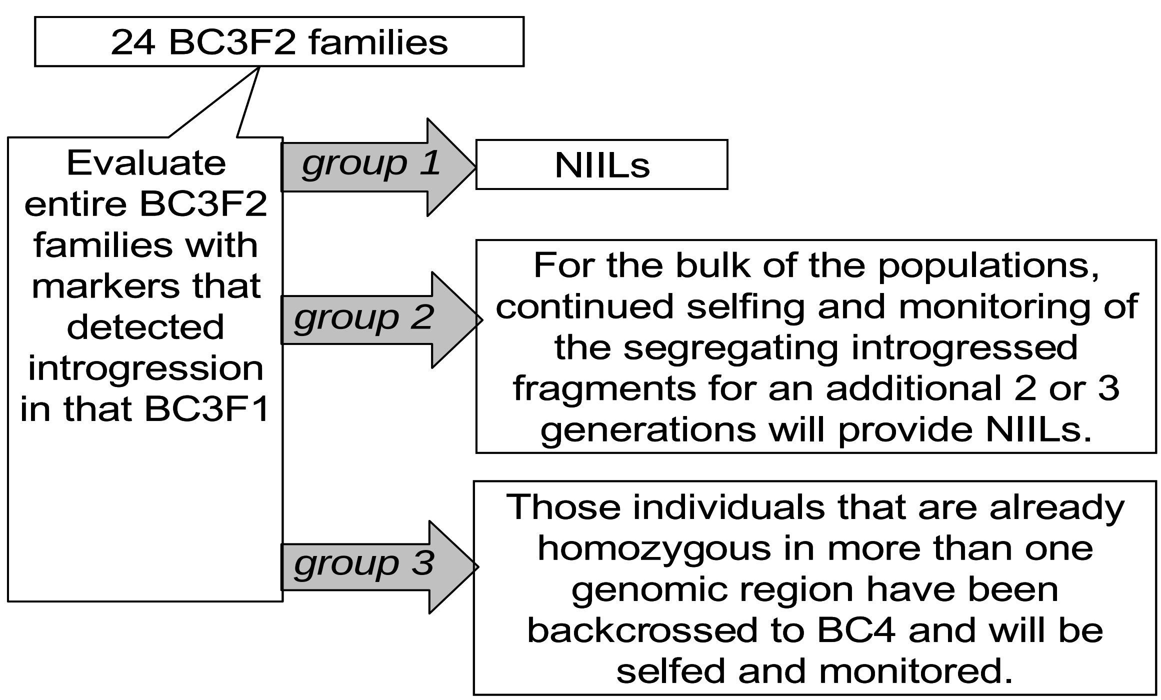

Fig. 2. The Methodology of the NIILs Development

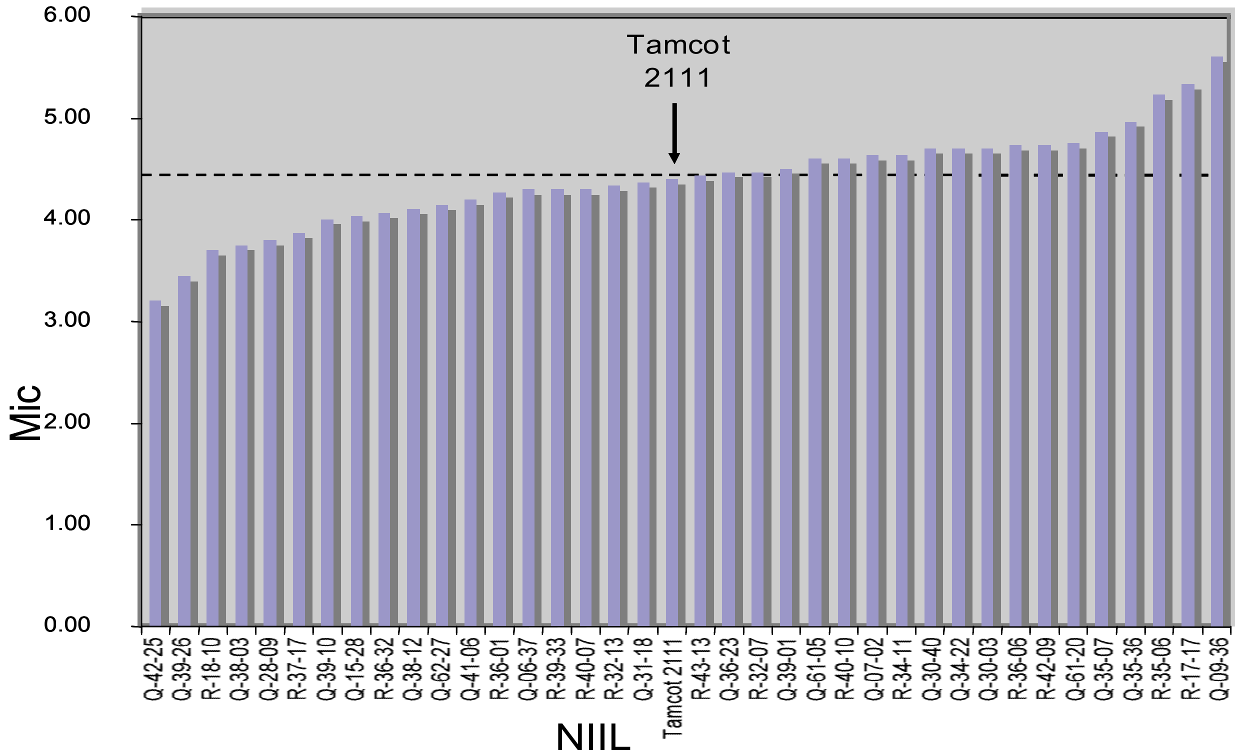

Fig. 3. The distribution of HVI micronaire of the *Group 1* NIILs

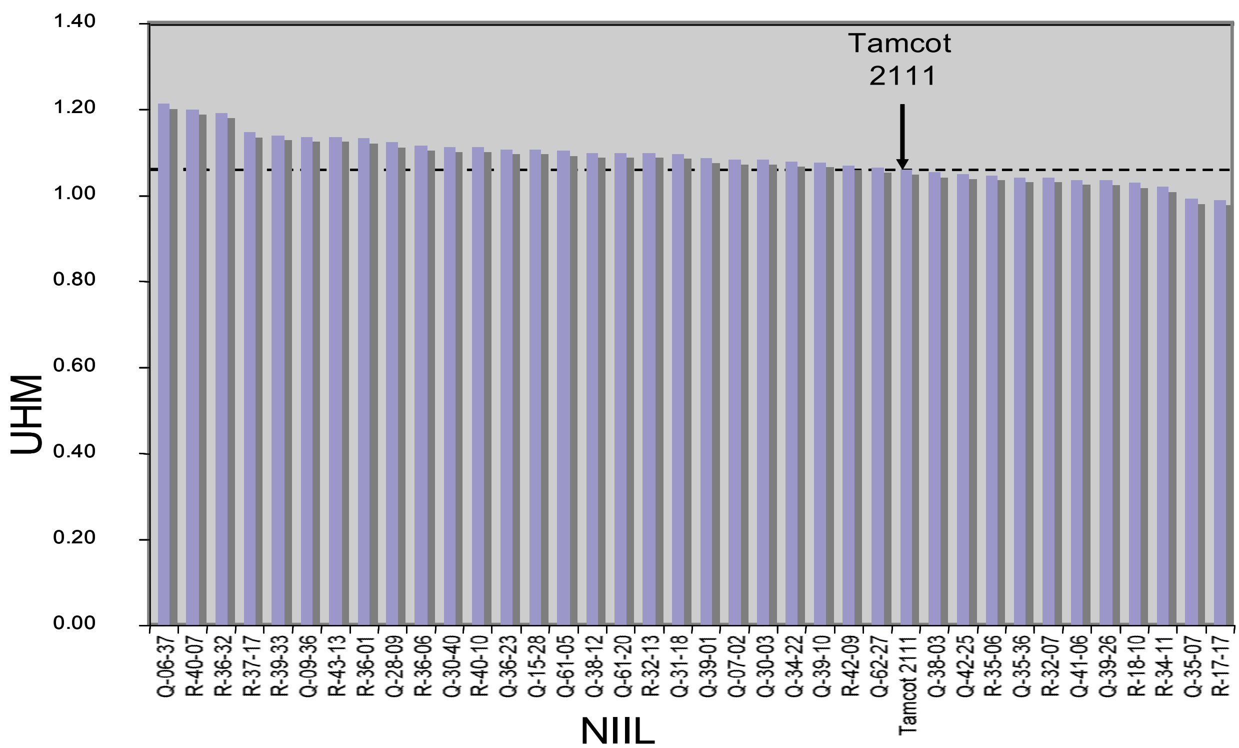

Fig. 4. The distribution of HVI UHM Length of the *Group 1* NIILs

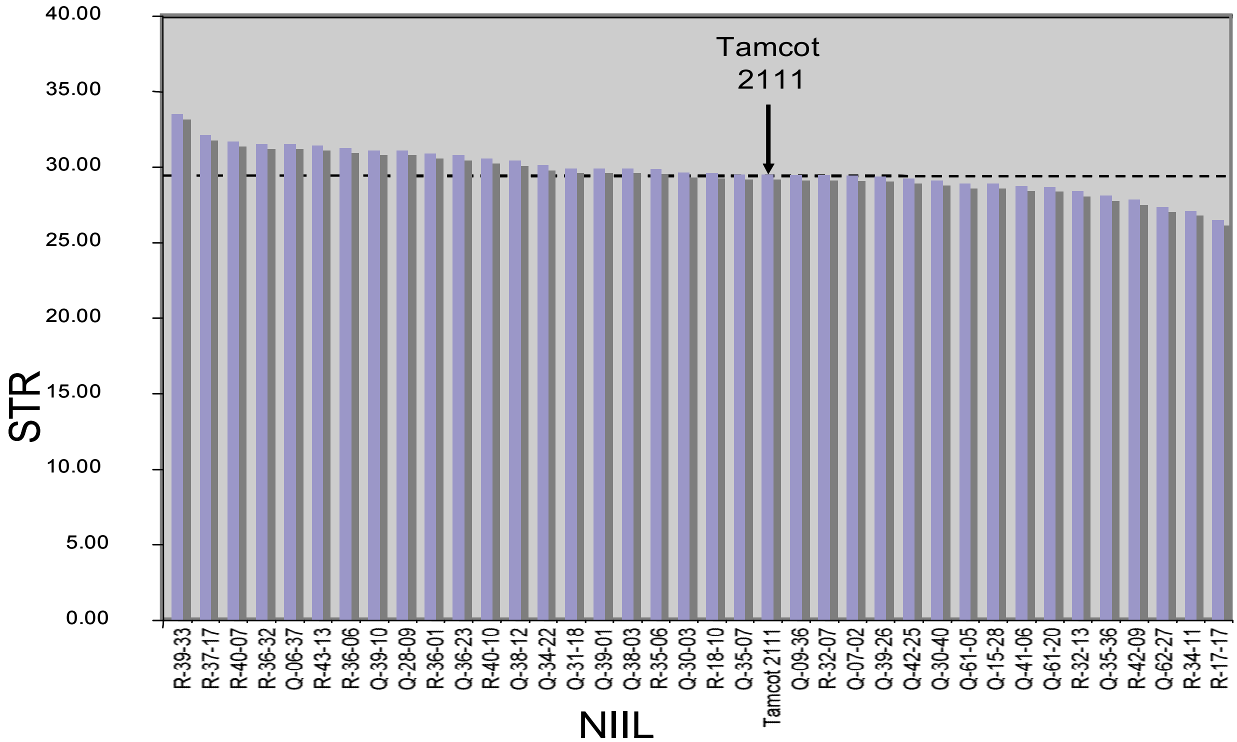

Fig. 5. The dist. of HVI Strength in g/tex of the *Group 1* NIILs

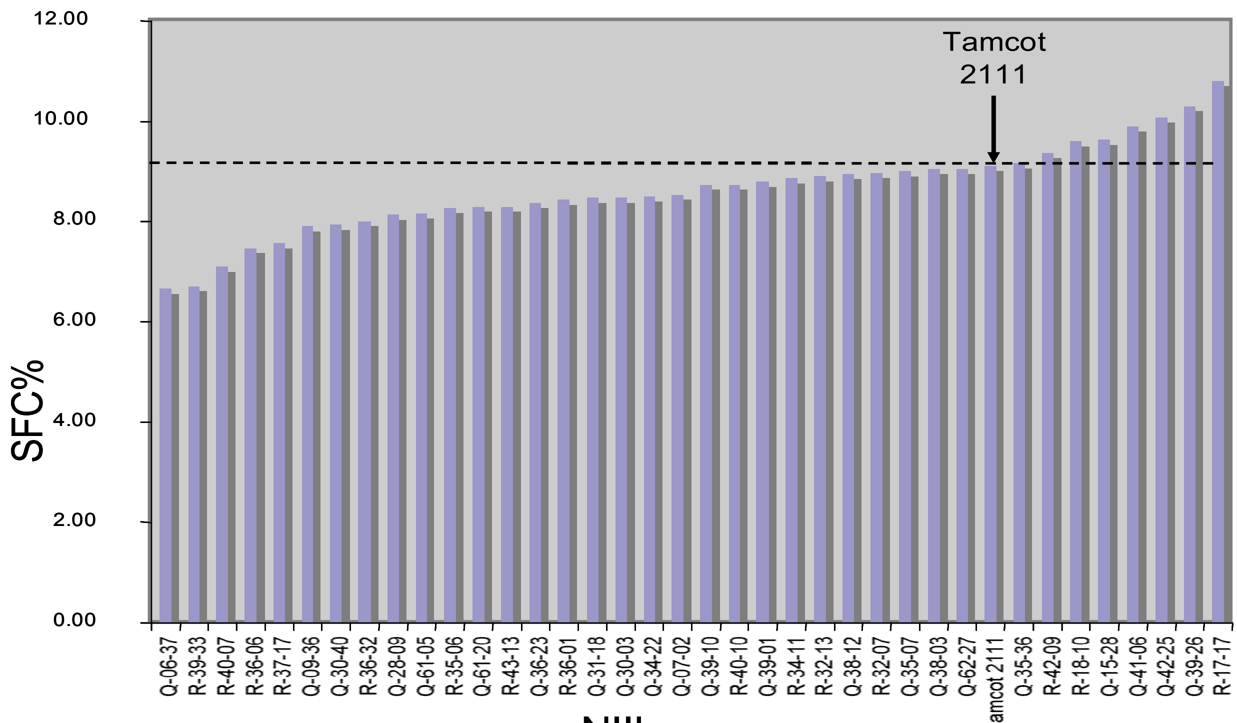

Fig. 6. The dist. of HVI % Short Fiber Content of the *Group 1* NIILs

TROPICAL SPIDERWORT WEED MANAGEMENT SYSTEMS IN ROUNDUP READY AND ROUNDUP READY FLEX COTTON

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Introduction

Tropical spiderwort is an invasive herbaceous perennial that grows as an annual in temperate climates (Holm et al. 1977) and has the ability to produce viable seed from both above and below ground flowers (Walker and Evenson 1985). It also has the ability to root and establish from cuttings created by cultivation. Since the introduction of Roundup Ready cotton in 1997, tropical spiderwort has fast become the most troublesome weed in several Southern counties in Georgia. In addition, tropical spiderwort poses a serious threat to agro-ecosystems of the Southern US due to recent changes in cultural practices and herbicide use patterns in our cropping systems. The objective of this experiment was to determine the most effective weed management system for control of tropical spiderwort program in Roundup Ready and Roundup Ready Flex cotton.

Materials and Methods

Cotton 'DP 555 BG/RR' was hill dropped on May 5th, 2005 with 3 seeds per 14 inch of row on 36 inch row spacing. Plots were 4 rows by 25 ft long and were prepared with conventional tillage practices. Weed management systems included six programs for Roundup Ready cotton and six programs for Roundup Ready Flex cotton, which will be commercialized in 2006.

In Roundup Ready cotton, systems included Prowl 3.3 EC (2 pt/A) preemergence followed by Roundup WeatherMax (22 oz/A) alone or mixed with Dual Magnum (8, 12, or 16 oz/A) applied overtop of 4-leaf cotton followed by a treatment precision directed to 10- to 12-leaf cotton (Table 1).

In Roundup Ready Flex cotton, systems included Roundup WeatherMax (16 oz/A) overtop of 1-leaf cotton and Roundup WeatherMax (22 oz/A) alone or mixed with Dual Magnum (8, 12, 16 oz/A) applied overtop of 6- to 8-leaf cotton and overtop of 10- to 12-leaf cotton (Table 2).

Tropical spiderwort was 1 inch, 1.5 inches, 3 inches, and 4 inches in height at the 1, 4, 6-8, and 10-12 leaf stages of cotton, respectively. Conditions throughout the growing season were ideal for postemergence weed control with lush spiderwort during times of Roundup WeatherMax application. Rainfall occurred within 28 hours of each Dual Magnum application for optimum herbicide activation.

Results and Discussion

In Roundup Ready cotton, Prowl 3.3 EC did not control tropical spiderwort (data not shown). At harvest, Roundup WeatherMax applied sequentially over the top of 4-leaf cotton and directed to 10- to 12-leaf cotton provided 56% control of tropical spiderwort (Table 1). Mixing Dual Magnum (16 oz/A) with Roundup WeatherMax at either the 4-leaf or the 10- to 12-leaf application improved control 29 to 31% at cotton harvest (Table 1). Sequential applications of Dual Magnum, regardless of rate, when mixed with Roundup WeatherMax and sprayed at the 4-leaf and 10- to 12-leaf timings were more effective, providing at least 95% control of tropical spiderwort at cotton harvest (Table 1).

Results in Roundup Ready Flex cotton were similar to those noted in Roundup Ready cotton. At harvest, applying Dual Magnum (16 oz/A) only once in mixture with Roundup WeatherMax at the 6- to 8-leaf or 10- to 12-leaf cotton stage was at least 20% more effective than three applications of Roundup WeatherMax applied alone to 1-leaf, 6- to 8-leaf, and 10- to 12-leaf cotton (Table 2). Systems with sequential Dual Magnum applications regardless of rate were the most effective herbicide programs, providing 96 to 97% control of tropical spiderwort at cotton harvest.

Conclusions

Sequential Dual Magnum applications should be used in Roundup Ready or Roundup Ready Flex cotton to manage tropical spiderwort. Dual Magnum only provides residual control and should be applied prior to tropical spiderwort emergence. The level of control observed in our treatments will only be achieved if tropical spiderwort is small and not stressed from environmental conditions and rainfall occurs within 48 hours of Dual Magnum application. Further testing is needed to determine if this control strategy will be successful in future growing seasons under periods of suboptimal growing conditions that places the tropical spiderwort plants under stress.

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Table 1. Tropical spiderwort control with Prowl 3.3 EC, Roundup WeatherMax, and Dual Magnum in Roundup Ready Cotton.

Herbicide Treatment					Tropical Spiderwort Control[a]				
Preemergence	Overtop of 4 leaf cotton		Directed to 10-12 leaf cotton		Days After Planting				
Prowl	Roundup WeatherMax	Dual Magnum	Roundup WeatherMax	Dual Magnum	35	61	83	116	147
pt/A	fl oz/A		fl oz/A		%				
2	22	—	22	—	44 c	56 c	50 d	49 c	56 c
2	22	16	22	—	99 a	97 a	90 b	83 b	85 b
2	22	—	22	16	72 b	76 b	82 c	84 b	87 b
2	22	8	22	8	99 a	99 a	99 a	94 a	96 a
2	22	12	22	12	99 a	99 a	98 a	95 a	95 a
2	22	16	22	16	99 a	100 a	98 a	96 a	96 a

[a] Means within a column followed by a common letter are not different according to Fisher's protected LSD test at P=0.05

Table 2. Tropical spiderwort control with Roundup WeatherMax and Dual Magnum in Roundup Ready Flex Cotton.

Herbicide Treatment					Tropical Spiderwort Control[a]				
1 leaf cotton	Overtop of 6-8 leaf cotton		Directed to 10-12 leaf cotton		Days After Planting				
Roundup WeatherMax	Roundup WeatherMax	Dual Magnum	Roundup WeatherMax	Dual Magnum	35	61	83	116	147
fl oz/A	fl oz/A		fl oz/A		%				
16	22	—	22	—	86 b	74 c	51 c	62 e	68 c
16	22	16	22	—	87 b	100 a	89 b	85 d	88 b
16	22	—	22	16	89 ab	86 b	96 ab	88 cd	89 b
16	22	8	22	8	89 ab	100 a	98 a	92 bc	96 a
16	22	12	22	12	96 a	100 a	99 a	96 ab	97 a
16	22	16	22	16	90 ab	100 a	99 a	98 a	97 a

[a] Means within a column followed by a common letter are not different according to Fisher's protected LSD test at P=0.05

DEVELOPMENT OF DIAGNOSTIC MARKERS FOR ROOT-KNOT NEMATODE RESISTANT GENES IN COTTON

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Introduction

Southern root-knot nematodes (*Meloidogyne incognita*; RKN) reduce profits from cotton producers through yield loss, due directly to RKN or indirectly due to other diseases associated with it such as seedling diseases and fusarium wilt (*Fusarium oxysporum*), and increased production cost by nematicide applications. Although nematicides are effective in controlling RKN, they do not provide season-long protection. Also, the future availability of nematicides is uncertain due to environmental concerns. Further, in fields below threshold levels of RKN, small yield losses not justifying cost of nematicide application can occur. With costs of cotton production increasing and prices of fiber at a historical low, any loss of yield can be considered economically significant.

The development and use of cultivars with resistance to RKN offers the best management tool for RKN. However, progress in developing RKN resistant cultivars has been slow because the current screening process to identify resistant genotypes is tedious, time consuming, and destructive. Molecular markers offer an alternative screening process for identifying resistant genotypes in breeding programs. The development of diagnostic markers for genes conditioning RKN resistance will accelerate the transfer of these genes among genotypes or germplasm for new cultivar development. The objective of this study is to develop diagnostic DNA markers for genes conditioning RKN resistance in cotton.

Materials and Methods

The RKN-resistant line M-120 RNR was crossed with Pima S-6, a susceptible *Gossypium barbadense* cotton line, to develop an F_2 population. The resistance of M-120 RNR comes from Auburn 623 RNR via Auburn 634 RNR, which was backcrossed to Coker 201 (Shepherd, 1982). Six plants of each parent, six F_1 plants, and 241 F_2 plants were inoculated with nematodes in a greenhouse. Variables measured were galling (rated on a 0-10 scale, where 0 = no galls and 10 = 91-100% galled), number of eggs extracted per root system, and eggs per gram of root. DNA extractions were obtained from F_2 plants. Approximately 200 restriction fragment length polymorphism (RFLP) markers were selected 20-25 centimorgans apart to cover the entire cotton genome. These markers were used to screen the 16 most resistant and 16 most susceptible F_2 plants. Regression analysis was utilized to test associations between the scores for RFLP markers and the phenotypic variables measured. The markers showing a significant ($P < 0.05$) association in this preliminary screening were used to screen the whole population in order to confirm the association.

Results and Discussion

As expected, M-120 had significantly lower galling, number of eggs, and eggs per gram of root than Pima S-6 (Table 1). The F_1 was highly resistant and was not significantly different from M-120 for any of the three variables, suggesting that one or more dominant genes are involved in the resistance to RKN. Coefficients of correlation among variables were calculated using the F_2 data. The correlation coefficients were significant, suggesting that the three variables measure similar genetic factors. Galling is the easiest and fastest way of measuring resistance to RKN. The phenotypic distribution of the F_2 plants for galling was skewed towards the resistant parent, suggesting that only few genes with dominant effects control RKN resistance.

We screened over 180 RFLP markers, covering all 13 chromosomes of the cotton genome. Statistical analyses performed using the extreme individuals detected seven putative chromosomal regions significantly associated with the resistant phenotype, suggesting that a resistant gene may be present in these regions, although random sampling or scoring errors can not be ruled out at this point. The markers that showed significant association in the preliminary screening were tested on the whole population to confirm the association. Two chromosome regions, chromosome LGA03 and chromosome 7, were significantly associated with the resistant phenotype.

The chromosome regions around the significant markers in LGA03 and Chromosome 7 were investigated in more detail by testing additional PCR-based DNA markers that are mapped to these regions. By searching various scientific publications, we identified 77 Simple Sequence Repeat markers (also commonly called SSRs) that target specifically to the two regions. They include 40 primers from CIRAD, France and 37 from the Brookhaven National Laboratory (BNL). PCR primers were synthesized from all these SSR sequences and tested on 186 F2 individuals where DNA was available.

Although more than half of the SSR markers showed genetic variation between the two mapping parents and therefore were useful for genetic linkage analysis, many were later determined to be mapped not to LGA03 or Chromosome 7. In total, we found only 8 SSRs mapped to LGA03 (Fig. 1) and 6 mapped to Chromosome 7 (Fig. 2). These SSRs were tested on whole population consisting of 186 F2 individuals. Statistical analysis to determine linkage was performed on a combined data set from SSRs and RFLPs (see Table 2 and 3). We have determined that the resistance gene on LGA03 is located near the end-point (telomere) of the linkage group, and the most likely position is between the SSR marker CIR316 and the RFLP marker pAR111. This resistance gene has turned out to be the major gene segregating in the mapping population. In addition, we have also identified another SSR marker linked to the resistance gene on Chromosome 7. However, this gene appears to have inherited from the susceptible Pima S6 parent. Further study is needed to determine if the gene from Chromosome 7 is authentic.

In summary, we have achieved our goal in identifying DNA markers linked to the genes that confer resistance to root-knot nematodes. Our next challenge would be to devise a strategy for which these DNA markers can be utilized in a breeding program to help accelerate the development of RKN-resistant cotton cultivars.

Acknowledgements

We thank the Georgia Cotton Commission (Project No. 05-654GA) and Cotton Incorporated Project No. 05-655) for financial support for this project.

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Table 1. Phenotype values for nematode resistance of F1, F2 and their parents.

Trait	Parents		F1	F2				
	Pima S-6	M120		Max	Min	Mean	SD	Skew
Galling	5.7	1.3	1	10	0	2.992	1.192	0.152
Root weight	21.5	10.7	32.7	26.0	0.4	7.249	4.282	1.447
Eggs	91650	550	3120	446400	0	17584	38800	6.667
Eggs/groot	4061.4	56.5	113.1	38483	0	2185.69	3767	4.907

Table 2. QTLs associated with nematode resistance on LGA03 with composite interval mapping.

Trait	Interval	LOD	Additive	Dominance	VAR
Galling	CIR316-pAR111	15.1	2.761	-2.997	62.81
Galling(log)	CIR316-pAR111	6.64	0.1476	-0.1667	35.43
eggs	CIR316-pAR111	5.52	15494	-15750	11.74
Eggs(log)	CIR316-pAR111	6.56	0.2414	-0.4684	14.26
Egg-root	CIR316-pAR111	6.42	1247	-1579	10.3
Egg-root(log)	CIR316-pAR111	5.22	0.2217	-0.4402	13.03

Table 3. QTLs associated with cotton nematode resistance on Chr07 with composite interval mapping.

Trait	Interval	LOD	Additive	Dominance	VAR
Galling	NAU474b-G1158b	3.45	-0.8118	-1.311	7.9
Galling(log)	NAU474b-G1158b	3.43	-0.0542	-0.1283	7.77
rootweight	NAU845-NAU1048	4.82	3.408	-2.905	28.1
rootweight(log)	NAU845-NAU1048	2.95	0.1089	-0.1265	10.91
eggs	NAU474b-G1158b	3.22	-13776	-10042	5.87
Eggs(log)	NAU474b-G1158b	3.27	-13.54	-0.4188	8.02
Eggs/groot	NAU474b-G1158b	2.71	-1298	-822	5.17
Eggs/groot(log)	NAU474b-G1158b	2.17	-0.101	-0.3578	5.9

Note: negative additive effect indicated the effect of increasing galling originated from M120.

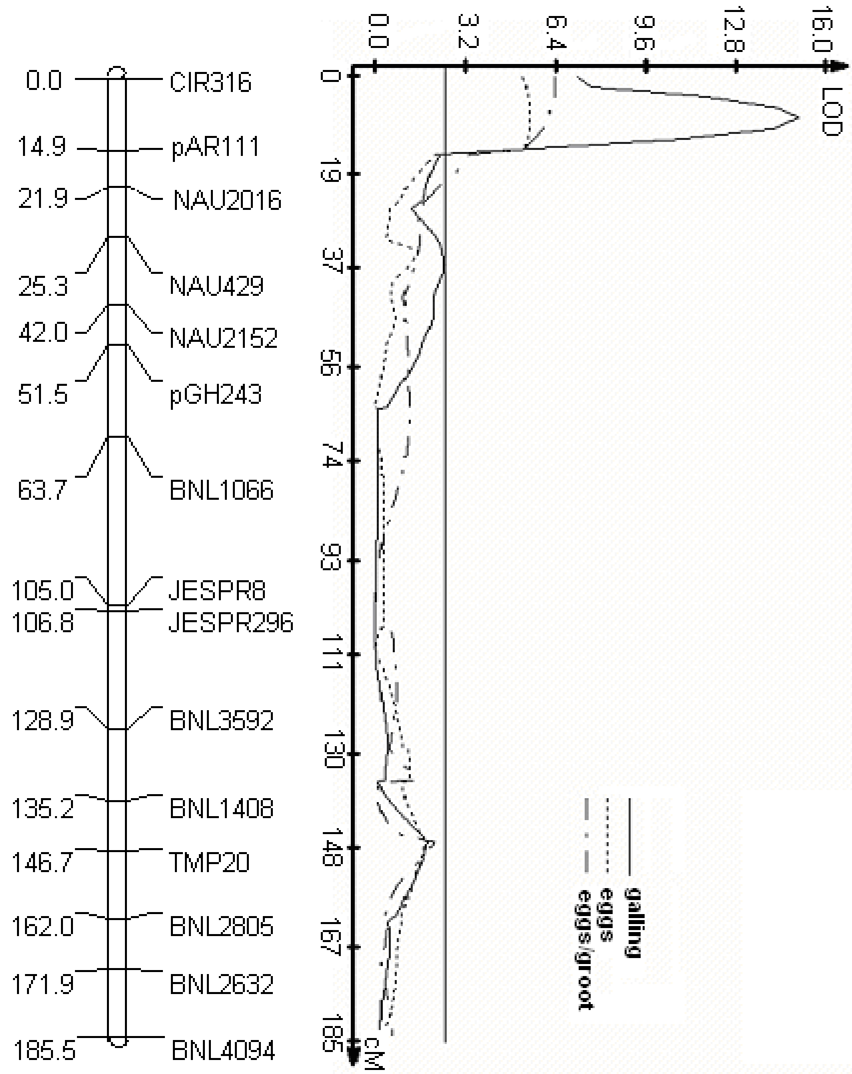

Figure 1. QTL map figure for LGA03

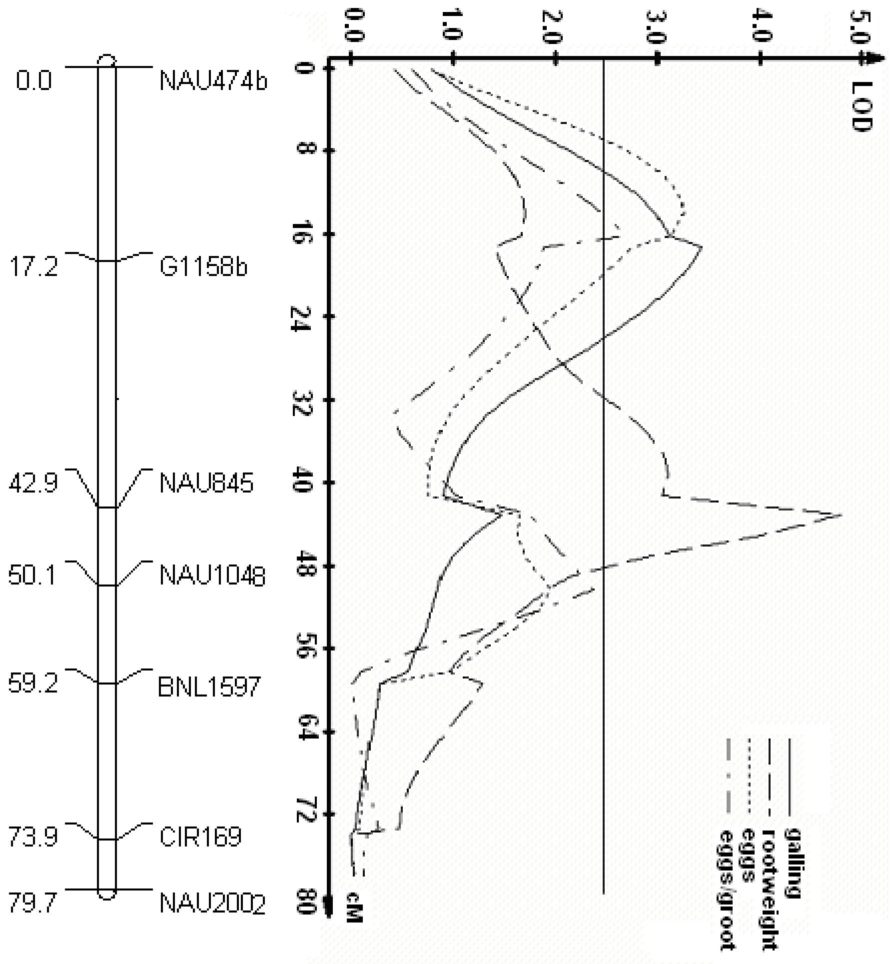

Figure 2. QTL map figure for Chr 07

PHYSIOLOGICAL CHARACTERIZATION OF GYLPHOSATE-RESISTANT PALMER AMARANTH (*AMARANTHUS PALMERI*)

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Abstract

Glyphosate resistance has been confirmed in a population of Palmer amaranth (*Amaranthus palmeri*) in central Georgia. The resistance/susceptible ratio are approximately 27 for this population. Uptake of foliar applied ^{14}C-glyphosate was examined in glyphosate-susceptible and –resistant biotypes. No differences in foliar uptake were observed. Leaf samples of from glyphosate-susceptible and –resistant biotypes were analyzed via atomic absorption spectrometry for differences in calcium concentration that could affect glyphosate activity. No differences were observed between the biotypes. A laboratory bioassay was conducted to determine the inhibition of EPSP via shikimate accumulation in glyphosate-resistant and – susceptible Palmer amaranth. In the glyphosate-susceptible biotype, shikimate accumulated at glyphosate concentrations above 40 µg glyphosate ml^{-1} at the lowest glyphosate concentration exposed (8.4 mg ae L^{-1}). In the glyphosate-resistant biotype, shikimate accumulation was not observed except at the highest glyphosate concentration of 84 mg L^{-1}. Translocation experiments were conducted to determine if glyphosate translocation out of the treated leaf was limited. Significant differences in glyphosate translocation out of the treated leaf were not observed between the glyphosate-susceptible and -resistant biotype. These data indicate that glyphosate-resistance for this Palmer amaranth biotype is based on a difference in the site of action rather than limited translocation.

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. A cotton grower in Macon County, Georgia was unable to control Palmer amaranth with glyphosate in 2004. The objectives of this research were as follows to identify the mechanism(s) allowing this biotype to tolerate glyphosate at rates known to be lethal to glyphosate-susceptible Palmer amaranth.

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.

^{14}C-Glyphosate Absorption. Plants were taken from the greenhouse experiment described above for analysis and were grown in a greenhouse with supplemental lighting by halide lamps at (400 µE m^{-2} s^{-1}) and temperature of 35/25 C). A commercial formulation of potassium salt of glyphosate at 0.84 kg ha^{-1} was mixed with ^{14}C-glyphosate (^{14}C-2-glycine, specific activity = 7.4 mCi $mmol^{-1}$; 99% purity). Ten 1-µl drops of herbicide solution containing a total of 3.4 kBq were applied uniformly to the upper surface of a mature leaf (2 cm length) when Palmer amaranth was 6 to 10 cm tall. The treated leaf was excised, petiole placed in 15 mL of distilled water in a 20 mL scintillation vial and treated with 3.4 kBq of 14C-glyphosate. After 24 h, the excised leaf was washed with two sequential applications of 1 ml of 70:30 methanol:water (v:v) for 10- 20 seconds. This wash was added to 18 ml of scintillation cocktail. in 2 ml of 70:30 methanol:water (v:v) mixed with 18 ml of scintillation cocktail. The ^{14}C in the leaf wash was quantified by liquid scintillation spectrometry. Absorbed herbicide, expressed as percent of applied, was calculated from the difference between applied ^{14}C and ^{14}C quantified in the leaf wash. Treatments were replicated three times, and the experiment was repeated once.

^{14}C-Glyphosate Translocation. Glyphosate-resistant and -susceptible Palmer amaranth were grown in the greenhouse as described and then moved into a growth chamber with a constant 28 C temperature and 50% relative humidity when they were 10 to 15 cm tall. Growth chamber lighting was provided by fluorescent and incandescent lamps at 450 µE m^{-2} s^{-1}. Plants were allowed to acclimate for 2 d before treatment with glyphosate. The study was a randomized complete block design with treatments arranged as a split plot and replicated five times. Whole plots were biotypes, and sub-plots were plant parts harvested. The study was repeated once.

The second fully expanded Palmer amaranth leaf was covered with polyethylene film before overspraying with potassium salt of glyphosate at 0.84 kg ha^{-1} mixed with deionized water. The film was then removed and the leaf was spotted with a radiolabeled solution. The spotting solution was prepared by mixing the spray solution with ^{14}C-labeled glyphosate (100:1, v:v) Technical grade phosphono-methyl-^{14}C-glyphosate[9] with 10,942 kBq mg^{-1} specific activity and 99% radiochemical purity was used. Five 1-µl droplets of ^{14}C-glyphosate were placed approximately 2 mm away from the center vein, beginning at the leaf's petiole end moving toward the leaf center, on the adaxial surface of the leaf. Total specific activity applied contained approximately 2 kBq of radioactivity. Plants were returned to the growth chamber immediately after spotting.

Plants were removed from soil 48 h after treatment and sectioned into meristematic treated leaf. Treated leaves were rinsed twice for 15 s with 5 ml of methanol:deionized water (1:1, v:v) to remove non-absorbed ^{14}C-glyphosate (Li et al. 2005). A 1-ml aliquot of the combined rinsates was added to 10 ml of scintillation fluid, and radioactivity was quantified by liquid scintillation spectrometry. The treated leaf was then further divided by dissecting a 3-mm wide zone completely around the outer edge to remove the meristematic tissue. All plant parts were dried for 48 h at 45 C, weighed, and combusted with a biological sample oxidizer. Radioactivity in the oxidized samples was quantified by liquid scintillation spectrometry. The amount of herbicide absorbed by plants was calculated as the total radioactivity recovered from the rinsate and oxidized tissues. Recovery efficiency was greater than 90%.

In Vivo Shikimate Assay. Glyphosate-resistant and -susceptible plants were grown in the greenhouse as previously described. Shikimate was determined according to a modification of the method of Gaitonde and Gordon (1958), Koger et al. (2005), and Shaner et al. (2005). Six leaf discs (3 mm dia.) per plant from the youngest fully expanded leaf of each biotype were excised and placed in a 1-ml solution containing 8.4, 42, or 84.5 mg L^{-1} of potassium salt of glyphosate[2] for 16 h at 25 C under supplemental light (400 µE m^{-2} s^{-1}). Leaf discs were then placed in 0.4 mL of 0.25 N HCl for 60 min after which a 100-µl aliquot was mixed with 0.4 ml of a 0.25% periodic acid with 0.25% metaperiodate solution for 60 min. After the periodic acid/metaperiodate reaction, a 0.4-ml aliquot of 0.6 M sodium hydroxide with 0.22 M sodium sulfite solution was added. Optical density of the solution at 380 nm was determined using a spectrophotometer. A shikimate standard curve was developed by adding known amounts of shikimate to vials containing leaf discs not exposed to glyphosate. Shikimate levels are reported as µg shikimate ml^{-1} HCl solution. Treatments were replicated three times, and the study was repeated three times.

Calcium Analysis. Glyphosate-resistant and -susceptible Palmer amaranth were grown in the greenhouse as described in the absorption experiment and foliage (1 g of leaves from the youngest leaves present) was harvested from plants at the 6- to 8-leaf stage. Three replicates consisting of 1 g dry weight each were used for each biotype. Plant material was analyzed for calcium content as a percent of total dry weight using an atomic adsorption spectrometer[14]. Treatments were replicated three times, and the study was repeated once.

Ploidy Determination*:* Nuclear DNA content of developing leaves of greenhouse-grown glyphsoate-resistant and -susceptible Palmer amaranth was measured by flow cytometry. Samples were prepared following the methods outlined by Morgan et al. (1998). Leaf tissue was chopped at room temperature using a razor blade in 0.5 ml of isolation medium (high-resolution DNA kit solution A, type T: DNA isolation) [16]. The suspension was filtered through a 40-µm filter and mixed with 4- to 5-fold volume of staining solution (high-resolution DNA kit solution B, type T: staining) with DAPI as the

DNA-specific fluorochrome. The nuclear suspension was analyzed on a PAS-III flow cytometer with 100-W high pressure mercury lamp; KG1, BG38, UG1, OG515 filters; TK 560 mirror; and GG 435 as barrier filter. Eleven thousand nuclei per plant sample were analyzed.

Statistical Analysis. All data were subjected to ANOVA using the general linear models of SAS (1999). Within each experiment, data were combined for analysis because there were no run interactions. In laboratory experiments, means were separated by Fisher's Protected LSD test at the 0.05 probability level and the standard error of the mean was calculated. For the shikimate assay, standard error of the means and a linear regression of the resulting shikimate values verses glyphosate concentration were computed for the susceptible biotype. Shikimate was not detectable in the glyphosate-resistant biotype, hence standard error and R^2 values are not reported for this biotype.

In the field and greenhouse experiments, which utilized a series of glyphosate rates, data were subjected to non-linear regression in addition to ANOVA. Visible Palmer amaranth control and fresh weight, expressed as a percent of the non-treated control, were regressed against the $\log_{10}$ of the glyphosate rate (SAS 1999). The intent was to determine if the response could be described by the log-logistic dose-response curve (equation [1]), where C = lower limit, D = upper limit, b= slope, and I_{50} = dose giving 50% response (Seefeldt et al. 1995).

$$y = C + \frac{D - C}{1 + (x / I_{50})^{(b)}} \qquad [1]$$

The log-logistic dose-response curve, commonly referred to as a sigmoid curve, is typical in dose-response studies where the dose (i.e. rate) ranges from no effect to complete death (Seefeldt et al. 1995). Constants generated by SAS® (SAS 1999) allowed the equation to be solved, and the glyphosate rates required to produce 50% visible control and 50% fresh weight reduction were determined. For presentation, parameters were fitted with a sigmoid response curve which had been previously generated.

Results and Discussion

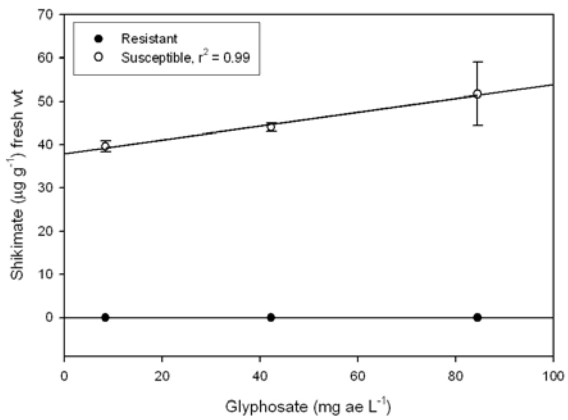
Uptake, Translocation , Absorption and Translocation. No differences in ^{14}C absorption were noted following ^{14}C-glyphosate application to glyphosate-resistant and -susceptible Palmer amaranth in either the absorption or translocation experiment. Resistant and susceptible plants absorbed 36 and 31%, respectively, of the applied ^{14}C 48 h after application in the absorption study. In the translocation study, differences in absorption in resistant and susceptible plants were not observed. Similar results were noted with glyphosate-resistant and -susceptible horseweed (Feng et al. 2004; Koger and Reddy 2005) and rigid ryegrass (Wakelin et al. 2004).

Translocation of ^{14}C out of the treated leaf and distribution of ^{14}C throughout the plant also did not differ between glyphosate-resistant and -susceptible Palmer amaranth biotypes. Forty-two percent and 34% of the applied ^{14}C was translocated out of the treated leaves of resistant and susceptible plants, respectively. These data indicate that neither reduced absorption nor reduced translocation of herbicide is the basis for resistance.

Ploidy. Higher numbers of chromosomes are often correlated with increased plasticity of a plant in relation to a stress. If glyphosate-resistant Palmer amaranth had higher ploidy levels relative to glyphosate-susceptible Palmer amaranth, then greater chromosome numbers could be related to herbicide resistance. That was not the case in this study as glyphostate-resistant and -susceptible Palmer amaranth had similar ploidy levels.

In Vivo Shikimate Assay. Shikimate was detected in leaf tissue of glyphosate-susceptible Palmer amaranth at the lowest concentration of glyphosate examined (8.4 mg ae L^{-1}), and shikimate concentration increased linearly as glyphosate concentration increased (Figure 1). Shikimate was not detected in leaf tissue of glyphosate-resistant Palmer amaranth regardless of the glyphosate concentration.

Figure 1. Effect of glyphosate concentration on shikimate levels from leaf discs from glyphosate-resistant and susceptible Palmer amaranth biotypes. Error bars indicate standard error of the mean.



Summary

Our results suggest that the glyphosate-resistant Palmer amaranth biotype from central Georgia possesses a different mechanism of resistance than glyphosate-resistant horseweed biotypes that have thus far been described. We observed no differences in glyphosate absorption and translocation between glyphosate-resistant and -susceptible biotypes. This is in contrast to results with horseweed and rigid ryegrass, where limited translocation of glyphosate out of treated leaves was observed with glyphosate-resistant biotypes (Feng et al. 2004; Koger and Reddy 2005; Wakelin et al. 2004).The level of resistance to glyphosate in this Palmer amaranth biotype (6- to 8-fold in whole plants) is less than that often observed in biotypes resistant to other modes of herbicide action. It is, however, similar to that in other species confirmed to be resistant to glyphosate (HRAC 2005). Regardless of the level of resistance, a grower's ability to manage this biotype of Palmer amaranth in the field with glyphosate no longer exists.

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THREE-YEAR EVALUATION OF WIDESTRIKE^{TM} COTTON FOR BOLLWORM CONTROL AT THE SOUTHEASTERN BRANCH RESEARCH AND EDUCATION CENTER NEAR MIDVILLE AND IN THE GREENHOUSE

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Introduction

WideStrike^{TM} *Insect Protection* gene technology is a trait incorporated into certain cotton varieties produced by Phytogen Seed Company LLC where plants express insecticidal proteins, Cry 1F and Cry 1Ac, derived from *Bacillus thuringiensis* Berliner (*Bt*). WideStrike^{TM} is registered as a plant incorporated protectant (PIP) and is known to express toxicity to various heliothine larvae. The greenhouse and field studies reported here were conducted during 2003-2005 as part of an insecticidal assessment of WideStrike^{TM} varieties with and without RoundupReady® gene technology and in research comparing WideStrike^{TM} to other *Bt* cotton varieties. Research emphasis was to evaluate WideStrike^{TM} on the corn earworm, *Helicoverpa. zea*, in artificial greenhouse infestations and in field tests at a Georgia location with a high proportion of *H. zea* in heliothine infestations of cotton.

Methods

Two greenhouse tests were conducted in the Entomology greenhouses at the University of Georgia, Athens. Cotton was grown for eight weeks to R7-R10 stage of development in one-gallon pots filled with commercial potting media. When tests were initiated, the plants were arranged in stainless steel trays filled with 1 inch of water. A potted plant served as an entry (treatment) and each was replicated four times in a randomized complete block arrangement within the watering trays. The trays of water (moat system) handled irrigation and prevented insect migration between plants.

Certain treatments were sprayed weekly with insecticide for four weeks using a rotating, compressed air, boom sprayer with three TX-3 hollow cone nozzles (one central nozzle and two drop nozzles). The sprayer boom was housed in a Plexiglas-sided unit (4 ft^3) and rotated at 3 mph, applying a spray volume of 10 gal/acre to the potted cotton arranged on the floor of the unit. Certain plants were sprayed with Roundup WeatherMax® at a rate of 20 oz product/100 gallons water 24 hours before the first insecticide applications were initiated.

Insect infestations were initiated 2 and 48 hours following insecticide applications on plants. Freshly hatched larvae (25 per plant) were placed on terminals, squares, flowers, and bolls using a fine brush. Terminals received 15 larvae and each fruiting structure 1 or 2 larvae at each infestation; at least 200 larvae were used per plant during a four-week period of testing. Plant terminals and fruiting structures were examined for damage and the presence and size of insects 7 days following the last insect infestation.

Three field tests were conducted during 2003-2005 at the University of Georgia Southeastern Branch Research and Education Center (SEB) in Burke County, Georgia. 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. Normal agronomic practices of fertilization, weed control, and irrigation used for cotton at the SEB were used in the tests. Each plot was separated from others by four buffer rows of a *Bt* cotton variety and the test fields were surrounded by at least 60 feet of *Bt* cotton. Treatments consisted of various varieties possessing either WideStrike™, Bollgard II®, or RoundupReady® traits or were non*Bt* cotton. The test fields were separated in half and all treatments in one section were sprayed with insecticide when cotton sampling indicated insect infestations were reaching threshold levels either in the test field or in adjacent cotton fields at the SEB. The plots were sprayed with a high-cycle sprayer with a four-row boom utilizing three TX3 nozzles (one centered over the row and two drop nozzles angled to the side of rows) at a spray volume of 10 gal/acre. 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 Tukey's Studentized Range Test for percent damage.

Results and Discussion

Tables 1, 2, and 3 present data from two sample dates for each year of the three years of tests. Weekly pheromone trapping data showed *H. zea:H. virescens* seasonal moth capture ratios of 95:5, 80:20, and 85:15 for 2003, 2004, and 2005, respectively, indicating that the cotton infestations were mostly *H. zea*. In all three years, the WideStrike™ cotton had significantly better control of insect infestations and a trend for higher yield than the non*Bt* cotton. Examination of trends in the data during the three years indicates that use of Karate® @ 0.03 lbs ai/acre + Tracer® @ 0.062 lbs ai/acre increased insect control and improved yield in both non*Bt* and *Bt* cotton, but separating the test fields into sprayed and unsprayed halves did not allow for statistical comparison of the different cotton varieties with and without insecticide treatment.

Table 1. *H. zea*[1] infestations of sprayed and unsprayed WideStrike™ cotton in Burke County, Georgia, at two selected sampling dates during 2003.

	% Damage[3]				
	August 7				
Treatment[2]	Terminals	Squares	Flowers	Bolls	
PS355	48.8 a	19.4 a	20.8 a	6.3 a	
P440W	0.0 b	0.0 b	0.8 b	0.0 a	
PS355S	6.3 a	2.5 a	3.5 a	1.9 a	
P440WS	0.0 b	0.0 a	0.0 a	0.0 a	
	August 22				Yield[4]
PS355	22.5 a	18.8 a	6.3 a	5.6 a	2328 a
P440W	0.0 b	3.8 b	1.3 a	1.3 b	2696 a
PS355S	0.0 a	0.0 a	0.6 a	0.0 a	2817 a
P440WS	0.0 a	0.0 a	0.0 a	0.6 a	2656 a

[1] Seasonal sex pheromone trapping had a ratio of 95:5 *H. zea*:*H. virescens*.
[2] PS355 = non-WideStrike™ variety; P440W = WideStrike™ variety; S = cotton was sprayed weekly with Karate® 2.09CS @ 0.03 lbs ai/acre + Tracer® 4SC @ 0.062 lbs ai/acre.
[3] Data analysis of sprayed and unsprayed blocks were done separately using SAS, ANOVA (p = 0.05, mean separation using Tukey's Studentized Range).
[4] Yield = lb seed cotton/acre.

Table 2. *H. zea*[1] infestations of sprayed and unsprayed WideStrike™ (RoundupReady® and non-RoundupReady®) cotton in Burke County GA at two selected sampling dates during 2004.

	% Damage[3]			
	July 20			
Treatment[2]	Terminals	Squares	Bolls	
P410R	15.0 a	11.9 a	4.4 a	
P470WR	5.0 b	1.9 b	1.3 b	
P440W	1.3 b	1.9 b	0.6 b	
P410RS	3.8 a	2.5 a	1.3 a	
P470WRS	0.0 a	0.0 a	0.0 a	
P440WS	0.0 a	0.0 a	0.0 a	
	July 27			Yield[4]
P410R	20.0 a	12.5 a	8.1 a	1959 a
P470WR	5.0 b	2.5 b	0.6 b	2441 a
P440W	5.0 b	5.6 b	0.6 b	2269 a
P410RS	1.3 a	2.5 a	0.6 a	2234 a
P470WRS	2.5 a	0.0 a	0.0 a	2407 a
P440WS	1.3 a	0.0 a	0.0 a	1815 a

[1] Seasonal sex pheromone trapping had a ratio of 80:20 *H. zea*:*H. virescens*.
[2] P410R = non-WideStrike™, RoundupReady® variety; P470WR = WideStrike™, RoundupReady® variety; P440W = WideStrike™, non-RoundupReady® variety; S = cotton was sprayed weekly with Karate® 2.09CS @ 0.03 lbs ai/acre + Tracer® 4SC @ 0.062 lbs ai/acre.
[3] Data analysis of sprayed and unsprayed blocks were done separately using SAS, ANOVA (p = 0.05, mean separation using Tukey's Studentized Range).
[4] Yield = lb seed cotton/acre.

Field tests in 2004 and 2005 showed that WideStrike™ cotton either with or without a RoundupReady® trait had no significant differences in insect control rate (Tables 2 and 3). In 2005, three WideStrike™ varieties were tested with a Bollgard II®/RoundupReady® variety (DP424B2/RR) and results showed that insect control and yield were statistically similar among the *Bt* varieties and all had significantly better insect control than the non*Bt* cotton (Table 3).

Table 3. *H. zea*[1] infestations of sprayed and unsprayed WideStrike™ and Bollgard II® cotton in Burke County GA at two selected sampling dates during 2005.

	% Damage[3]				
	August 2				
Treatment[2]	Terminals	Squares	Flowers	Bolls	
P410R	27.5 a	10.0 a	1.9 a	0.6 a	
P470WR	7.5 b	1.9 b	0.0 a	0.0 a	
P475WRF	2.5 b	1.3 b	0.0 a	0.0 a	
P440W	6.3 b	3.1 ab	0.0 a	0.0 a	
DP424B2/RR	2.5 b	0.6 b	0.0 a	0.0 a	
P410RS	16.3 a	7.5 a	1.9 a	0.0 a	
P470WRS	5.0 b	1.3 b	0.6 a	0.0 a	
P475WRFS	1.3 b	3.1 ab	0.0 a	0.0 a	
P440WS	5.0 b	2.5 ab	0.0 a	0.0 a	
DP424B2/RRS	1.3 b	1.9 b	0.0 a	0.0 a	
	August 9				Yield[4]
P410R	31.3 a	11.3 a	5.0 a	1.3 a	1998 a
P470WR	3.8 b	4.4 ab	0.6 a	0.0 a	1448 a
P475WRF	7.5 b	1.3 b	0.6 a	0.0 a	1931 a
P440W	5.0 b	3.8 b	0.6 a	0.0 a	1727 a
DP424B2/RR	2.5 b	0.0 b	0.6 a	0.0 a	2210 a
P410RS	17.5 a	5.0 a	2.5 a	0.0 a	2896 a
P470WRS	3.8 b	0.0 b	0.0 a	0.0 a	2708 a
P475WRFS	6.3 b	2.5 b	0.0 a	0.0 a	2528 a
P440WS	2.5 b	1.3 b	0.6 a	0.0 a	2699 a
DP424B2/RRS	0.0 b	0.0 b	0.0 a	0.0 a	3006 a

[1] Seasonal sex pheromone trapping had a ratio of 85:15 *H. zea*:*H. virescens*.
[2] P410R = non-WideStrike™, RoundupReady® variety; P470WRS = WideStrike™, RoundupReady® variety; P475WRF = WideStrike™, RoundupReady® variety; P440WS = WideStrike™, non-RoundupReady® variety; DP424B2/RR = Bollgard II®, RoundupReady® variety; S = cotton was sprayed weekly with Karate® 2.09CS @ 0.03 lbs ai/acre + Tracer® 4SC @ 0.09 lbs ai/acre.
[3] Data analysis of sprayed and unsprayed blocks were done separately using SAS, ANOVA (p = 0.05, mean separation using Tukey's Studentized Range).
[4] Yield = lb seed cotton/acre.

The greenhouse test was conducted to simulate severe *H. zea* pressure on the *Bt* cotton varieties using at least 200 freshly hatched larvae on infestations of each plant during four weeks. Table 4 shows that in the first test infestations developed on all unsprayed cotton, but damage was significantly reduced on the WideStrike™, Bollgard I® and Bollgard II® varieties. Treatments sprayed with Karate® @ 0.03 lbs ai/acre + Tracer® @ 0.062 lbs ai/acre produced good control on all of the cotton. Use of a single Roundup® application on certain treatments did not significantly influence *H. zea* infestations on either insecticide sprayed or unsprayed cotton.

Table 4. Greenhouse evaluations of the influence of Roundup® treatment on *H. zea* infestations of sprayed and unsprayed WideStrike™, Bollgard®, and Bollgard II® cotton.

	% Damage[2]			
	Test 1		Test 2	
Treatment[1]	Terminals	Fruiting Structures	Terminals	Fruiting Structures
Roundup®				
No Insecticide				
P410R NBt	100.0 a	53.2 a	75.0 a	35.3 ab
SG521 NBt	100.0 a	36.7 bc	50.0 ab	46.9 a
P470WR	25.0 b	14.4 def	25.0 bc	6.3 d
P480WR	25.0 b	6.1 efg	0.0 c	0.0 d
SG215BGIR	100.0 a	27.1 cd	75.0 a	6.3 d
DP424BGIIR	25.0 b	0.0 g	0.0 c	0.0 d
+ Insecticide				
P410R NBt+I	0.0 b	0.0 g	0.0 c	0.0 d
SG521 NBt+I	0.0 b	0.0 g	0.0 c	0.0 d
P470WR+I	0.0 b	0.0 g	0.0 c	0.0 d
P480WR+I	25.0 b	0.0 g	0.0 c	0.0 d
SG215BGIR+I	25.0 b	3.1 g	25.0 bc	3.1 d
DP424BGIIR+I	0.0 b	0.0 g	0.0 c	0.0 d
No Roundup®				
No Insecticide				
P410R NBt	100.0 a	42.0 ab	75.3 a	22.5 bc
SG521 NBt	100.0 a	52.5 a	50.0 ab	42.6 a
P470WR	100.0 a	40.2 ab	0.0 c	12.5 cd
P480WR	75.0 a	18.8 de	0.0 c	0.0 d
SG215BGIR	75.0 a	0.0 g	50.0 ab	8.2 d
DP424BGIIR	25.0 b	8.1 efg	0.0 c	0.0 d
+ Insecticide				
P410R NBt+I	0.0 b	0.0 g	0.0 c	0.0 d
SG521 NBt+I	0.0 b	0.0 g	0.0 c	0.0 d
P470WR+I	0.0 b	0.0 g	0.0 c	0.0 d
P480WR+I	0.0 b	0.0 g	0.0 c	0.0 d
SG215BGIR+I	25.0 b	0.0 g	25.0 bc	0.0 d
DP424BGIIR+I	0.0 b	1.6 fg	0.0 c	0.0 d

[1] P410R = non-WideStrike™, RoundupReady® variety; SG521 = non-WideStrike™, RoundupReady® variety; P470WR = WideStrike™, RoundupReady® variety; P480WR = WideStrike™, RoundupReady® variety; SG215BGIR = Bollgard®, RoundupReady® variety; DP424BGIIR = Bollgard II®, RoundupReady® variety; +I = cotton was sprayed weekly for 4 weeks with Karate® 2.09CS @ 0.03 lbs ai/acre + Tracer® 4SC @ 0.062 lbs ai/acre.

[2] Data analysis using SAS, ANOVA (p = 0.05, mean separation using Tukey's Studentized Range).

HERBIVORE FEEDING AND INDUCTION OF SYSTEMIC RESISTANCE IN COTTON PLANTS

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Abstract

Cotton plants defend themselves against feeding injury from the beet armyworm, *Spodoptera exigua*, by direct and indirect (incurred through natural enemies of the herbivore) resistance, both of which can be systemic and inducible. Numerous studies have demonstrated that plant signals are transmitted upward in the cotton plant, but no attempts have been made to examine the potential that the systemic response is transported downward in cotton, although such movement has been demonstrated in the lima bean. Therefore, we examined the direction of systemically induced resistance in cotton using the beet armyworm as eliciting herbivore. In addition, we evaluated the roles that herbivore density and duration of herbivory play in the process of induction and the systemic response in cotton plants. Plants should be favored to respond differentially to variations in the magnitude and duration of defoliation because resistance induction is assumed to be costly. Results confirmed upward transmission of induced systemic resistance (ISR) in cotton, as bioassay *S. exigua* caterpillars reared on both young, expanding leaves and mature leaves following previous *S. exigua* herbivory on lower leaves performed worse than those on control plants. ISR was not observed in leaves lower than actual damaged leaves, however, as bioassay *S. exigua* caterpillars raised on leaves immediately below the damaged leaves performed equally well in comparison with their counterparts from control plants. The duration of feeding did not affect the magnitude of ISR, provided that the feeding damage was kept at the same level. The feeding damage following 1 d herbivory was not statistically significant than that following 3 d herbivory. Therefore, the levels of ISR of 1 and 3 d herbivory did not differ. The relationship between amount of feeding damage inflicted within the same period of time and magnitude of ISR in young, expanding leaves was best expressed as quadratic. The magnitude of ISR increased as feeding damage mounted before reaching a peak value, then it leveled off or even decreased as feeding damage kept increasing.

Introduction

Gossypium hirsutum L. is one of the four main cotton species planted throughout the world. Both constitutive and induced resistance (IR) have been observed in cotton. ‘Built-in’ plant traits, such as morphological foliar form (reviewed in Niles, 1980), stored terpenoid aldehydes (Stipanovic et al., 1986), and volatiles such as monoterpenes and sesquiterpenes (Loughrin et al., 1994) stored in lysigenous glands (Elzen et al., 1985), are constitutive. They are present independent of wounding.

IR in cotton is induced in the area surrounding the wound site (induced local resistance, hereafter referred as to ILR) after herbivore feeding. Green leafy volatiles (GLVs) (e.g., (Z)-3-hexenal, (Z)-3-hexenol, and (Z)-3-hexenyl acetate), acyclic monoterpenes, sesquiterpenes, homoterpenes, and indole are typical volatile plant secondary compounds expressed in ILR in cotton (Loughrin et al., 1994; McCall et al., 1994; Turlings et al., 1995; Paré and Tumlinson, 1997, 1998). These compounds are released at the onset of herbivore feeding or after some period (ca. 12-24 h) of continuous feeding (Loughrin et al., 1994). Several monoterpenes, sesquiterpenes, and indole are demonstrated to be *de novo* synthesized (Paré and Tumlinson, 1997).

In addition to ILR, several of the inducible volatile and non-volatile plant compounds are found to be released from intact cotton leaves located above the actual feeding site (hereafter referred as to induced systemic resistance or ISR). ISR traits such as gossypol (Parrott, 1990) and terpenoid aldehydes (McAuslane et al., 1997) are non-volatile and are induced in young developing leaves. They inflict negative effects directly on herbivore performance (direct resistance). Volatile plant compounds such as (Z)-3-hexenyl acetate, acyclic monoterpenoid, sesquiterpenes and homoterpenes are also induced in large quantities (Loughrin et al., 1994; Röse et al., 1996; Paré and Tumlinson, 1997, 1998) following herbivory, and parasitoids have been demonstrated to respond to these herbivore-induced plant volatiles. The parasitoids *Cotesia marginiventris* and *Microplitis croceipes* are attracted to cotton plants damaged by the beet armyworm, *Spodoptera exigua,* and corn earworm, *Helicoverpa zea*, respectively (Röse et al., 1998). *Cardiochiles nigriceps*, a parasitoid of the tobacco budworm, *Heliothis virescens*, flies more frequently to host damaged plants (De Moraes et al., 1998). The resistance realized through the action of natural enemies is termed indirect resistance. Employing natural enemies of herbivores as indirect plant resistance can be so striking that these entomophagous natural enemies are referred to as ‘plant bodyguards’ (Dicke and Sabelis, 1988; Whitman, 1994; Cortesero et al., 2000).

Studies conducted so far on ISR in cotton have clearly demonstrated the upward transmission of plant signal within the plant (McAuslane et al., 1997; Paré and Tumlinson, 1998). No investigations of the potential downward transmission of ISR in cotton have been conducted, although ISR is indicated to move downward to the rhizosphere in lima bean plants. ISR messenger within lima bean can be collected from the leaf petioles and even roots of lima bean plants damaged by the spider mite *Tetranychus urticae* (Dicke et al., 1993; Chamberlain et al., 2001; Dicke and Dijkman 2001). Predatory mites, *Phytoseiulus persimilis*, are attracted to uninfested lima bean plants that are incubated in elicitor-collecting water compared to uninfested plants incubated in control water.

In our studies, we first examine the direction of ISR using *S. exigua* as an eliciting herbivore. We evaluated ISR through its direct effect on the performance of *S. exigua* caterpillars placed on intact leaves of induced plants. Bioassays of herbivores on detached leaves can be problematic, particularly if the bioassay is conducted for more than one day. Detached corn and lima bean leaves release volatile plant secondary compounds in higher quantities than intact leaves (Arimura et al., 2001; Schmelz et al., 2001). It also is difficult to maintain the turgidity of excised leaves for a prolonged period even if the petioles are covered with wet cotton ball (personal experience).

The release of some volatile inducible terpenes induced by *S. exigua* follows a diurnal pattern in cotton (Loughrin et al., 1994). But the amount seems not to increase day by day as herbivore feeding continues. The quantities of some other terpenes that do not follow diurnal patterns even decline after about 24 h of continual herbivore feeding. This may suggest that either cotton plants actively avoid over-investment of resources in defense or their ability to defend themselves against herbivory is limited. ISR may have the same fate. Hence, we then separately investigated the magnitude of ISR in response to various lengths of feeding time while keeping the amount of feeding damage about the same, and the magnitude of ISR in response to differential levels of feeding damage that was inflicted within a fixed period of time.

Materials and methods

Cotton plants and herbivores

Cotton plants, *Gossypium hirsutum* (variety FiberMax 989), were grown in a greenhouse in plastic flower pots (15 cm in diameter) filled with peat moss and potting soil. Sta-Green all purpose plant fertilizer ca. 1 tea spoon per pot was evenly mixed with peat moss and potting soil before potting. Day/night cycle was about 14L:10D. Plants were watered as needed. Plants with 5 or 6 fully expanded leaves were used in all the experiments. Cotton plants for different treatments were generally matched for height and size of leaves. If difference in these two traits was noticed, plants with different traits were then arranged into different blocks before being randomly assigned to treatments and control within a block. All experimental cotton plants were so spaced to avoid direct leaf contact with each other. We also assumed no plant-plant communications through airborne messengers.

Beet armyworm (BAW), *S. exigua* caterpillars originated from a laboratory colony in the Department of Entomology, UGA, on the Tifton campus. Newly-emerged caterpillars were reared on semi-artificial diet until they were early second instars (ca 3 d old). Early second-instar caterpillars were used throughout the experiments unless otherwise noted.

Direction of ISR transmission evaluated through direct resistance

The experiment was a 3×2 factorial design with leaf positions and induction condition as two factors. Leaf positions tested were the third fully expanded leaf (L3), the fifth fully expanded leaf (L5), and the seventh young expanding leaf (L7) (cotyledons numbered as node 0). Induction condition entails induced and control. Fifteen early second-instar BAW caterpillars (induction BAW) were caged on the fourth fully-expanded true leaf (L4) for 2 d to elicit ISR. Cages were made according to Cortesero et al. (1997), but modified. Instead of perforating the plastic soft-drink lids, we cut a disk (3 cm in diameter) out of the center of the lids and glued with fine mesh gauze. Another 10 early second-instar BAW caterpillars (bioassay BAW) were separately caged on L3, L5, and L7 for bioassay 2 d after removing the induction caterpillars. Only one leaf position was used for bioassay on each cotton plant to avoid potential interactions due to feeding on more than 1 leaf position in the same plant. All 6 treatments were replicated 4 times except 1 treatment—induced and L5, where one replicate in the treatment was lost. ISR induction feeding damage was quantified daily over a 3-d period using images from a digital camera (Canon D-30 camera, Japan) and digital imaging software -- Image Processing and Analysis in Java (ImageJ, version 1.34s, available in public domain). Leaf area eaten per caterpillar (cm^2 per caterpillar) on Days 1, 2, and 3 was calculated. Numbers of bioassay BAW caterpillars recovered were recorded and and caterpillars were weighed daily with a Mettler Analytical Balance (AE 100, Mettler Instrument Corp., Switzerland). Average weight gain of bioassay BAW (g per caterpillar) was calculated by subtraction of initial weight from weight measured daily and then divided by numbers of bioassay BAW caterpillars collected. Bioassay BAW weight was measured daily for 5 d.

Bioassay BAWs were reared in cups with semi-artificial diet in an environmental chamber after the greenhouse bioassay. They were checked daily for pupation and emergence.

Does feeding time play a role in ISR?

The experiment was arranged as a randomized complete block design with feeding time as treatments. Treatments and control were each replicated 4 times. Ten, 15, and 30 early second-instar BAW caterpillars were allowed to feed on the third fully expanded leaf of different cotton plants for 1 (T1), 2 (T2), and 3 (T3) d, respectively. Caterpillars were replaced daily with the same density designated for treatment in order to exclude the possible effect of herbivore age on ISR. Feeding area caused by each induction BAW caterpillar was quantified and calculated as described above. Another 10 caterpillars of the same species and age (bioassay BAW) were caged on the sixth leaf (still expanding) right after removal of induction BAW for bioassay. The average weight of each bioassay BAW caterpillar was determined each day throughout the experiment. BAW caterpillars used in the experiments were very small, we assume the individual weight was negligible. Because the sixth leaf was not sufficient to support caterpillar feeding for 6 d, caterpillars were reared on the fifth leaf on Days 5 and 6.

Does feeding damage play a role in ISR?

Five, 10, 20, and 30 early second-instar BAW caterpillars were allowed to feed on the third fully expanded leaf for 24 h to inflict differential levels of feeding damage. Total feeding damage was measured using the method described before. Another 5 BAW caterpillars of the same age were caged on the sixth leaf (a young expanding leaf) right after removal of induction BAW. Numbers of bioassay BAW caterpillars were recorded and total weight determined daily for 5 d as described above. Average bioassay BAW weight was calculated as total weight of bioassay BAW caterpillars divided by number of caterpillars recovered. Because the sixth leaf was too small for caterpillars to feed for 5 d, caterpillars were moved to the fifth leaf on Days 4 and 5. The experiment was arranged as a randomized complete block design with four treatments and a control each blocked 5 times.

Statistical analyses

Leaf area consumed, average weight gain, average weight of bioassay BAW, pupal weight, days from onset of bioassay to pupation, and days from pupation to adult emergence per caterpillar in all experiments were analyzed with PROC GLM (version 8, SAS Institute Inc., Cary, NC). Percent of BAW pupae yielding adults was analyzed with non-parametric method (PROC NPAR1WAY, WILCOXON). Data were checked for model assumptions before analysis. Data were untransformed unless otherwise noted.

Results

Direction of ISR transmission evaluated through direct resistance

ISR in the young leaf (L7) reduced herbivore mass from day 1 of bioassay (Fig. 1A). Average weight gains of each bioassay BAW reared on L7 of the damaged cotton plants were 86% less within 1 d, 88% within 2 d, 86% within 3 d, 84% within 4 d, and 86% within 5 d less than corresponding weight gains of BAW reared on L7 of control plants. The weight gain differences of bioassay BAW between ISR and control were all statistically significant (p = 0.0295, 0.0297, 0.0323, 0.0366, respectively for 1, 2, 3, 4 d), except for those on D5, which were nearly significant (p = 0.0543). Leaf areas eaten on L7 of damaged cotton plants were reduced from the onset of the experiment compared to corresponding areas of control plant (Fig. 1B). Although the differences in leaf area consumed between L7 of damaged and control plants were not statistically significant all 3 d, each bioassay BAW on L7 of damaged plant consumed half the area by D1, one third the area by D2 and D3 of BAW counterparts on L7 of control plants. Time from onset of the bioassay to pupation of bioassay BAW on damaged plants was 18.2±0.63 d, which was significantly longer than the time to pupation of bioassay BAW on control plants (15.2±0.63 d) (Table 1). No significant difference was observed in time from pupation to adult emergence, percent adult emergence or pupal weight between treatment and control (Table 1).

ISR was observed in the leaf immediately above the induction leaf (L5) in form of weight gain of bioassay BAW. The weight gains of bioassay BAW raised on L5 of damaged plants were consistently less than those of BAW reared on L5 of control plants (Fig. 1C). Each bioassay BAW caterpillar gained ca. 30% within 1 d, 35% within 2 d, 33% within 3 d, and 41% within 4 d, less mass on L5 of damaged plants in comparison to its counterpart on L5 of control plants, though weight gain differences between bioassay BAW reared on L5 of damaged and control plant were not significant until Day 4 (p = 0.0403). Leaf areas eaten by bioassay BAW on L5 of damaged plant within 1, 2, and 3 d were not different from those eaten on L5 of control plants (Fig. 1D). No significant differences between bioassay BAW reared on damaged and control plants were observed in terms of time from onset of bioassay to pupation, time from pupation to adult emergence, and percent adults emerged (Table 1). However, mean pupal weight of each bioassay caterpillar on damaged plant was found to be ca. 16% higher than that on control plant (Table 1).

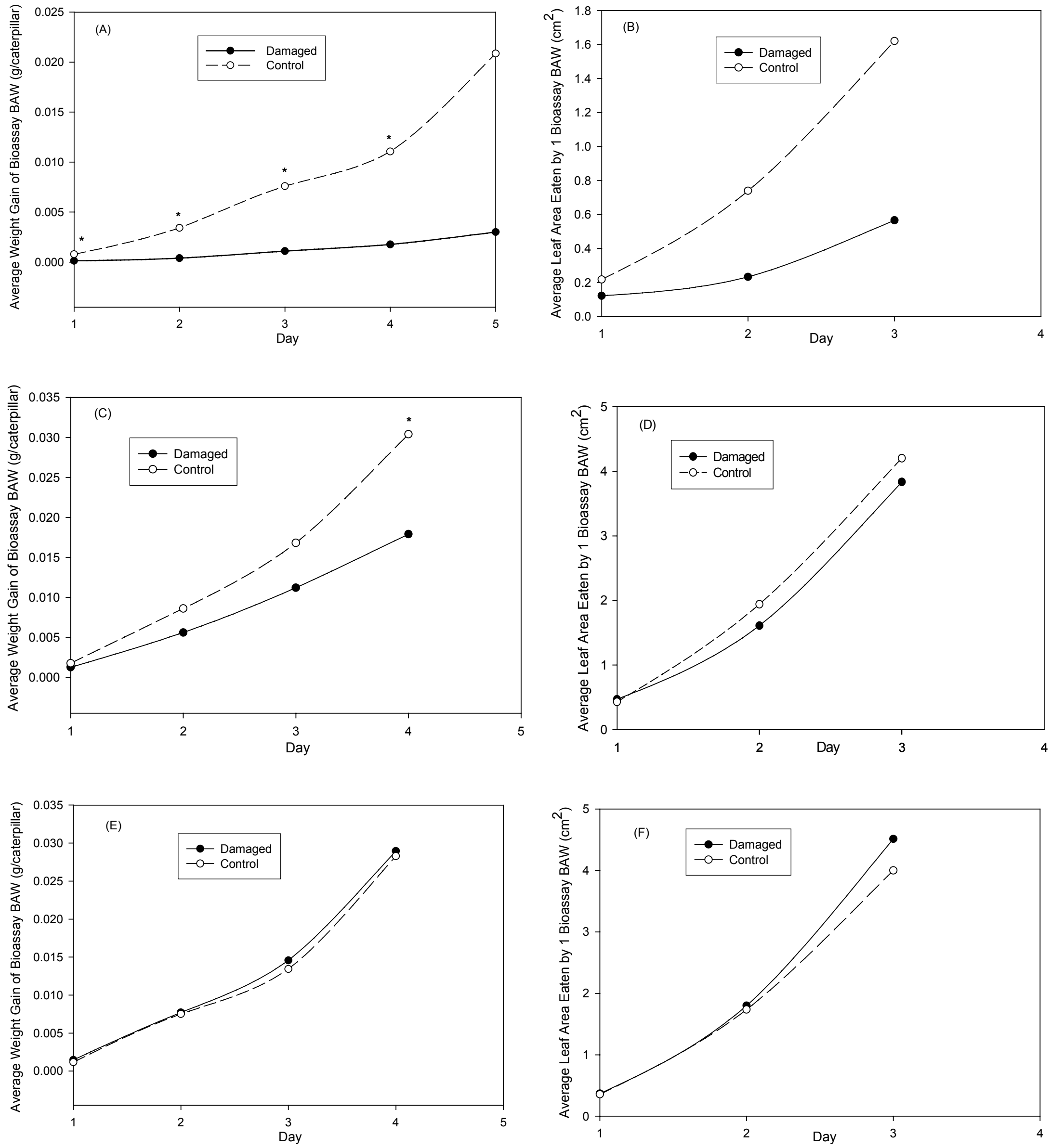

Figure 1. Average weight gain and leaf area eaten of bioassay BAW caterpillars reared on leaves with ISR and on control plants over the course of several days. (A) and (B), on still expanding leaves (L7); (C) and (D), on leaves immediately above damaged leaves (L5); (E) and (F), on leaves immediately below damages leaves (L3).

Table 1 Effects of ISR direction expression by leaf position on bioassay BAW life history variables[1].

	Time from bioassay to pupation (Mean±MSE) (d)	Time from pupation to adult emergence (Mean±MSE) (d)	Percent of adults emerged (Mean±MSE) (%)	Pupal weight (Mean±MSE) (g)
L7				
Damaged	18.18±0.63*	10.91±0.22	96.43±0.07	0.13±0.01
Control	15.17±0.63	10.41±0.22	100.00±0.0	0.13±0.00
L5				
Damaged	14.07±0.03	10.50±0.23	96.67±0.06	0.13±0.00**
Control	14.05±0.03	9.79±0.20	100.00±0.00	0.11±0.00
L3				
Damaged	14.06±0.07	9.89±0.23	100.00±0.0	0.12±0.01
Control	14.10±0.07	9.53±0.23	97.22±0.06	0.12±0.01

[1] L7, young expanding leaf; L5, mature leaf immediately above damaged leaf; L3, mature leaf immediately below damaged leaf. * and ** significant difference between damaged and control plants at 0.05 and 0.01 level, respectively.

BAW rearing on the leaf immediately below (L3) the induced leaf had no measurable effect on BAW development or leaf consumption. The differences between those variables on damaged and control plants measured over a period of several days were small and not significant (Fig. 1E and 1F). No significant differences between bioassay BAW reared on damaged and control plants were observed in terms of time from onset of bioassay to pupation, time from pupation to adult emergence, percent adults emerged, and pupal weight (Table 1).

Does feeding time play a role in ISR?

The ANOVA results and multiple comparisons of initial feeding damage are summarized in Table 2. The damaged areas of treatments T1, T2, and T3 were all significantly different from 0. The damaged areas of T1 (11.8±0.36 cm^2) and T3 (12.3±0.36 cm^2) were not statistically different from one another (p = 0.3223). However, the damaged area of T2 (13.1±0.36) was 1.32 cm^2 greater than that of T1, and T1 and T2 were significantly different (p = 0.0403).

One day's feeding by bioassay BAWs on induced leaves of T2 and T3 reduced the weights of BAW significantly compared to those feeding on control leaves (p = 0.0103 and 0.0249, respectively) (Table 3). The bioassay BAW weight from T1 was not significantly different from BAW reared on control plants (p = 0.3649). The patterns were consistent for 3 d (Table 3), but on Day 3, bioassay BAW of T1 plants weighed ca. 30% less in comparison with corresponding BAW on control plants. From Day 4 to Day 6, bioassay BAW weights of all T1, T2, and T3 BAW were consistently and significantly lower than those of BAW on control plants (Table 3).

Table 2. Summary of ANOVA table and multiple comparisons of initial feeding damage inflicted by same number of BAW caterpillars but with various feeding time.

ANOVA table

Source	DF	Type Ш SS	F Value	Pr > F
Block	3	1.2822	0.83	0.5227
Treatment	2	3.5193	3.43	0.1016
Error	6	3.0785		

Multiple comparisons among treatments

Treatment*	Mean±SEM** (cm^2)
T1	11.79±0.36 a
T2	13.11±0.36 b
T3	12.34±0.36 ab

*T1, 1 d feeding; T2, 2 d feeding; T3, 3 d feeding; * *different letters following mean±SEM implies that they are different from each other at α=0.05 level. Pairwise *t*-test was used to perform multiple comparisons across treatments.

Table 3 Average weight of bioassay BAW and leaf area eaten over a period of several days.

Weight of bioassay BAW (Mean±SEM) (mg/caterpillar)*						
Treatment**	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Control	2.4±0.00a	5.3±0.00a	11.8±0.00a	28.5±0.00a	57.0±0.00a	116.0±0.01a
T1	2.2±0.00ab	4.0±0.00ab	8.5±0.00ab	15.3±0.00b	30.2±0.00b	56.7±0.01b
T2	1.7±0.00b	2.5±0.00b	4.6±0.00b	9.8±0.00b	16.1±0.00b	35.2±0.01b
T3	1.8±0.00b	2.9±0.00b	6.0±0.00b	11.5±0.00b	20.5±0.00b	38.0±0.01b

Leaf area eaten (Mean±SEM) (cm^2/caterpillar)***		
Control	0.268±0.03a	0.814±0.12a
T1	0.254±0.03a	0.567±0.12ab
T2	0.121±0.03b	0.339±0.12b
T3	0.144±0.03b	0.419±0.12b

*T1, 1 d feeding; T2, 2 d feeding; T3, 3 d feeding; * * and *** different letters following mean±SEM implies that they are different from each other at α=0.05 level. Pairwise *t*-test was used to perform multiple comparisons across treatments.

Each bioassay BAW of T1, T2, and T3 consumed less leaf mass within 24 h than BAW feeding on control leaves did within the same period of time (Table 3). Within the first 24 h, the leaf area consumed by each bioassay BAW on T1 was 2.20±0.00 mg, which was not significantly different from that consumed on control leaf (2.4±0.00 mg) (p = 0.7639). The leaf mass eaten by each bioassay BAW on T2 and T3 in the first 24 h were 1.7±0.00 and 1.8±0.00 mg, respectively, which were both significantly lower than corresponding leaf mass consumed in the controls (p = 0.0102 and 0.0228, respectively). Each bioassay BAW on T2 and T3 consumed significantly less leaf area than its counterpart on T1 plants. Within the second 24 h, bioassay BAW on T2 and T3 plants also consumed significantly less leaf that that BAW on controls. Though the leaf mass consumed by bioassay BAW on T1 was not significantly different from that on control (p = 0.1887), it was 34% less.

Does feeding damage play a role in ISR?

Mean initial feeding damage of 4 treatments caused by induction BAWs with the densities of 5, 10, 20, and 30 early 2nd-instar caterpillars for 24 h was statistically significant from 0 (table 4). The differences among the 4 treatments were all significant as well. The weights of bioassay BAW raised on the treatment and the control plants over 5 d are shown in Fig. 2. Average weight of 1-d-old bioassay BAW reared on 5 BAWs treatment (2.10±0.10mg) was not significantly different from corresponding bioassay BAW of control (2.20±0.10 mg) (p = 0.2846). Weight of 1-d-old bioassay BAW from the 10, 20, and 30 BAWs treatments were significantly lower than that of BAW on control plants (p = 0.0285, 0.0038, and 0.0204, respectively). Compared to bioassay BAW of the 5 BAWs treatment, the weights of bioassay BAWs of the 20 BAWs treatment were statistically lower on Day 1 (p = 0.0372). No other significant difference was observed on Day 1. On Day 2, weights of bioassay BAW in all treatments (5, 10, 20 and 30 BAWs) were significantly lower than those of BAWs in the control (p = 0.0251, 0.0041, 0.0006, and 0.0016, respectively). The differences between treatments were not significant. A similar pattern was observed on Day 3. The weight of 4-d-old bioassay BAW of the 10, 20 and 30 BAW treatments were significantly lower than corresponding BAW in the control. In comparison to the weight of bioassay BAW in the control (16.5±1.40 mg), the weight of bioassay BAW of 5 BAW treatment (12.8±1.40 mg) was ca. 23% less, though statistically they were not different (p = 0.0919). On Day 5, the weights of BAW in the 5, 10, 20, and 30 BAW treatments were statistically lower than corresponding BAW weight in the control treatment (p = 0.0408, 0.0027, 0.0013, and 0.0016, respectively).

The relationship between ISR (expressed as weight of bioassay BAW caterpillar, the lighter the weight of caterpillar, the stronger the ISR) and feeding damage area was best represented by quadratic expressions. The pattern was consistent over the experimental course of 5 d (Fig. 3).

Discussion

Direction of ISR transmission evaluated through direct resistance

Induced systemic resistance (ISR) in young, expanding leaves above the feeding site has been observed in cotton (Alborn et al., 1996; McAuslane et al., 1997; Paré and Tumlinson, 1998). Our experiment confirmed the occurrence of ISR in cotton plants, and of upward movement of the response. The average weight gains of bioassay BAW reared on undamaged young expanding leaves (L7) of cotton plants with one mature leaf (L4) damaged by BAW before bioassay were consistently and significantly lower over a period of 5 d than weight gains of BAW on undamaged L7 of cotton plant (Fig. 1A). The pattern was mirrored in the leaf area eaten by each bioassay BAW (Fig. 1B). Bioassay BAW caterpillars (3-d-old) fed on L7 of induced plants needed 3 d more time to complete larval development to pupation in comparison to those fed on L7 of control plants (Table 1). Bioassay BAW caterpillars were fed with identical artificial diet after 5 d bioassay on leaf still attached to plant. It's likely that the difference might be greater provided that bioassay BAWs were restricted to feed on live plant throughout the larval period.

Table 4 Summary of ANOVA table and multiple comparisons of initial feeding damage inflicted by various densities of induction BAWs.

ANOVA table

Source	DF	Type Ш SS	F Value	Pr > F
Block	4	1.4825	1.09	0.4029
Treatment	3	139.3252	137.12	<0.0001
Error	12	4.0643		

Multiple comparisons among treatments

Treatment	Mean±SEM* (cm^2)
5 BAWs	1.2880±0.2603 a
10 BAWs	2.6466±0.2603 b
20 BAWs	5.0770±0.2603 c
30 BAWs	8.2314±0.2603 d

* different letters following mean±SEM implies that they are different from each other at α=0.01 level. Pairwise *t*-test was used to perform multiple comparisons across treatments.

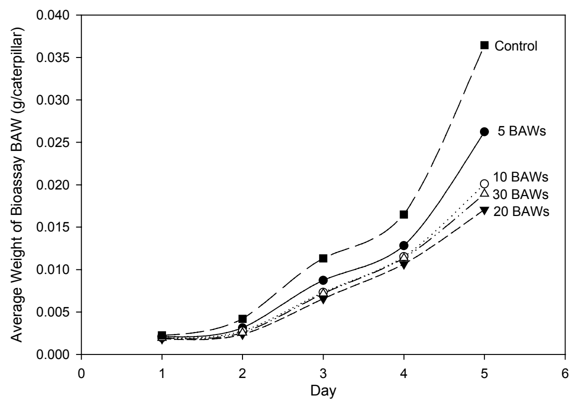

Fig. 2 Average weight of bioassay BAW caterpillars reared on leaves from plants with different levels of feeding damage and control plant over 6 days.

ISR on mature leaves immediately above the damaged leaf was suggested from our results. Bioassay BAW reared on undamaged mature leaves (L5) from plants with L4 damaged before bioassay consistently gained less biomass than those reared on L5 from control plants (Fig. 1C). Within 4 d, weight gain of bioassay BAW on L5 from damaged plant was ca. 41% lower than that of bioassay BAW on L5 of control plants. The weight gain difference was statistically significant (p = 0.0403). Our finding was consistent with Alborn et al. (1996), that mature leaves cut from cotton plants whose oldest two true leaves had been fed on by two third-instar *Spodoptera littoralis* for 16 h were avoided by bioassay conspecifics in the feeding choice tests. However, McAuslane et al. (1997) observed no significant effects of ISR (gland density, total glands, quality and quantity of terpenoid aldehydes produced) on upper mature leaves on plants with the two oldest leaves being on fed by *S. exigua* for 24 h. One possible explanation is that McAuslane et al. (1997) used 2 third-instar caterpillars while we used 15 early second-instars to induce ISR. The age difference of inducing caterpillars might partly account for the inconsistent results, since herbivore age has been suggested to affect the production of parasitoid-attracting volatile synomones (Takabayashi et al., 1995; Gouinguené et al., 2003). Second, feeding time and damage amount might also account for some of the difference. In our experiment, leaves were fed by BAW for 2 d, with 15.6 cm^2 leaf consumed. Third, the potential effects caused by different bioassay methods couldn't be excluded. Bioassays of herbivores on detached plant leaves could be problematic, as noted above.

ISR was not observed on the leaf below the damaged leaf which had been continuously fed on by BAW for 2 d. None of the measured bioassay parameters for bioassay BAW were significant between those from treatment and control plants (Figs. 1E, 1F; Table 1). The parasitoid *Microplitis croceipes*, in no-choice wind tunnel tests, responded the same way to the lower half of plants whose upper half had been fed on by its host the tobacco budworm, *Heliothis virescens*, for 24 h and to the lower half of plants with no feeding damage (unpubl. data). It's likely that the benefits of resource investment in protecting old leaves are lower than costs. So, ISR in old leaves does not occur. These data, however, did not exclude the possibility of ISR being transmitted down below the real feeding site, possibly into the rhizosphere. From an evolutionary and population perspective, it would be advantageous for cotton plants to warn neighboring conspecifics. More studies are needed before making conclusions.

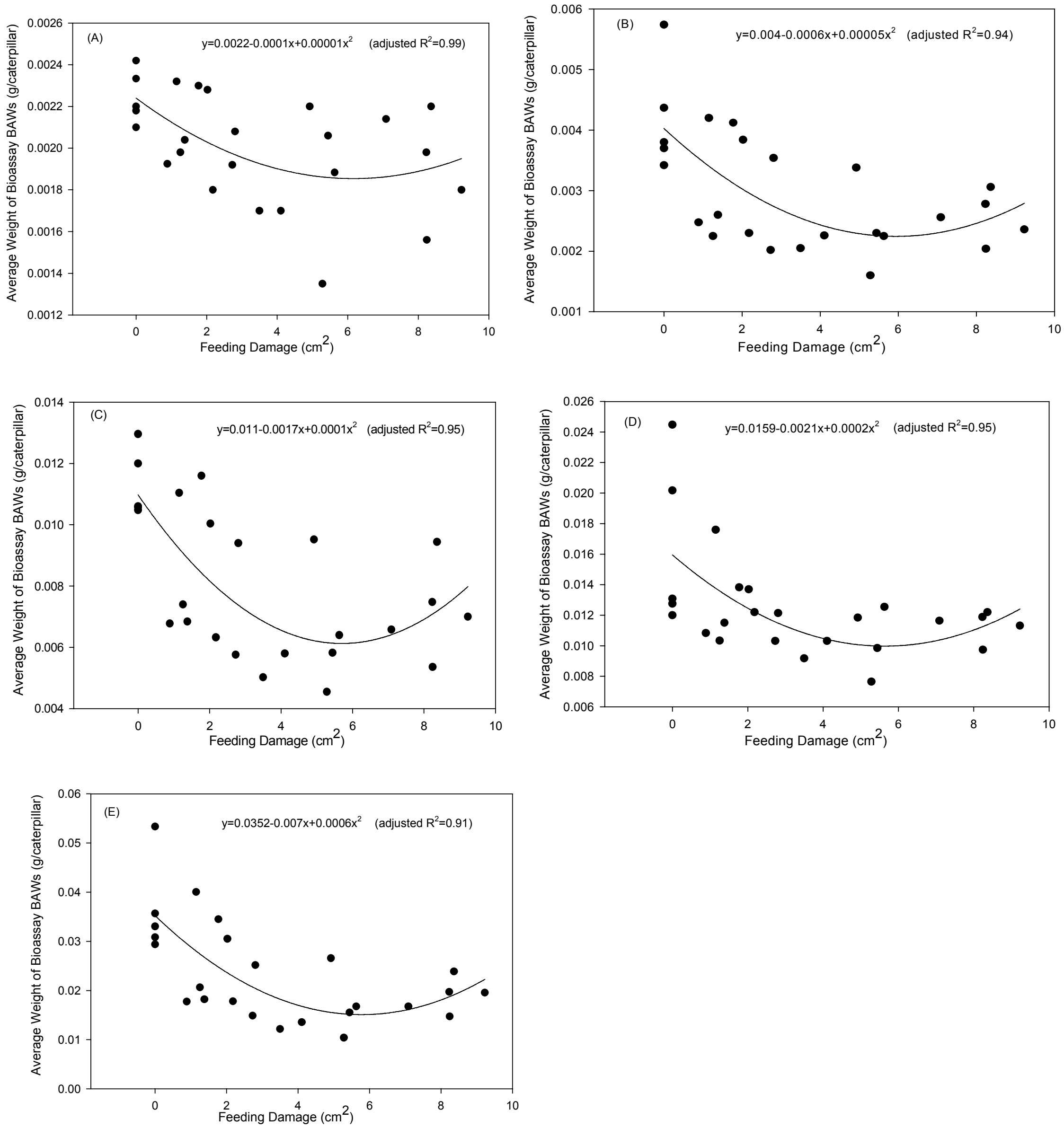

Fig. 3 Quadratic regression ($y = y_0+ax+bx^2$) of average weight of bioassay BAWs against feeding damage over a period of 5 d. (A), 1-d-old BAWs, $p(y_0)<0.0001$, $p(a)=0.0335$, and $p(b)=0.1187$; (B), 2-d-old BAWs, $p(y_0)<0.0001$, $p(a)=0.0036$, and $p(b)=0.0244$; (C), 3-d-old BAWs, $p(y_0)<0.0001$, $p(a)=0.0008$, and $p(b)=0.0067$; (D), 4-d-old BAWs, $p(y_0)<0.0001$, $p(a)=0.0069$, and $p(b)=0.0292$; and (E), 5-d-old BAWs, $p(y_0)<0.0001$, $p(a)=0.0009$, and $p(b)=0.0077$.

The roles feeding time and feeding damage play in ISR

Feeding on mature leaves by 10 early second instar *S. exigua* caterpillars for 24 h induced ISR in young undamaged cotton leaves. Continuous feeding longer than 24 h increased the induction of ISR in young leaves, but the magnitude of ISR was not significantly different from the magnitude of ISR induced following 24 h feeding, provided the feeding damage of the different treatments was kept at same level. The initial feeding damage of 1 d feeding (T1) was 11.8±0.36 cm^2, which was not significantly different from that of 3 d feeding (T3) (12.3±0.36 cm^2) (Table 2). Therefore, the magnitude of ISR of T1 and T3 did not differ significantly from one other (Table 3). The same pattern was detected between T2 and T3 (Table 3). Loughrin et al. (1994) also found that the release of some volatile inducible terpenes induced by *S. exigua* did not increase day by day as herbivore feeding continues. The quantities of some other terpenes that do not follow diurnal patterns even decline after about 24 h of continual herbivore feeding. Furthermore, after feeding damage reached a certain level, any additional feeding damage might alter the magnitude of ISR a little, but not significantly (Table 3, between T1 and T2). This finding was further confirmed by the relationship between feeding damage and magnitude of ISR (the lighter the bioassay caterpillar, the stronger the ISR) (Fig. 3). Cotton leaves of the same leaf position from different treatments were fed on by different densities of *S. exigua* to inflict various levels of feeding damage but for the same duration of feeding. The relationship was best expressed as quadratic (Fig. 3). The ISR increased as feeding damage mounted before reaching a peak value, then it leveled off or even attenuated as feeding damage kept increasing. This may suggest that either cotton plants actively avoid over-investment of resources in defense since further investment (costs) will exceed benefits, or their ability to protect themselves from herbivory is limited after feeding damage reaches a certain level. From *S. exigua* perspective, aggregative feeding seems to be a strategy adapted to break down cotton plant defense. Typically, *S. exigua* eggs are laid in clusters of from 50 to over 100 eggs on the lower surface of lower leaves of host plants. After egg emergence, 1^{st}-instar caterpillars feed together around the oviposition site until the 3^{rd}-instar, when they start to disperse (personal observation).

Plants act quickly in response to herbivory. ISR in young leaves was found a few hours after onset of herbivory on lower mature leaves. *S. exigua* caterpillars ate significantly less young leaf mass of plants whose 2 oldest mature leaves had been previously fed on by 2 of their conspecifics for as short as 6 hr, in comparison with *S. exigua* caterpillars on control plants with no previous herbivore damage (Alborn, 1996). Phytochemicals (e.g.,jasmonic acid) upregulating defense genes or production of volatile plant secondary metabolites in maize (*Zea mays* cv. Delprim) were increased over 10-fold minutes after mechanical wounding or a combination of mechanical wounding and volicitin (elicitor isolated from oral secretion of *S. exigua*) application, compared to intact maize plants (Schmelz et al., 2003). Nevertheless, the strength of the response is mediated by the amount of feeding damage. The production of headspace volatile (ILR) from spider mite, *Tetranychus urticae*-infested kidney bean plants mainly correlated with the spider mite densities (Meada and Takabayashi, 2001; Horiuchi et al., 2003). Volatile emission peaked as spider mite density peaked. In maize, ILR (expressed as volatile sesquiterpene and indole production) positively correlated with *S. exigua* herbivory levels (Schmelz et al., 2003). No limitation of volatile production was detected in these studies, however. To authors' knowledge, this paper is the first to suggest a limitation of ISR, and the first to elucidate the interacting role of feeding damage and duration of feeding in ISR.

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EVALUATION OF COTTON SEED TREATMENTS FOR THRIPS CONTROL IN EARLY COUNTY

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Introduction

Thrips are predictable and annual pests of seedling cotton in Georgia and the use of preventive insecticides for thrips control are recommended. At-plant systemic insecticides have historically provided consistent yield responses. During recent years several cotton seed treatments for thrips control have been commercialized. This trial was established to evaluate two seed treatments, Cruiser and Bracket, against a standard in-furrow treatment with Temik.

Materials and Methods

DP 555 BGRR was planted on May 11, 2005 in an irrigated field in Early County, Georgia in a strip-till system. The plot design was a complete block with 5 replications of each treatment. Plots were six rows wide (36 inch row spacing) by the length of the field (400-800 feet). Cruiser was applied to the seed by Delta and Pineland, and Bracket was applied to the seed by Blakely Farm Supply. Temik 15G was applied in-furrow at a rate of 3.5 lbs. per acre. Seeding rate was 2 seeds hilldropped every 10 inches. Stand counts were taken on May 27 on a 100 row feet of each treatment. Thrips populations were sampled 14 (May 25) and 28 (June 7) days after planting (DAP) by randomly collecting 10 plants per plot and immediately immersing and swirling in a container filled with 70 percent ethyl alcohol to dislodge thrips. Adult and immature thrips were counted in the laboratory using a dissecting microscope. A visual thrips rating was also taken at 28 DAP. The center two rows from each plot were harvested on November 8, 2005. A lint fraction of 0.397 (actual lint fraction for the trial area) was used to determine lint yield per acre.

Results and Discussion

Thrips populations were approximately one per plant at 14 DAP in all treatments which is below the recommended threshold of 2-3 thrips per plant (Table 1). At 28 DAP, immature thrips populations, less than one per plant, were low and similar for all treatments. However Cruiser had significantly greater adult thrips compared with Temik and Brackett treatments. Visual thrips damage ratings were made on a scale of 1-5 where 1=no damage and 5=treatable levels of damage at 28 DAP. Damage ratings were similar, however Temik was slightly better than Brackett and Cruiser with ratings of 3.0, 3.5, and 4.0 respectively. Cruiser yielded significantly greater lint per acre compared with Temik but was not significantly different compared with Brackett. No significant difference in yield was observed between Brackett and Temik treatments.

Based on thrips populations, differences in yield do not appear to be associated with the level of thrips control. Thrips populations were below threshold levels in all treatments at 14 DAP but did exceed thresholds at 28 DAP. As cotton seedlings develop from 14 to 28 DAP, tolerance to thrips increases. It is unusual for thrips to lower cotton yields once seedlings develop 5 leaves per plant and are growing rapidly.

Table 1. Immature and adult thrips per 10 plants and lint yield per acre in cotton treated with selected preventive thrips insecticides, Early Co. GA 2006.

	Thrips per Ten Plants				
	14 DAP (May 25)		28 DAP (June 7)		Yield
Treatment	immatures	adults	immatures	adults	(lint/acre)
Temik 15G 3.5 lb/acre	6.4 a	4.0 a	5.2 a	21.2 a	1077 b
Brackett seed treatment	7.2 a	2.6 a	5.2 a	23.6 a	1180 ab
Cruiser seed treatment	6.6 a	4.6 a	6.6 a	51.8 b	1207 a

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

THRIPS EFFICACY TRIALS IN SOUTH GEORGIA

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Abstract

A set of studies was conducted in Tifton, GA, in 2005 to evaluate the efficacy of a variety of thrips-active products. In separate trials, compounds provided by Bayer (4 treatments evaluated), Syngenta (11 treatments evaluated; and two different planting dates), and Valent (16 treatments evaluated) were compared against local standards. Immature and adult thrips were counted in the various treatments, plant densities and heights were measured, damage ratings were taken, and yields were assessed. Temik® provided significant control where used, but Gaucho Grande® and Orthene® also provided significant and comparable levels of control. Cruiser® generally performed well, but was improved by the addition of A14006 at 0.15 mg. Timing of boll opening was modified somewhat by treatments, but the warm, dry conditions of the late summer and early fall may have masked effects. Yields were unaffected by treatments.

Introduction

Thrips in the genus *Frankliniella* are perennial pests of cotton in Georgia, and can have various impacts on cotton production, ranging from minor cosmetic damage to delay of crop maturity, or even to stand destruction (Watts 1937, Hawkins et al. 1966). Cotton plants are at greatest risk early in the season, when the small plants can be quite susceptible to thrips injury caused by feeding on 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, thrips can reduce yields by as much as 50-60%, if not controlled. This concern over potential crop injury and loss provides the impetus for continued evaluations of thrips management tools in southern Georgia. The objective of this study was to evaluate the efficacy of management tools for thrips in south Georgia.

Methods

Evaluations consisted of three trials performed on cotton planted on 4 May 2005, at the Lang-Rigdon Farm of the University of Georgia's Coastal Plain Experiment Station in Tift County, Georgia, using a Monosem pneumatic planter equipped to add granular insecticides in the furrow. Treated seed was provided by Bayer (DPL 555), Syngenta (DPL 555), and Valent (Stoneville 5599). In the trial with seed provided by Syngenta Corp., the trial was repeated in a second planting on 26 May (using DPL 555) to look for possible differences due to planting date. Plots were 4 rows by 50 ft long, with a 36 inch row spacing and a minimum of 4 replications per treatment. The treatments and cotton varieties in the respective trials are listed in Tables 1, 2, and 3.

Thrips were sampled on 16, 23, and 30 May 2005 (12, 19, and 26 DAP), except in the late-planted Syngenta trial, which was sampled on 6, 13, and 20 June (11, 18, and 25 DAP). 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. Adults and nymphs were counted, though the numbers of both stages were pooled for statistical analysis. In addition to thrips numbers, damage ratings were obtained by rating each plot (scale of 1-5, with 1 being no damage and 5 being total destruction). Ratings were made in all of the plots on 31 May, except the late-planted Syngenta trial, which was evaluated on 27 June.

Plant density (number of plants per 10 row feet) was assessed on 9 June by measuring the number of plants in 4 random samples of 10 feet each per plot. Plant heights and node numbers were evaluated on 9 and 20 June for 10 plants per plot, and height:node ratios were determined. Percentage of bolls open was used to assess possible developmental delays among treatments. All of the bolls on each of 10 plants per plot were examined late in the season and the percentage of bolls that were open was recorded (sample dates are in Tables 1-3). Seed cotton yields were taken by mechanically picking the middle 2 rows of each plot 14 November 2005.

Data were analyzed using analysis of variance (PROC GLM, SAS Institute 1999), followed by separation of significantly different means using the Waller Duncan Bayesian *k* ratio, with *k*=100 (equivalent to $p<0.05$) as the upper limit for significance (SAS Institute 1999). Percentage data (% bolls open) were transformed ($\arcsin\sqrt{x}$) prior to analysis. The results presented are back-transformed.

Results and Discussion

Bayer Trial: Thrips Numbers, Plant Damage

Thrips numbers in all treatments differed significantly from the controls on 23 May (Table 1). However, there were few other significant differences. In contrast, the damage ratings of the plots indicated clearly significant differences, with the untreated plots sustaining the heaviest damage (Table 2). The Cruiser plots were the second most-heavily damaged, and the Gaucho and L0263/L1012 treatment were statistically the same, with the lowest amount of damage. Thus, although the thrips numbers were not consistently reduced by the treatments, there were clear differences in the damage inflicted.

Table 1. Number of thrips per plant 12, 19, and 26 days after planting in the Bayer trial (planted 4 May 2005). Tift Co., GA. 2005.

Treatment/rate	16 May	23 May	30 May	Season Avg.
Untreated	0.25 ± 0.38 a	7.00 ± 1.72 a	9.25 ± 2.86 a	5.50 ± 1.48 a
Gaucho 0.375 mg AI/seed	0.65 ± 0.44 a	2.95 ± 1.25 b	8.50 ± 2.38 a	4.03 ± 1.02 ab
L0263 150 g AI/100 kg seed plus L1012 350 g AI/100 kg seed	0.60 ± 0.52 a	3.15 ± 0.52 b	10.00 ± 2.51 a	4.58 ± 0.72 ab
Cruiser® seed tmt 5FS 0.3 mg/seed	0.80 ± 0.36 a	2.55 ± 1.61 b	6.60 ± 2.66 a	3.32 ± 1.40 b

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

Table 2. Damage ratings of plots in relation to thrips treatment in the Bayer trial (rated 31 May 2005). Ratings are from 1 to 5, with 1 being no damage and 5 being total destruction.

Treatment	Rating
Untreated	3.8 ± 0.29 a
Gaucho 0.375 mg AI/seed	1.8 ± 0.29 c
L0263 150 g AI/100 kg seed plus L1012 350 g AI/100 kg seed	1.9 ± 0.63 c
Cruiser® seed tmt 5FS 0.3 mg/seed	2.6 ± 0.48 b

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

The apparently contradictory abundance and damage results may indicate that the predominant thrips in the study was *Frankliniella fusca*, as this species is reported to feed less on plant tissues containing imidacloprid (Groves et al. 2001, Joost and Riley 2005). In contrast, *Frankliniella occidentalis* was reported to increase feeding when imidacloprid was present. Neither of these cited studies was conducted on cotton plants, but the same behavioral modifications also may apply to cotton. Regardless of mechanisms, it was clear that the experimental treatments significantly improved the condition of the plants, and that the Gaucho and L0263/L1012 treatments had the greatest positive impact.

Syngenta Trial: Thrips Numbers, Plant Damage

Early-planted trial. The numbers of thrips were moderate during both periods of the study, and the plants sustained considerable damage. Thrips numbers were significantly reduced in many treatments relative to the control plots on 2 of 3 sample dates (Table 3). Thrips numbers were low on the first sample date, with no significant differences. The Temik and local standard treatments generally had the fewest thrips on the 2 later sample dates (Table 3). Cruiser treatments did not differ significantly from the untreated control, except on the 2nd sample date and with the addition of A14006. Thiram combined with Temik reduced thrips numbers somewhat, but generally not as much as the Temik alone or some of the local standard treatments.

Table 3. Number of thrips per plant 12, 19, and 26 days after planting in the Syngenta trial (planted 4 May and 26 May 2005). Tift Co., GA. 2005.

Treatment/rate	Cotton Planted 4 May, 2005				Cotton planted 26 May, 2005			
	16 May	23 May	30 May	Season Avg.	6 June	13 June	20 June	Season Avg.
Untreated	0.50 ± 0.38	2.50 ± 1.00a	6.30± 4.17ab	3.10 ± 1.39 ab	2.60 ± 1.17a	5.90 ± 3.53a	1.55 ± 1.00ab	3.35 ± 1.33 a
Cruiser® seed tmt 5FS 0.3 mg/seed	0.15 ± 0.10	1.80 ± 0.99ab	7.90± 0.97a	3.28 ± 0.42 a	0. 70 ± 0.53bc	2.75 ± 1.56 ab	1.35 ± 0.85ab	1.60 ± 0.74 b
Cruiser® seed tmt 5FS 0.34 mg/seed	0.15 ± 0.19	1.20 ± 0.49bc	6.80± 1.77ab	2.72 ± 0.67 abc	1.45 ± 0.52b	1.95 ± 1.26 b	1.55 ± 0.52ab	1.65 ± 0.53 b
Cruiser® seed tmt 5FS 0.34 mg/seed plus A14006 0.15 mg/seed	0.05 ± 0.10	0.90 ± 0.53bc	4.80± 3.51abc	1.92 ± 1.19 bcde	0.75 ± 0.34 bc	1.95 ± 2.46 b	1.05 ± 0.44ab	1.25 ± 0.70 b
Temik® 15G in-furrow 3.5 lb/a	0.00 ± 0.00	0.35 ± 0.19c	1.75 ± 0.41c	0.70 ± 0.13 e	0.75 ± 0.70bc	1.50 ± 1.19 b	0.45 ± 0.44 b	0.90 ± 0.66 b
Temik® 15G in-furrow 5 lb/a	0.25 ± 0.25	0.30 ± 0.12c	1.55 ± 0.91c	0.70 ± 0.23 e	0.55 ± 0.30bc	0.65 ± 0.55 b	0.40 ± 0.16 b	0.53 ± 0.20 b
Thiram 41 GA/100 kg seed plus Temik® 15G in-furrow 5 lb/a	0.20 ± 0.28	1.20 ± 0.99bc	3.20 ± 3.92bc	1.53 ± 1.66 cde	0.50 ± 0.20c	1.05 ± 0.57 b	0.50 ± 0.35 b	0.68 ± 0.30 b

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

The damage ratings reflected the thrips numbers (Table 4), with the greatest damage in the control plots, and the least damage expressed in the Temik and local standard treatments. The high-rate Cruiser treatments also suffered significantly less damage than did the control plots.

Table 4. Damage ratings of plots in relation to thrips treatment and planting date in the Syngenta trials (rated 31 May and 27 June for planting dates of 4 May and 26 May, respectively). Ratings are from 1 to 5, with 1 being no damage and 5 being total destruction.

Treatment	Planting date	
	4 May	26 May
Untreated	3.9 ± 0.25 a	2.9 ± 0.25 a
Cruiser® seed tmt 5FS 0.3 mg/seed	3.3 ± 0.29 b	2.6 ± 0.48 ab
Cruiser® seed tmt 5FS 0.34 mg/seed	3.0 ± 0.41 bc	2.3 ± 0.29 bc
Cruiser® seed tmt 5FS 0.34 mg/seed plus A14006 0.15 mg/seed	2.9 ± 0.48 bcd	2.0 ± 0.41 cd
Local standard	2.4 ± 0.25 defg	2.1 ± 0.48 bcd
Local standard 1	2.0 ± 0.50 g	2.0 ± 0.00 cd
Local standard 2	2.8 ± 0.45 cde	2.2 ± 0.57 bc
Local standard 3	2.4 ± 0.48 defg	1.6 ± 0.25 de
Temik® 15G in-furrow 3.5 lb/a	2.1 ± 0.25 fg	1.4 ± 0.25 e
Temik® 15G in-furrow 5 lb/a	2.3 ± 0.29 efg	1.3 ± 0.29 e
Thiram 41 GA/100 kg seed plus Temik® 15G in-furrow 5 lb/a	2.6 ± 0.63 cdef	1.3 ± 0.29 e

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

Late-planted Trial

Thrips numbers tended to be somewhat lower in this trial than in the early-planted trial. There were significant differences among the treatments on all sample dates, with the untreated controls having the highest numbers on each day except 20 June (Table 3). The general pattern was similar to that observed in the early-planted trial, with the Temik treatments and several of the local standards typically exerting the greatest reduction in thrips populations. The Thiram+Temik treatment also performed well in this trial, although not significantly better than Temik alone.

The damage ratings were generally lower than was the case in the early-planted trial (Table 4). This is to be expected, as thrips populations tend to decline as the season progresses. Damage was lowest in the Temik and Thiram/Temik treatments, with local standard 3 comparable. Cruiser in combination with A14006 performed similar to most of the local standards, all of which were superior to the untreated control. There was an apparent rate effect with Cruiser, as the higher rate performed somewhat better than the lower rate.

Valent Trial: Thrips Numbers, Plant Damage
The numbers of thrips were rather high during the study, and the plants sustained considerable damage. Thrips numbers were significantly reduced in many treatments relative to the control plots on all sample dates (Table 5). The treatments of Venom alone numerically reduced thrips numbers relative to the controls, but were not significantly different on any sample date. The addition of Orthene to the Venom treatments resulted in generally significant reductions in thrips at the higher rates of Venom, but not at the lowest rate (75 g ai/100 lbs seed). None of the Venom treatments with Orthene performed better than Orthene alone. The V10170 alone treatments (112 and 150 g ai/100 lbs seed) did not reduce thrips numbers significantly relative to the controls. The addition of Orthene to the V10170 treatments generally reduced thrips numbers significantly. Generally, the best treatments in the trial for reducing thrips numbers were Orthene alone and Gaucho Grande.

Table 5. Number of thrips per plant 12, 19, and 26 days after planting in the Valent trial (planted 4 May 2005). Tift Co., GA. 2005.

Treatment	16 May	23 May	30 May	Season Avg.
Untreated	1.30 ± 0.20ab	6.20 ± 1.82ab	11.25 ± 5.89ab	6.25 ± 2.58ab
Venom 75 g ai/100 lb seed	0.35 ± 0.57cd	4.20 ± 2.65abcde	12.95 ± 3.69a	5.83 ± 1.85abc
Venom 150 g ai/100 lb seed	1.40 ± 0.49a	4.95 ± 1.33abcd	9.65 ± 2.66ab	5.33 ± 0.95abcd
Venom 200 g ai/100 lb seed	0.90 ± 0.53abcd	6.50 ± 0.89a	9.85 ± 4.14ab	5.75 ± 1.80abcd
Orthene 15 oz ai/100 lb seed	0.90 ± 0.12abcd	3.00 ± 0.49cde	7.10 ± 1.15bc	3.67 ± 0.28cdef
Venom 75 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	0.70 ± 0.62abcd	4.20 ± 2.54abcde	10.50 ± 1.10ab	5.13 ± 0.98abcde
Venom 150 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	0.50 ± 0.35cd	2.45 ± 1.86de	9.30 ± 2.64abc	4.08 ± 0.48bcde
Venom 200 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	0.35 ± 0.30cd	2.40 ± 1.02de	9.35 ± 2.17abc	4.03 ± 0.87bcdef
V10170 150 g ai/100 lb seed	0.80 ± 0.00abcd	3.40 ± 1.01bcde	10.85 ± 2.80ab	5.02 ± 1.22 abcde
V10170 112 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	0.25 ± 0.25d	2.60 ± 2.14cde	6.10 ± 3.26bc	2.98 ± 1.18ef
Gaucho 0.375 mg AI/seed	0.65 ± 0.41bcd	3.25 ± 2.22bcde	6.50 ± 1.00bc	3.47 ± 0.55def
Cruiser® seed tmt 5FS 0.3 mg/seed	0.90 ± 0.20abcd	4.45 ± 2.38abcde	12.95 ± 2.42a	6.10 ± 0.74ab
V10170 75 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	0.50 ± 0.38cd	3.35 ± 1.96bcde	10.00 ± 2.42ab	4.62 ± 1.04abcde
V10170 150 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	0.70 ± 0.50abcd	2.30 ± 2.02de	8.25 ± 4.12abc	3.75 ± 1.74cdef
V10170 112 g ai/100 lb seed	1.05 ± 0.74abc	5.65 ± 2.38abc	13.70 ± 5.80a	6.80 ± 2.35a

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

Damage ratings were significantly different among treatments on 31 May, but only the Gaucho treatment differed significantly from the control (Table 6). Damage in all plots was moderate to heavy, and the damage in the control plots was numerically highest, despite the lack of statistical significance.

Table 6. Damage ratings of plots in relation to thrips treatment in the Valent trial (rated 31 May 2005). Ratings are from 1 to 5, with 1 being no damage and 5 being total destruction.

Treatment	Damage rating
Untreated	3.8 ± 0.29 a
Venom 75 g ai/100 lb seed	3.4 ± 0.25 a
Venom 150 g ai/100 lb seed	3.5 ± 0.00 a
Venom 200 g ai/100 lb seed	3.6 ± 0.25 a
Orthene 15 oz ai/100 lb seed	3.5 ± 0.00 a
Venom 75 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	3.1 ± 0.75 ab
Venom 150 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	3.3± 0.29 a
Venom 200 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	3.0 ± 0.41 ab
V10170 150 g ai/100 lb seed	3.3 ± 0.29 a
V10170 112 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	3.3 ± 0.29 a
Gaucho 0.375 mg AI/seed	2.4 ± 0.63 b
Cruiser® seed tmt 5FS 0.3 mg/seed	3.3 ± 0.87 a
V10170 75 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	3.1 ± 0.25 ab
V10170 150 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	3.0 ± 0.71 ab
V10170 112 g ai/100 lb seed	3.6 ± 0.25 a

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

Bayer Trial: Boll Opening and Yield

There was considerable variability in the data for boll opening, which necessitated a transformation of the data before analysis (arcsin√x). The results presented are back-transformed. The percentage of open bolls was determined on 12 October, and between 70 and 80% of the bolls had opened in all treatments, with no significant differences among them (Table 7). Thus, by this point in the season, there was no developmental advantage resulting from the various thrips treatments. An earlier assessment may have indicated differences. However, we had an exceptionally warm and dry late summer and early fall that were ideal for boll maturation. The results quite likely would differ in a more “normal” year.

The cotton was harvested on 14 November, and there were no significant differences among treatments for yields (Table 7). The Gaucho treatment was numerically highest, but all of the treatments were similar in their yields.

Table 7. Percent of bolls open on 12 October and yield (lbs seed cotton/acre) in the Bayer trial at harvest on 14 November in relation to thrips treatment. Tift Co., GA. 2005.

Treatment	% open bolls	Yield/acre
Untreated	79.9 ± 5.9	2773.3 ± 366.4
Gaucho 0.375 mg AI/seed	79.1 ± 14.9	3056.5 ± 592.4
L0263 150 g AI/100 kg seed plus L1012 350 g AI/100 kg seed	73.8 ± 8.8	2628.1 ± 585.5
Cruiser® seed tmt 5FS 0.3 mg/seed	75.3 ± 6.6	2668.0 ± 87.4

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

Syngenta Trial: Boll Opening and Yield

Percentage of open bolls was similar among all treatments for the first planting date, and quite variable among treatments on the second planting date, with only the Temik 3.5 lb treatment (highest percentage) and the Cruiser treatment (lowest percentage) being significantly different (Table 8). No other treatment effects were observed.

The cotton was harvested on 14 November for both planting dates, so that some of the later opening plots had had an opportunity for their bolls to open. As a result, there were no significant differences among treatments for yields for either planting date, despite the significant treatment effects on thrips numbers and plant damage (Table 8). There was, however, considerable variability among the treatments, and the relative rankings of the treatments were inconsistent across planting dates.

Table 8. Percent of bolls open on 11 October and yield (lbs seed cotton/acre) in the Syngenta trial at harvest on 14 November in relation to thrips treatment. Tift Co., GA. 2005.

Treatment	% open bolls		Yield/acre	
	Planted 4 May	Planted 26 May	Planted 4 May	Planted 26 May
Untreated	69.0 ± 10.6	50.6 ± 18.0 ab	1727.9	2526.5
Cruiser® seed tmt 5FS 0.3 mg/seed	67.6 ± 15.0	43.6 ± 9.7 ab	2112.7	3608.2
Cruiser® seed tmt 5FS 0.34 mg/seed	67.1 ± 17.6	38.5 ± 6.0 b	2199.8	3169.0
Cruiser® seed tmt 5FS 0.34 mg/seed plus A14006 0.15 mg/seed	68.0 ± 4.7	45.1 ± 9.9 ab	2145.3	2047.3
Temik® 15G in-furrow 3.5 lb/a	64.8 ± 6.5	56.2 ± 9.5 a	1960.2	2762.4
Temik® 15G in-furrow 5 lb/a	64.6 ± 13.9	42.9 ± 6.0 ab	2036.4	2384.9
Thiram 41 GA/100 kg seed plus Temik® 15G in-furrow 5 lb/a	61.1 ± 10.4	41.4 ± 7.5 ab	2141.7	2958.5

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

Valent Trial: Boll Opening and Yield

Boll opening was delayed in the control plots relative to some of the other treatments (Table 9). Boll opening in the Venom only and the V10170 only plots was generally not significantly different from the controls (except V10170 112 g ai/100 lbs seed). The plants were most advanced in the Cruiser and Gaucho Grande plots, as well as the some of the Venom and V10170 treatments where Orthene was added. There was considerable variability in the data for boll opening.

The cotton was harvested on 14 November, so that some of the later opening plots had had an opportunity for their bolls to open. As a result, there were no significant differences among treatments for yields (Table 9). The addition of Orthene to Venom and V10170 produced variable results, with some yields increasing (Venom 75g and Venom 200g, and V10170 150g) and others decreasing (Venom 150g and V10170 112g). However, none of these differences were statistically significant. The Cruiser and Gaucho Grande treatments yielded comparable to the other treatments, although numerically they were among the highest yielding treatments.

Table 9. Percent of bolls open on 24 October and yield (lbs seed cotton/acre) in the Valent trial from harvest on 14 November in relation to thrips treatment. Tift Co., GA. 2005.

Treatment	% open bolls	Yield (lbs seed cotton/acre)
Untreated	34.2 ± 5.2 d	1836.8 ± 742.0
Venom 75 g ai/100 lb seed	42.9 ± 13.1 bcd	1851.3 ± 726.0
Venom 150 g ai/100 lb seed	48.5 ± 14.4 abcd	2580.9 ± 978.8
Venom 200 g ai/100 lb seed	40.6 ± 6.1 cd	1786.0 ± 301.6
Orthene 15 oz ai/100 lb seed	50.9 ± 10.9 abcd	2243.3 ± 520.9
Venom 75 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	62.7 ± 7.6 a	2733.4 ± 704.5
Venom 150 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	39.2 ± 2.7 cd	1600.8 ± 317.8
Venom 200 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	54.5 ± 18.7 abc	2439.4 ± 926.9
V10170 150 g ai/100 lb seed	38.5 ± 10.0 cd	2123.6 ± 435.3
V10170 112 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	42.9 ± 7.8 bcd	1775.1 ± 332.4
Gaucho 0.375 mg AI/seed	53.8 ± 9.7 abc	2417.6 ± 969.1
Cruiser® seed tmt 5FS 0.3 mg/seed	58.3 ± 15.8 ab	2642.6 ± 1013.2
V10170 75 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	44.1 ± 4.4 bcd	2156.2 ± 781.2
V10170 150 g ai/100 lb seed plus Orthene 15 oz ai/100 lb seed	49.0 ± 11.8 abcd	2580.9 ± 1157.7
V10170 112 g ai/100 lb seed	42.6 ± 4.8 bcd	2301.4 ± 364.5

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

Conclusions

In most instances, the various seed treatments reduced thrips numbers, some significantly. Temik® performed well in the Valent and Syngenta trials (Tables 2, 3).

Gaucho Grande® also performed reasonably well in the Valent trial, where thrips pressure was the greatest, as did those treatments to which Orthene® was added in the same trial (Table 3). In the Bayer trial, all of the experimental treatments yielded comparable suppression (Table 1). In the Syngenta trial, Temik provided the greatest level of suppression, and the low rate of Cruiser® provided somewhat more variable levels of suppression than did the higher rate (Table 2). The addition of A14006 to the high rate of Cruiser® tended to improve overall suppression in the Syngenta trial for both planting dates. The late-planted Syngenta trial experienced thrips numbers slightly more than the early-planted trial the first two weeks, but pressure declined thereafter (Table 2), and the pattern of results was similar to that obtained in the early-planted trial. The greatest thrips numbers were encountered in the Valent trial 4 weeks post-planting (Table 3). The mechanism for this substantial difference is unclear. The thrips may exhibit a preference for Stoneville 5599 over DPL 555, or maturation rates may have differed between varieties, affecting exposure to thrips. The increased thrips pressure also may have delayed maturity in the Stoneville 5599. Though planted the same day, the Stoneville 5599 was not ready for harvest until more than two weeks after the DPL555 in the Bayer and early-planted Syngenta trials.

The timing of boll opening was significantly affected by treatments, but the pattern was not always as expected. For example, in both Syngenta trials, the percentage of open bolls in the untreated plots was at the high end on both planting dates. In contrast, the untreated plots had the lowest percentage of open bolls in the Valent trial, and this trial lagged behind the others in boll opening. Yield did not differ among treatments in any of the trials, probably due largely to the exceptionally warm, dry conditions of the fall in 2005 that allowed considerable opportunity for the plants to compensate.

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INSECTICIDE RESISTANCE MONITORING IN LEPIDOPTERAN COTTON PESTS

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Abstract

In 2005, larvae and adults of the bollworm, *Helicoverpa zea*, and the tobacco budworm, *Heliothis virescens*, were bioassayed for resistance to selected pyrethroid and carbamate insecticides.

Bollworm cultures were established from larvae collected in Tift County corn in June 2005. Tobacco budworm cultures were established from larvae collected in tobacco or cotton in June 2005 in Appling, Bacon, Coffee, Jeff Davis, Tift, Treutlen, and Ware Counties. Third instar F_1 or F_2 progeny were treated with 89.9% technical grade cyhalothrin, 92.4% technical grade cypermethrin, or 98% technical grade methomyl. Stock solutions in acetone were prepared and serially diluted to obtain the desired concentrations. Larvae were observed 72 hr post-treatment for mortality.

For adult bollworm and tobacco budworm bioassays, moths were collected in the summer of 2005 from pheromone traps placed near cotton fields in Tift, Sumter, and Decatur Counties. Tests were performed using 20 ml scintillation vials coated with an acetone solution of 92.4% technical grade cypermethrin with dosages ranging from 1 to 10 µg/vial and an acetone check. One moth was placed in each vial and survival was checked after 24 hours.

In the adult bioassays of corn earworms from three different counties, we observed elevated cypermethrin tolerance compared to previous years. For Tift County tobacco budworms, a diagnostic dosage displayed nearly 3x greater survival than in 2004 and 6x greater survival than in 2003. Similar elevated tolerance was observed in larval bioassays of corn earworms from Baker, Crisp, Seminole, and Terrell counties.

In the larval bioassays, susceptibility of all the various populations of tobacco budworms for both cyhalothrin and cypermethrin was increased in comparison with historical levels. Tift Co. F_1 and F_2 larvae were found to be ca 49x and 6x more tolerant to cyhalothrin, respectively, than the Tift Co. long-term average. For cypermethrin, they were ca 9x and 3x more tolerant to cyhalothrin, respectively, than the long-term average. Corn earworm larvae appeared more tolerant to both cypermethrin and methomyl in comparison with 2004 values and more tolerant to cypermethrin than historical levels. These results indicate that tolerance to pyrethroids in the bollworm and tobacco budworm may be increasingly widespread in Georgia, and that there is a great need for growers to utilize insecticide resistance management practices to steward these products.

Introduction

Insecticides remain the method of choice for control of lepidopteran pests in Georgia cotton, though great strides have been made during the past two decades in reducing chemical use. The successful eradication of the boll weevil combined with the planting of transgenic cotton, effective scouting, and careful crop management have all served to significantly lessen reliance on insecticides. Nevertheless, the older insecticides, particularly pyrethroids, continue to play a key role in management of pests in cotton due to their general effectiveness and low costs. Newer insecticides have become available, but their specificity tends to impose limits on their general utility, and they are more expensive to use. It is, therefore, important that we understand the susceptibility of target pests to insecticides so that we can continue to use them effectively and make appropriate management decisions to prolong the life of effective insecticides.

Since 1979, we have performed bioassays on major lepidopteran cotton pests to monitor development of insecticide resistance. In recent years, there have been increasingly frequent reports of pyrethroid failures targeting tobacco budworm in cotton and tobacco. Throughout most of the past 26 years, Georgia did not experience any widespread resistance problems, while other states did. In 2004, we documented significantly greater pyrethroid tolerance in populations of the tobacco budworm from Colquitt, Terrell, and Tift Counties than was observed in our historical dataset. We expanded the sampling area in 2005 to examine unsprayed populations of tobacco budworm from tobacco fields of south-central Georgia. Sampling insects prior to insecticide application would provide us with a baseline of susceptibility for the early generations of tobacco budworm prior to insecticidal selection. We also monitored corn earworm pheromone traps in 4 counties, and collected corn earworm larvae in several locations where pyrethroid failures were reported.

Materials and Methods

Larval Bioassays. Bollworm cultures were established from larvae collected in Tift County corn in June 2005. Tobacco budworm cultures were established from larvae collected in tobacco or cotton in June 2005 in Appling, Bacon, Coffee, Jeff Davis, Tift, Treutlen, and Ware Counties. Field-collected larvae were reared to adulthood and eggs were collected from the moths confined in 1 gal plastic containers with cheesecloth lids serving as oviposition sites. Upon hatching, neonate larvae were placed on pinto bean meal synthetic diet in 30 ml plastic cups. Both F_1 and F_2 larvae were used for the bioassays. 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. zea* basically followed protocol outlined in the ESA Standard Test Method for detection of resistance in *Heliothis* spp. (Anon. 1970). Larvae were treated with 99.2% technical grade acephate, 89.9% technical grade cyhalothrin, 92.4% technical grade cypermethrin, 98% technical grade methomyl, or 95% technical grade permethrin. 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 to present a more complete picture of dosage-response. Data were analyzed using Daum's (1970) probit analysis computer program.

Adult Bioassays. For adult tobacco budworm bioassays, moths were collected in the summer of 2005 from pheromone traps placed near a Tift Co cotton field. For adult bollworm bioassays traps were placed in the same Tift Co. location as well as adjacent to cotton fields at Branch Stations of the University of Georgia in Attapulgus (Decatur Co.) and Plains (Sumter Co.). Pheromone lures attached to each trap were replaced every two weeks. The morning of each test, the trap tops were brought to the laboratory and the moths were removed for the bioassays. The empty trap tops were then returned to the field. In all instances, bioassayed moths were trapped the previous night and never confined during the heat of the day.

Tests were performed using 20 ml scintillation vials coated with an acetone solution of 92.4% technical grade cypermethrin with dosages ranging from 1 to 10 µg/vial and an acetone check. A total volume of 0.5 ml of acetone/insecticide mixture was placed in each vial and rolled horizontally on a modified hot dog roller until the acetone had evaporated. The vials were then stored in a freezer until used. As in the larval bioassays, the amount of technical compound weighed out for the stock solution was corrected for purity. One moth was placed in each vial with the cap screwed on loosely. Percent survival was checked after 24 hours. Counts were taken for live, knocked-down (moribund), and dead moths. Only moths able to fly in a normal manner were counted as alive. Numbers assayed varied with the number of moths available and the percentage data were transformed (arcsin(√%)) prior to analysis with the General Linear Models procedure of SAS (SAS Institute 1988).

To evaluate corn earworms, we set up pheromone traps in 6 Georgia counties (Burke, Decatur, Jeff Davis, Screven, 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. In addition, Dr. Phillip Roberts collected corn earworm larvae in several cotton fields where pyrethroid applications had failed to provide acceptable results. These fields were in Baker, Crisp, Seminole, and Terrell counties. Collected larvae were held placed on diet and held in the laboratory to obtain adults. Emerged adults were set up in oviposition cages (supplied with a 5% honey water solution; 25EC, L:D 14:10) in groups of 40-60 moths. Eggs were collected from the cages as they became available. Most of the eggs were shipped to Dr. B. Rogers Leonard (Louisiana State University) for testing. We retained some eggs here, but oviposition declined quickly and we were unable to obtain enough eggs to conduct tests here. The results from Dr. Leonard are provided below.

Results and Discussion

Larval Bioassays. The ED_{50}, ED_{90}, LD_{50}, and LD_{90} values for the 2005 Tift Co. bollworm larval bioassays are presented in tables 1, 2, 3, and 4, respectively. All values for cypermethrin and methomyl were higher than the Tift Co. value for 2004. All values for cypermethrin were higher than the average of bioassays performed on Tift Co. larvae since 1983. The ED_{50} of 1.02 μg/g larval wt. was ca 4x greater than the 2004 value and ca 3x greater than the Tift Co. long term average (including 2005) of 0.87 μg/g larval wt. since testing began in 1983 (Table 1). The ED_{50} of 5.54 μg/g larval wt. for methomyl was ca 3x greater than the 2004 value and only slightly higher than the Tift Co. long term average (including 2005) of 5.52 μg/g larval wt. since testing began in 1979 (Table 1).

The ED_{50}, ED_{90}, LD_{50}, and LD_{90} values for the 2005 tobacco budworm larval bioassays are presented in tables 5, 6, 7, and 8, respectively. All values for cyhalothrin were higher (or the same in the case of the ED_{50} for Ware Co.) than the Tift Co. value for 2004, and higher still than the average of bioassays performed on Tift Co. larvae since 1985. An ED_{50} of 4.87 μg/g larval wt. was found in Tift Co. F_1 larvae and 0.56 μg/g larval wt. in Tift Co. F_2 larvae, ca 49x and 6x higher, respectively, than the Tift Co. long term average (including 2005) of 0.10 μg/g larval wt. since 1985 (Table 5). If the 2005 bioassay is not included in the long-term Tift Co. average, Tift Co. F1 larvae are ca 77x higher and Tift Co. F2 larvae are ca 9x higher. Prior to 2004, our highest Tift Co. ED_{50} was 0.13 μg/g larval wt. in 1988. Even larvae from Ware Co., which appeared the culture most susceptible to cyhalothrin, had an ED_{50} ca 3x greater than the long-term Tift Co. average. For cypermethrin, some ED_{50} values were lower than those of Tift Co. in 2004, but all were increased in comparison with the Tift Co. long-term average (including 2005) of 0.87 μg/g larval wt. since testing began in 1983 (Table 5). An ED_{50} of 7.70 μg/g larval wt. was found in Tift Co. F1 larvae and 2.44 μg/g larval wt. in Tift Co. F2 larvae, ca 9x higher and almost 3x higher, respectively, than the Tift Co. long-term average. These findings should be of special concern as it appears there is pyrethroid resistance in tobacco budworms from all counties bioassayed.

Ware Co. tobacco budworm larvae bioassayed with our carbamate insecticide, methomyl, gave an ED_{50} of 1.24 μg/g larval wt. (Table 5). This was considerably lower than Tift Co. larvae for 2004 as well as the long-term Tift Co. average (including 2005) of 7.90 μg/g larval wt. since testing began in 1979. Time and labor constraints precluded us from additional methomyl bioassays. A value of 2.84 μg/g larval wt. was observed in F2 tobacco budworm larvae from Terrell Co. bioassayed in 2004. This apparent lack of concomitant elevation of tolerance for carbamate insecticides contrasts with the findings of Zhao et al. (1996). They observed cross-resistance among both the carbamate and organophosphate insecticides in a budworm population from Louisiana. Similar cross-resistance between pyrethroids and other insecticides have also been observed elsewhere (McCaffrey 1998), but multiple pyrethroid resistance mechanisms have been reported in various heliothine species. Nevertheless, the difference between our results and those of Zhao et al. (1996) suggests that other resistance mechanisms may be present in our populations than those for at least some populations in the Midsouth.

Adult Bioassays. A diagnostic dose of cypermethrin is considered to be 10 µg/vial for *H. virescens* and 5 µg/vial for *H. zea*. At 10 µg/vial, there was 19.4% survival for Tift Co. *H. virescens*, nearly 3x greater than the 2004 value of 6.7% and 6x greater than the 2003 value of 3.2% (Table 9). At 5 µg/vial, there was 14.0% survival for *Helicoverpa zea* from Tift County compared to 3.8% from the same location last year (Table 9). Similar survival results were found for 5 µg/vial with moths from both Decatur and Sumter Counties, though far fewer trials were run to obtain them.

The corn earworms assayed by Dr. Leonard (from Baker, Crisp, Seminole, and Terrell counties) also exhibited elevated tolerance to pyrethroids, although not to the extent observed in the tobacco budworms we studied. Based on comparisons with a susceptible laboratory colony, Dr. Leonard reported the LD_{50}'s and resistance ratios (RR) for the counties as follows: Baker County LD_{50} = 0.077, RR = 1-6; Crisp County LD_{50} = 0.056, RR = 0-4; Seminole County LD_{50} = 0.091, RR = 1-7; Terrell County LD_{50} = 0.067, RR = 1-5. The LD_{50} of the susceptible populations ranged from 0.013 to 0.065.

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. 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. The magnitude of pyrethroid resistance in Georgia corn earworms is still somewhat low, but the occurrence of this phenomenon in multiple spatially disparate counties indicates that growers must be more cautious in their use of pyrethroids than has been the case in the past. Growers must be certain to use the higher labeled rates when treating corn earworm populations to eliminate heterozygous individuals. 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 observed in Georgia corn earworms may behave as the South Carolina tolerance, which disappeared the season following detection. Or it may not. 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.

Apparent pyrethroid resistance in larval and adult tobacco budworms should be viewed with great concern. Our 2005 results were the most widespread incidence of pyrethroid tolerance in the bollworm and tobacco budworm of any year to date. Future monitoring in Georgia is essential.

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Table 1. ED_{50}'s for various insecticides against Tift Co. larval *Helicoverpa zea* (CEW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	ED_{50} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cypermethrin	F_1	5	1.02	0.78 - 1.31	+0.78	+0.69	2.26 ± 0.33
Methomyl	F_2	4	5.54	3.78 - 7.44	+3.86	+0.02	2.17 ± 0.43

Table 2. ED_{90}'s for various insecticides against Tift Co. larval *Helicoverpa zea* (CEW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	ED_{90} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cypermethrin	F_1	4	3.76	2.65 - 6.62	+2.85	+2.56	2.26 ± 0.33
Methomyl	F_2	4	21.54	14.44 - 47.10	+11.84	-16.24	2.17 ± 0.43

Table 3. LD_{50}'s for various insecticides against Tift Co. larval *Helicoverpa zea* (CEW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	LD_{50} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cypermethrin	F_1	5	1.42	1.08 - 1.92	+1.11	+0.49	1.96 ± 0.30
Methomyl	F_2	4	10.49	7.33 - 15.77	+8.37	-21.59	1.91 ± 0.44

Table 4. LD_{90}'s for various insecticides against Tift Co. larval *Helicoverpa zea* (CEW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	LD_{90} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cypermethrin	F_1	5	6.44	4.12 - 13.97	+4.74	+0.99	1.96 ± 0.30
Methomyl	F_2	4	49.20	27.41 - 204.08	+26.53	-1605.23	1.91 ± 0.44

Table 5. ED_{50}'s for various insecticides against larval *Heliothis virescens* (TBW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	ED_{50} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope $\pm$ SE
Cyhalothrin							
Appling Co.	F_2	4	0.96	0.68 - 1.51	+0.68	+0.86	1.22 $\pm$ 0.22
Bacon Co.	F_2	4	1.12	0.73 - 1.78	+0.84	+1.02	1.09 $\pm$ 0.23
Jeff Davis Co.	F_2	3	0.66	0.45 - 0.99	+0.38	+0.56	1.54 $\pm$ 0.35
Tift Co.	F_1	4	4.87	2.32 – 5.47	+4.59	+4.77	1.78 $\pm$ 0.32
Tift Co.	F_2	4	0.56	0.42 - 0.72	+0.28	+0.46	1.85 $\pm$ 0.27
Ware Co.	F_2	4	0.28	0.18 - 0.41	+0.0	+0.18	1.13 $\pm$ 0.18
Cypermethrin							
Appling Co.	F_1	4	3.42	2.65 - 4.45	-2.39	+2.54	1.82 $\pm$ 0.22
Bacon Co.	F_1	5	2.84	1.93 - 4.49	-2.97	+1.96	1.02 $\pm$ 0.17
Coffee Co.	F_1	4	3.16	2.34 - 4.17	-2.65	+2.28	1.72 $\pm$ 0.23
Jeff Davis Co.	F_2	4	1.01	0.75 - 1.33	-4.80	+0.14	1.63 $\pm$ 0.19
Tift Co.	F_1	4	7.70	5.72 - 11.04	+1.89	+6.82	1.46 $\pm$ 0.22
Tift Co.	F_2	4	2.44	1.85 - 3.32	-3.37	+1.56	1.65 $\pm$ 0.25
Treutlen Co.	F_2	4	3.46	2.72 - 4.43	-2.35	+2.58	1.89 $\pm$ 0.24
Ware Co.	F_1	4	2.27	1.63 - 3.15	-3.54	+1.40	1.41 $\pm$ 0.20
Methomyl							
Ware Co.	F_2	5	1.24	0.98 - 1.56	-11.68	-6.66	2.03 $\pm$ 0.26

Table 6. ED_{90}'s for various insecticides against larval *Heliothis virescens* (TBW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	ED_{90} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cyhalothrin							
Appling Co.	F_2	4	10.65	4.83-53.04	+8.86	+10.21	1.22 ± 0.22
Bacon Co.	F_2	4	16.76	6.86-136.07	+14.97	+16.32	1.09 ± 0.23
Jeff Davis Co.	F_2	3	4.51	2.30-23.46	+2.72	+4.07	1.54 ± 0.35
Tift Co.	F_1	4	18.29	10.14-55.19	+16.50	+17.85	1.78 ± 0.32
Tift Co.	F_2	4	2.76	1.86-5.29	+0.97	+2.32	1.85 ± 0.27
Ware Co.	F_2	4	3.79	2.00-12.02	+2.00	+3.35	1.13 ± 0.18
Cypermethrin							
Appling Co.	F_1	4	17.36	11.62-32.02	-25.18	+12.32	1.82 ± 0.22
Bacon Co.	F_1	5	51.01	21.71-255.86	+8.47	+45.97	1.02 ± 0.17
Coffee Co.	F_1	4	17.47	11.55-33.52	-25.07	+12.43	1.72 ± 0.23
Jeff Davis Co.	F_2	4	6.15	4.21-10.55	-36.39	+1.11	1.63 ± 0.19
Tift Co.	F_1	4	57.71	31.98-159.71	+15.17	+52.67	1.46 ± 0.22
Tift Co.	F_2	4	14.66	8.83-35.52	-27.88	+9.62	1.65 ± 0.25
Treutlen Co.	F_2	4	16.52	11.25-29.96	-26.02	+11.48	1.89 ± 0.24
Ware Co.	F_1	4	18.46	10.77-45.39	-24.08	+13.42	1.41 ± 0.20
Methomyl							
Ware Co.	F_2	5	5.31	3.83-8.72	-84.20	-89.52	2.03 ± 0.26

Table 7. LD_{50}'s for various insecticides against larval *Heliothis virescens* (TBW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	LD_{50} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cyhalothrin							
Appling Co.	F_2	4	1.73	1.04 - 4.89	+1.38	+1.45	0.91 ± 0.22
Bacon Co.	F_2	4	2.28	1.36 - 6.21	+1.93	+2.00	0.86 ± 0.22
Jeff Davis Co.	F_2	3	1.09	0.72 - 2.34	+0.74	+0.81	1.30 ± 0.34
Tift Co.	F_1	4	5.74	3.56 – 10.71	+5.39	+5.46	1.43 ± 0.28
Tift Co.	F_2	4	1.19	0.86 - 1.81	+0.84	+0.91	1.34 ± 0.23
Ware Co.	F_2	4	0.51	0.32 - 0.84	+0.16	+0.23	0.91 ± 0.17
Cypermethrin							
Appling Co.	F_1	4	5.85	4.50 - 8.00	-2.78	+1.20	1.70 ± 0.20
Bacon Co.	F_1	5	3.90	2.63 - 6.68	-4.73	-0.75	0.99 ± 0.16
Coffee Co.	F_1	4	4.59	3.45 - 6.16	-4.04	-0.06	1.67 ± 0.23
Jeff Davis Co.	F_2	4	1.44	1.09 - 1.89	-7.19	-3.21	1.67 ± 0.19
Tift Co.	F_1	4	11.78	8.36 - 19.29	+3.15	+7.13	1.36 ± 0.22
Tift Co.	F_2	4	4.32	3.27 - 6.31	-4.31	-0.33	1.77 ± 0.27
Treutlen Co.	F_2	4	6.02	4.55 - 8.53	-2.61	+1.37	1.58 ± 0.22
Ware Co.	F_1	4	3.13	2.26 - 4.53	-5.50	-1.52	1.31 ± 0.18
Methomyl							
Ware Co.	F_2	5	2.70	1.48 - 7.36	-10.72	-29.69	1.95 ± 0.45

Table 8. LD_{90}'s for various insecticides against larval *Heliothis virescens* (TBW) at 72 hr post-treatment. 2005.

Chemical	Gen.	No. Reps	LD_{90} (µg/g larval wt.)	95% C.I.	Change (+/-) from Tift Co. 2004	Change (+/-) from Tift Co. avg	Slope ± SE
Cyhalothrin							
Appling Co.	F_2	4	44.48	11.06-1,920.95	+41.61	+41.21	0.91 ± 0.22
Bacon Co.	F_2	4	68.96	16.26-4,976.83	+66.09	+65.69	0.86 ± 0.22
Jeff Davis Co.	F_2	3	10.54	3.90-213.44	+7.67	+7.27	1.30 ± 0.34
Tift Co.	F_1	4	45.38	20.27-243.45	+42.51	+42.11	1.43 ± 0.28
Tift Co.	F_2	4	10.78	5.37-40.95	+7.91	+7.51	1.34 ± 0.23
Ware Co.	F_2	4	13.22	5.01-95.66	+10.35	+9.95	0.91 ± 0.17
Cypermethrin							
Appling Co.	F_1	4	33.13	20.58-68.78	-58.89	-66.95	1.70 ± 0.20
Bacon Co.	F_1	5	76.56	29.82-458.80	-15.46	-23.52	0.99 ± 0.16
Coffee Co.	F_1	4	26.81	16.89-56.67	-65.21	-73.27	1.67 ± 0.23
Jeff Davis Co.	F_2	4	8.49	5.76-14.87	-83.53	-91.59	1.67 ± 0.19
Tift Co.	F_1	4	103.38	49.19-410.97	+11.36	+3.30	1.36 ± 0.22
Tift Co.	F_2	4	22.99	13.18-61.65	-69.03	-77.09	1.77 ± 0.27
Treutlen Co.	F_2	4	39.12	22.45-100.49	-52.9	-60.96	1.58 ± 0.22
Ware Co.	F_1	4	29.68	15.97-83.97	-62.34	-70.40	1.31 ± 0.18
Methomyl							
Ware Co.	F_2	5	12.26	5.31-372.59	-80.86	-747.21	1.95 ± 0.45

Table 9. Percent survival at 24 hr post-treatment of Tift Co. adult *Heliothis virescens* and *Helicoverpa zea* in glass vial cypermethrin bioassays. Tifton, GA, 2005.

Dosage (µg/vial)	*H. zea*			*H. virescens*		
	No. of trials	Total No. of moths	% Survival ± SD	No. of trials	Total No. of moths	% Survival ± SD
10	19	222	1.6 ± 2.5	13	83	19.4 ± 4.9
5	19	222	14.0 ± 4.1	13	83	50.9 ± 3.7
1	19	222	41.8 ± 4.0	13	82	58.1 ± 4.7
0	19	232	89.2 ± 0.3	13	83	82.6 ± 1.1

Table 10. Percent survival at 24 hr post-treatment of Attapulgus and Plains, GA adult *Heliothis zea* in glass vial cypermethrin bioassays. Tifton, GA, 2005.

Dosage (µg/vial)	*H. zea* - Attapulgus			*H. zea* - Plains		
	No. of trials	Total No. of moths	% Survival	No. of trials	Total No. of moths	% Survival ± SD
10	1	20	0.0	3	69	1.1 ± 3.3
5	1	20	15.0	3	69	15.2 ± 11.4
1	1	20	25.0	3	69	34.8 ± 5.6
0	1	20	95.0	3	69	81.2 ± 0.8

INFLUENCE OF STINK BUG DAMAGE ON FIBER QUALITY OF MACHINE PICKED COTTON GINNED AT THE UGA MICROGIN

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Introduction

Boll feeding bugs have elevated in pest status during recent years due primarily to the reduction of broad spectrum insecticide use. Successful elimination of the boll weevil as an economic pest and utilization of Bt transgenic cottons have eliminated the need for boll weevil and tobacco budworm insecticide sprays and significantly reduced the number of applications for corn earworm. Additionally, selective insecticides which have no activity on bug pests are being used to a greater degree. Sucking bug pests such as stink bugs and plant bugs have exploited this low insecticide use environment.

Stink bugs and tarnished plant bugs are the most common sucking bug pests infesting cotton in the southeast. Stink bugs are primarily boll feeders and capable of damaging bolls 25 days past anthesis (Greene 2001, Willrich 2004). Historically tarnished plant bug feeding on bolls has not been considered a major source of yield loss; however tarnished plant bugs can damage bolls in the early stages of development (Gore and Cachot 2005, Russell et al. 1999, Horn et al. 1999). Excessive bug damage on small bolls may cause abscission, whereas bolls may remain on the plant when damage is limited or inflicted on older bolls. In Georgia, the most common boll feeding bugs include the southern green stink bug and the brown stink bug. Additional boll feeding bugs occasionally observed include the green stink bug, several *Euschistus* species, tarnished and clouded plant bugs, and leaf-footed bugs.

Stink bugs damage developing cotton bolls by piercing the boll wall and feeding on or near the developing seed. Callous growths or warts form on the inner surface of the boll wall at the feeding site within 48 hrs (Bundy et al. 2000). Stained lint may also be associated with stink bug feeding. The objective of these trials was to generate seedcotton samples of varying levels of stink bug damage allowing for inferences to be made on the relationship of stink bug damage on fiber quality.

Methods

Replicated field trials were established at various locations in Georgia during 2005 which included bug protected (weekly insecticide applications) and unprotected plots and in some locations one or more intermediate treatments such as protection at various plant phenology stages or a 20% internal boll damage threshold. Plots ranged in size from 6 rows wide and 40 feet in length to 36 rows wide and 125 feet in length. At some locations, trials were established in high risk areas for bug infestations, i.e. near or in peanut plantings, to assure damaging stink bug infestations.

Data Collection: Plant and pest based sampling procedures were conducted to varying degrees depending upon the objective of individual trials (Table 1). Pest based sampling procedures included the use of a drop cloth to sample and quantify species of boll feeding bugs on 12 row feet per plot. Plant based sampling procedures included internal boll injury, symptoms of external boll injury and internal lint staining, square retention, and dirty or damaged white blooms.

Table 1. Plant and pest based data collected in respective boll feeding bug trials (Georgia 2005).

	Boll Injury						
Trial	Internal Injury	External Stain/Rot	Year End	Drop Cloth	Square Retention	Dirty Blooms	Lint Fraction
RDC	x		x				x
ABAC	x	x	x				x
TVP	x	x	x	x	x	x	x
PD1	x	x	x	x	x	x	x
PD2	x	x	x	x	x	x	x
EXPO	x						x
Scout School	x						x
Hardlock	x		x				x
Pheno #1	x	x	x	x	x	x	x
Pheno #2			x				

Fiber Quality: All plots were machine picked and seedcotton was ginned at the University of Georgia MicroGin to obtain lint fractions for determining lint yields per acre. The University of Georgia MicroGin is a small scale gin which processes cotton consistent with commercial ginning practices. Lint samples were submitted to Cotton Incorporated for HVI and AFIS fiber quality analysis.

Variability in the Relationship Between Bug Damaged Bolls and Yield: Year end boll damage assessments were conducted by collecting 100 bolls from each plot which comprised a representative sample of harvestable bolls at first open boll. Bolls were examined for internal bug damage. Bolls were considered damaged if a callous growth or wart was observed on the inner surface of the boll wall and/or stained lint was present. No attempts were made to quantify the number of callous growths or the degree of stained or rotten lint for this analysis. Due to the large amount of bolls to examine and the time required for examination, bolls were often frozen for a period of time prior to making damage evaluations. Regression equations were generated for percent of maximum yield against percent year end internal boll damage for each trial. The y-intercept (percent of maximum yield) was set at 100 percent. Treatment means for all trials were also combined and a similar regression equation was generated.

Results

Yields: Stink bug populations were light to heavy depending on location and treatment. Untreated and bug protected plots were included in eight of the nine trials conducted during 2005. Yields were increased in protected plots for an average yield increase of 542 lbs. lint per acre (Table 2). Yield increases ranged from 222 to 842 lbs. lint per acre in protected compared with untreated plots.

Table 2. Trial name, location, variety, lint yield, and number of insecticide applications applied (#) for respective boll feeding bug treatments. Insecticide applications included Bidrin at 8 ozs./acre or Bidrin at 8 ozs./acre plus Baythroid at 3.2 ozs./acre.

			Treatments			
Trial	County	Variety	Untreated	Threshold	Protected	Other
[p]RDC	Tift	DP 555BR	791		1294 (7)	
ABAC	Tift	PHY 470WR	1060	1303 (2)	1311 (8)	1375 (3)
TVP	Tift	DP 555BR	773	1541 (3)	1584 (5)	
[p]PD1	Sumter	DP 543BGIIRR	523	1168 (4)	1335 (7)	
[p]PD2	Sumter	DP 543BGIIRR	556	855 (1)	1123 (5)	
EXPO	Colquitt	DP 543BGIIRR	949	1336 (2)		1372 (3), 1417 (3)
Scout School	Tift	DP 444 BR	862		1088 (4)	
Hardlock	Colquitt	DP 555BR	635		1142 (4)	
[p]Pheno#1	Tift	DP 543BGIIRR	452		1294 (4)	1318 (6), 1169 (5), 1144 (4), 957 (3)
Pheno#2	Tift	DP 543BGIIRR	1718		1665 (7)	1687 (6), 1884 (5), 1738 (4), 1721 (3), 1540 (2), 1360 (1)

[p] The RDC, PD1, PD2, and Pheno#1 trials were established in or immediately adjacent to peanuts.

Untreated, 20 percent internal boll damage threshold, and protected treatments were included in four trials. Yields were significantly greater in the threshold and protected treatments compared with the untreated. Although not significantly different, yields were numerically lower in the threshold treatments, 1217 lbs. lint per acre, compared with protected treatments, 1338 lbs. lint per acre. Threshold treatments required an average of 2.5 insecticide applications compared with protected plots which were treated 6.25 times on average.

Pest Based Sampling Procedures: A complex of boll feeding bugs was sampled and included tarnished and clouded plant bugs, southern green, brown, and green stink bugs, and several *Euschistus* species. Stink bugs were the predominant boll feeding bugs sampled; plant bugs generally comprised a minor percentage of the bug complex. The most common stink bugs observed were the southern green and brown.

Plant Based Sampling Procedures: Internal boll damage appeared to be the most reliable plant based sampling procedure for stink bugs compared with square retention and dirty blooms. Although small differences in square retention and dirty blooms were present between untreated and protected plots; damage rarely approached the threshold levels of 80 percent square retention and 15 percent dirty blooms in the presence of high stink bug infestations. Internal boll damage commonly exceeded the 20 percent threshold in untreated plots.

Fiber Quality: Eight of the nine trials which included untreated and protected treatments conducted in Georgia have been ginned at the University of Georgia MicroGin. HVI data has been received from Cotton Incorporated but AFIS fiber quality analysis is still ongoing. Means from the eight trials for untreated and protected treatments for HVI parameters as well as lint yield and lint fraction are presented in Table 3. T-tests were conducted on trial means for untreated and protected treatments. Both yield and percent lint were greater in protected treatments compared with untreated. Significant differences were observed for all HVI quality measures with the exception of strength. Micronaire was lower in untreated and is most likely due to immature fibers resulting from feeding damage and/or delayed maturity. Staple and uniformity were improved by 0.49 and 0.47 units respectively in the protected treatment. Reflectance was reduced and yellowness increased in the untreated compared with protected treatments. AFIS fiber quality data are included in Table 4. These differences represent a worst case scenario in that few farmers would not treat stink bug infestations which would cause yield losses in excess of 500 lbs. However, these data do suggest that stink bug damage can reduce fiber quality which is machine picked and ginned by processes similar to commercial ginning practices. Our intention is to correlate the various fiber quality measures to year end boll damage as we have done with yields.

Table 3. Lint yield, lint fraction, and HVI measures for untreated and protected treatments in eight trials conducted (Georgia 2005)

	Untreated	Protected	Prob t
Lint (lbs/acre)	707	1271	0.0001
Percent Lint	35.89	37.12	0.0013
Micronaire	4.26	4.49	0.0026
Staple (32nds)	35.72	36.21	0.0002
Uniformity	81.39	81.86	0.0022
Strength	30.00	29.90	0.2812
Reflectance	76.15	78.63	0.0001
Yellowness	8.87	8.03	0.0005

Variability in the Relationship Between Bug Damaged Bolls and Yield: Bug damaged bolls and yield losses ranged from low to high in the various treatments and trials conducted during 2005. Examination of bolls for internal boll damage was time consuming since many of the bolls were approaching maturity and difficult to manually open. Older bolls which had been frozen and thawed were much easier to open, i.e. could be easily squashed between your thumb and forefinger. Originally, freezing bolls was used to preserve the integrity of the boll, but fortunately it also allowed for easier examination.

Stink bug populations and bug damaged bolls were moderate to high at all Georgia locations during 2005. Regression equations for individual trials indicated that for one percent year end boll damage 0.5767, 0.6261, 0.6899, 0.7724, 0.8085, 0.8386, 1.1134, and 1.1434 percent yield loss would occur. When all trials from Georgia were combined and percent maximum yield in a trial was regressed against percent boll damage for respective treatments the subsequent equation was y = -0.8353x+100 (y=percent of maximum yield and x=percent boll damage) with an R^2 of 0.8233 (Figure 1).

Table 4. Lint yield, lint fraction, and AFIS measures for untreated and protected treatments in eight trials conducted (Georgia 2005)

	Untreated	Protected	Prob t
Lint (lbs/acre)	707	1271	0.0001
Percent Lint	35.89	37.12	0.0013
Nep size (um)	707	692	0.0043
Neps per Gm	325	249	0.0014
L(w) [in]	0.9624	0.9949	0.0004
L(w) CV [%]	36.09	34.30	0.0005
UQL (w) [in]	1.18	1.20	0.0015
SFC (w) [%]	10.68	8.86	0.0005
L(n) [in]	0.6989	0.7461	0.0002
L(n) CV [%]	61.58	57.50	0.0003
SFC (n) [%]	35.59	31.15	0.0003
L5% (n) [in]	1.32	1.34	0.0006
Total Cnt/g	441	329	0.0036
Trash Size [um]	374	373	0.4286
Dust Cnt/g	349	260	0.0042
Trash Cnt/g	91.42	68.49	0.0042
VFM [%]	1.97	1.40	0.0025
SCN Size (um)	1067	1090	0.0257
SCN (Cnt/g)	27.17	18.52	0.0016
Fine [mTex]	164	168	0.0112
IFC [%]	5.68	5.09	0.0021
Mat Ratio	0.8948	0.9089	0.0012

Yield response to percent of year end bug damaged bolls varied by trial. A two fold difference in yield response to bug damaged bolls occurred among trials. Reasons for variability in yield response to percent year end bug damaged bolls are not fully understood. Bolls were scored as damaged or undamaged and obviously the degree of injury will vary greatly from single feeding sites to multiple feeding sites and boll rot for damaged bolls. Perhaps the species complex present in individual trials creates variability in yield response to boll damage. Various species of stink bugs, tarnished and clouded plant bugs, leaf-footed bugs, and other bugs are capable of causing warts or callous growths on the inner surface of the boll wall and may impact yield differently. Other potential explanations of variability include spatial and temporal distribution of damage on plants, variety, growing conditions, and compensation ability of plants. There are also questions on how bug damage manifests itself in a developing boll. In some situations we observe severe boll rots associated with stink bug damage whereas in others an individual lock may fail to fluff. These data demonstrate that the percent of harvestable bolls which exhibit internal signs of bug feeding is correlated to yield and that variability among locations exists.

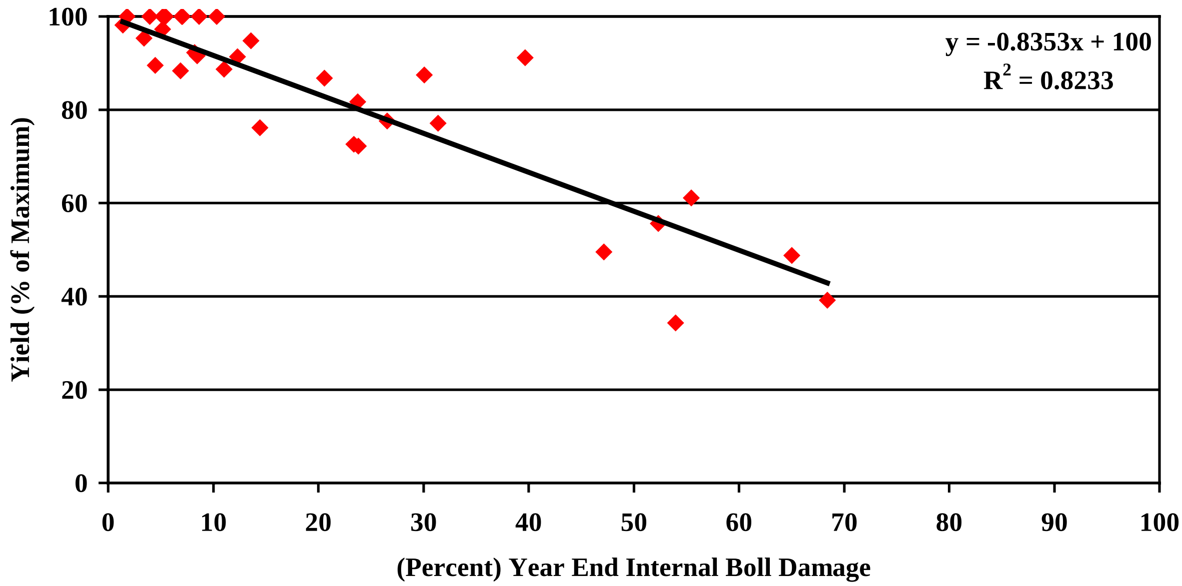

Figure 1. Percent of maximum yield in individual trials and percent year end boll damage for bug protected, unprotected, and intermediate bug protection treatments in Georgia during 2005.

Additional studies will be conducted during 2006 to build upon the current database which will allow for greater precision of correlating sampling procedures, yield, and fiber quality with bug damage.

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CONTROL OF EARLY SEASON THRIPS WITH SELECTED INSECTICIDES

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Introduction

Thrips are predictable pests of seedling cotton and failure to use a preventive treatment will require the use of foliar sprays for thrips which are typically less effective than at-plant treatments. Thus, the majority of cotton planted in Georgia receives a preventive systemic insecticide for control of early season thrips. Various preventive treatments provide a range of thrips control and residual activity. Herbicide tolerant cottons allow opportunity for foliar thrips insecticides to be tank-mixed with herbicides. Growers have questions about the value of supplemental foliar thrips insecticide applications when various preventive treatments have been used. The objective of these trials was to evaluate selected preventive thrips insecticides and also the value of supplemental foliar thrips insecticides applied at the one and five leaf stage.

Methods

Small plot replicated field trials were established in Tift County, GA at the RDC Pivot on the Coastal Plain Experiment Station and on the ABAC farm. Plots were 2 rows wide, 40 feet in length, and arranged in a split plot design with four replications at the RDC location with at-plant insecticides as the main plots and foliar sprays as subplots. Foliar sprays (Orthene 97 at 3 ozs/acre) were applied on May 19 (1 true leaf) and June 1 (5 true leaves). Plots were of similar size and arranged in a randomized complete block design with four replications at the ABAC site. Plots were seeded with a cone planter on May 3, 2005 at both locations. A Roundup Ready Flex Bollgard II variety was used at the RDC location and DP 555 BG/RR was used at the ABAC site.

Thrips populations were sampled at 2, 3, and 4 weeks after planting by randomly collecting five seedlings per plot and immediately immersing and swirling in a container filled with 70 percent ETOH to dislodge thrips. Adult and immature thrips were then counted in the laboratory with a dissecting microscope. Visual damage ratings were made for individual plots at 3 and 4 weeks after planting. A rating scale of 1-5 was used where 1=no damage, 2=slight damage, 3=moderate (acceptable damage), 4=heavy damage, and 5=severe damage. Mean plant heights were assessed at 4 weeks after planting by measuring 10 plants per plot. Plots were machine harvested on September 8 and 22 at the RDC and ABAC locations respectively.

Results

Thrips populations were moderate at the ABAC location, exceeding 10 plants per plot at 3 WAP in untreated plots (Table 1). All treatments significantly reduced immature thrips per five plants at 2 and 3 WAP compared with the untreated, however only Temik treatments significantly reduced thrips at 4 WAP compared with the untreated. STAN (abamectin, nematicide seed treatment) provided limited, but statistically significant, control of immature thrips at 2 and 3 WAP. Differences were observed in damage ratings at 3 and 4 WAP, but insecticides typically provided acceptable control. Most treatments significantly increased yield compared with the untreated.

Table 1. Thrips infestations, and damage ratings, plant heights, and lint yields for selected thrips control programs, Tift County GA (ABAC) 2005.

DP 555 BG/RR Planted May 3, 2005			Immature Thrips per Five Plants			Damage Rating (1-5)		Plant Height (cm)	Lint/a (lbs)
Treatment Name		Rate Unit	May 17	May 24	May 31	May 24	May 31	May 31	Sep 22
1	Untreated		8.00	73.50	40.50	3.88	4.50	15.50	1359
2	STAN	0.15 mg ai/seed	4.00	33.50	40.00	3.63	4.00	17.50	1615
3	Cruiser	0.3 mg ai/seed	0.25	25.25	53.50	2.50	3.13	18.48	1554
4	Cruiser	0.34 mg ai/seed	0.50	20.00	59.75	2.25	3.13	18.88	1687
5	Cruiser Diamond	0.3 mg ai/seed	0.50	25.25	72.50	2.25	3.00	18.35	1605
6	Cruiser Diamond	0.34 mg ai/seed	1.75	13.75	49.00	2.00	3.00	18.50	1512
7	Cruiser	0.34 mg ai/seed	1.75	16.50	56.00	2.00	3.13	18.80	1593
	+ STAN	0.15 mg ai/seed							
8	Cruiser Diamond	0.34 mg ai/seed	1.00	18.75	50.25	1.75	3.00	18.75	1686
	+ STAN	0.15 mg ai/seed							
9	Gaucho	250 g ai/100 kg	1.00	45.25	52.25	2.13	3.38	18.48	1588
10	Temik	4 lb/a	0.00	3.25	16.75	1.00	1.63	20.23	1578
11	Temik	5 lb/a	0.25	3.50	15.75	1.00	1.38	20.35	1689
		LSD (P=0.05)	1.70	14.56	19.68	0.33	0.29	1.29	193

Thrips populations were moderate to heavy at the RDC location, exceeding 10 immature thrips per plant at 3 and 4 weeks after planting (WAP) in untreated plots (Table 2). Only immature thrips are reported since immature thrips are considered a better measure of insecticide efficacy compared with adult or total thrips counts. All insecticide treatments including Temik 15G at 3.5 lbs/acre, Cruiser seed treatment, and Orthene 97 treated seed at 22.5 ozs per cwt significantly reduced immature thrips per five plants at 2 and 3 WAP compared with the untreated. However, only Temik significantly reduced immature thrips at 4 WAP compared with the untreated. At four weeks after planting, foliar Orthene applications at the 1 leaf stage significantly reduced immature thrips compared with the untreated. A significant at-plant by foliar insecticide interaction also occurred at 4 WAP. Immature thrips were significantly reduced by the Orthene spray in untreated and Cruiser plots, but populations were similar regardless of Orthene sprays in Temik plots. Thrips damage ratings and mean plant heights followed similar trends as immature thrips counts. All at-plant insecticide treatments numerically increased yield compared with the untreated, however only Temik and Cruiser treatments significantly improved yield. Temik treatments were significantly greater than Cruiser treatments at this location. Orthene foliar sprays tended to increase yields in untreated, Cruiser, and

Orthene seed treatments. There appeared to be no yield benefit of treating cotton with Orthene at the 1 and 5 leaf stage compared with only at the 1 leaf stage.

Table 2. Thrips infestations, and damage ratings, plant heights, and lint yields for selected thrips control programs, Tift County GA (CPES RDC Pivot) 2005.

Planted May 3, 2005		Immature Thrips per Five Plants			Damage Rating (1-5)		Plant Height (cm)	Lint/a (lbs)
Treatment Name		May 17	May 24	May 31	May 24	May 31	May 31	Sep 8
Factorial/Pooled Error AOV (Prob (F)								
At-Plant Insecticides		***	***	***	***	***	***	***
Foliar Insecticides		*	*	***	***	***	**	*
At-Plant by Foliar		**	n.s.	***	n.s.	***	n.s.	n.s.
At-Plant Insecticide Means								
No At-Plant		13.04	39.69	32.11	3.56	3.68	12.88	735
Temik 15G		1.25	3.25	23.25	1.08	1.42	14.67	932
Cruiser		0.92	11.58	38.92	1.92	2.33	14.67	850
Orthene ST		0.84	4.19	16.65	1.73	1.94	14.06	804
	LSD (P=0.05)	2.02	18.88	9.96	0.20	0.26	0.62	77
Foliar Insecticide Means								
No Foliar		2.81	23.88	46.75	2.25	2.81	13.65	785
Foliar 1 leaf		4.60	6.09	17.63	2.00	2.08	14.29	862
Foliar 1 & 5 leaf		4.63	14.06	18.81	1.97	2.13	14.27	844
	LSD (P=0.05)	1.75	16.35	8.62	0.18	0.18	0.53	67
At-Plant by Foliar Means								
No At Plant	No Foliar	7.50	71.75	68.75	4.00	4.50	12.00	645
No At Plant	Foliar 1 leaf	15.62	9.81	12.07	3.32	3.28	13.39	834
No At Plant	Foliar 1 & 5 leaf	16.00	37.50	15.50	3.38	3.25	13.25	727
Temik	No Foliar	0.50	3.75	25.00	1.13	1.63	14.42	953
Temik	Foliar 1 leaf	2.25	2.50	22.50	1.13	1.25	14.83	904
Temik	Foliar 1 & 5 leaf	1.00	3.50	22.25	1.00	1.38	14.75	938
Cruiser	No Foliar	1.75	15.25	69.75	2.00	2.88	14.33	798
Cruiser	Foliar 1 leaf	0.25	10.00	22.00	1.88	2.13	14.92	886
Cruiser	Foliar 1 & 5 leaf	0.75	9.50	25.00	1.88	2.00	14.75	865
Orthene ST	No Foliar	1.50	4.75	23.50	1.88	2.25	13.83	744
Orthene ST	Foliar 1 leaf	0.28	2.06	13.94	1.68	1.68	14.01	822
Orthene ST	Foliar 1 & 5 leaf	0.75	5.75	12.50	1.63	1.88	14.34	845
	LSD (P=0.05)	3.49	32.69	17.24	0.35	0.36	1.07	134

In summary, these trials illustrate the need to use a preventive systemic insecticide at planting for control of thrips on seedling cotton. Insecticide seed treatments in these trials provided thrips control up to 3 weeks after planting and Temik treatments provided thrips control for up to 4 weeks after planting. An Orthene foliar spray at the 1-leaf stage increased yields in untreated plots. There appeared to be little value of a second Orthene foliar spray at the 5-leaf stage in terms of yield.

EFFECTS OF TIMING OF INSECTICIDE APPLICATIONS FOR CONTROL OF PHYTOPHAGOUS STINK BUGS IN COTTON

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Introduction

In recent years, Georgia's cotton pest complex has undergone dramatic changes. Phytophagous stink bugs have become more abundant in and are increasingly damaging to cotton. Boll weevil eradication and increasing use of transgenic cotton varieties are generally viewed as contributing factors due to the reduced insecticide use following in the wake of the application of these technologies. Large and damaging stink bug populations have been observed in many areas of Georgia during the past few growing seasons, magnifying the need for specific threshold guidelines and effective management tools. Insecticidal measures are often used by growers to control stink bugs and this report presents the results of a field trial that attempts to characterize the phenological timing of damage to cotton by stink bugs. It was designed to examine the effects of various weekly Bidrin® spray regimens on damage caused by populations of phytophagous stink bugs (to help elucidate windows of susceptibility to stink bug attack), as well as the resulting yield of the cotton crop.

Methods

On 6 June 2005, DPL 424 Bollgard II/RR cotton was planted at the UGA Coastal Plain Experiment Station's Lang-Rigdon Farm. In one treatment, applications of 8 oz/acre of Bidrin® commenced at first bloom and were applied weekly until 15 Sept. Six additional Bidrin® treatments were included, with sprays initiated at 1, 2, 3, 4, 5, and 6 weeks post-bloom, and all continuing weekly until the last application on 15 Sept. An additional set of untreated plots provided a control, for a total of 8 treatments. There were four replications of each treatment arranged in a randomized, complete block design. Each plot was 8 rows wide by 75 feet long, and plots were longitudinally separated by 10-foot long alleyways. The plots were laterally separated by alternations of two rows of peanuts (Georgia Green), planted 25 May expressly for the purpose of attracting stink bugs to the cotton plants. With this layout, each plot was bordered by peanuts on at least one side. All insecticide applications were made using a John Deere 6000 Hi-Cycle sprayer applying 6.4 gallons per acre with TX-6 hollow-cone nozzles, at 60 psi. In addition to natural rainfall, all plots received 0.7" irrigation on 16 June, 0.9" on 26 July, 0.6" on 15 Aug., 1.0" on 22 Aug., 0.8" on 7 Sept., 0.9" on 13 Sept., and 0.7" on 20 Sept. 2005.

Stink bug damage was assessed at first open boll on 22 Sept. 2005. Approximately 25 bolls were harvested from each of the center four rows in each plot. The bolls were kept frozen until examined. Bolls with callous growths on the inner surface were counted as having internal stink bug damage. The number of bolls having lint obviously stained or rotten was also determined. On 21 Oct., the percentage of open bolls was sampled to assess any developmental delays among the treatments. Ten plants were randomly selected in each plot and the total number of open bolls and closed bolls per plant was recorded. The total of open bolls was divided by the total of all bolls to determine percent open bolls. Yield was taken by mechanically picking and weighing the middle 2 rows of each plot on 10 Nov. The experimental results (internal boll damage, stained/rotten bolls, percent open bolls, and yield) were analyzed using the general linear models procedure (GLM) with significant means separated using Duncan's New Multiple Range Test (SAS 1999).

Results and Discussion

Table 1 presents all of our experimental results. Bolls in plots receiving Bidrin® sprays beginning at bloom, as well as 1, 2 3, and 4 weeks post-bloom, displayed significant reductions in percent internal stink bug boll damage and percent stained/rotten bolls in comparison with the untreated control. Internal damage was also significantly reduced by sprays beginning at 5 weeks (2 applications) and 6 weeks post-bloom (1 application). These treatments were significantly less effective in reducing internal damage, however, than all other spray regimens. Numerically, the greatest percentage of open bolls on 21 Oct. occurred in the plots receiving 6 Bidrin® applications, beginning at 1 week post-bloom. Some of the other spray regimens produced numerically higher percentages of open bolls, though none were statistically significant, and no clear pattern emerged. From the data, it appears that the greatest risk to stink bug damage occurs from approximately the third week after initiation of blooming, and afterward.

From a yield perspective, 3-5 Bidrin® applications provided among the highest numerical benefits. However, the untreated plots performed equally well. It's possible that populations of beneficial insects were negatively impacted by too few sprays (1-2) or too many (6-7). Unless the fiber quality of the untreated plots was greatly reduced, it is unlikely that the cost of any insecticidal treatment in this particular study would have been justifiable. Each growing season will have numerous factors affecting the influence of phytophagous stink bugs on cotton yields. Scouting for stink bug numbers and damage is essential for assessing effective timing and numbers of insecticidal applications. As these insects become more of a problem for Georgia cotton growers, additional research is essential to know how to best combat them for the greatest economic gains.

Acknowledgments

We also appreciate the assistance of Mark Freeman and Javier Madrigal-Sanchez in collecting and processing data, as well as his help with the harvest.

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Table 1. Phytophagous stink bug numbers (per shake sample) in relation to insecticide treatment. Tift Co., GA, 2004.

Bidrin® Treatment Initiated at:	22 Sept. % internal damage	22 Sept. % stained or rotten	21 Oct. % open bolls	10 Nov. Yield lb. seed cot./acre
untreated	39.7a	8.0a	64.9ab	3182ab
bloom (7 applications)	6.9c	3.2b	63.1b	3083ab
1 week post-bloom (6 applications)	4.5c	1.5b	78.2a	3124ab
2 week post-bloom (5 applications)	5.5c	2.0b	71.7ab	3490a
3 week post-bloom (4 applications)	8.2c	2.2b	63.0b	3219ab
4 week post-bloom (3 applications)	12.3c	2.0b	70.4ab	3187ab
5 week post-bloom (2 applications)	23.7b	4.4ab	72.1ab	2853ab
6 week post-bloom (1 application)	23.8b	5.8ab	65.0ab	2519b

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

COMPARISON OF AVICTA AND N-HIBIT TO TEMIK 15G AND TELONE II FOR MANAGEMENT OF NEMATODES IN GEORGIA

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Abstract

Nematodes are an important problem for cotton growers in Georgia. In addition to crop rotation, growers use nematicides to reduce damage and increase yields. In this study three seed treatments, Avicta, N-Hibit, and an abamectin treatment from Bayer CropScience, have been assessed for efficacy and compared to standard nematicides. Trials were conducted in 2004 and 2005. Field sites were naturally infested with southern root-knot, reniform, or Columbia lance nematodes. Avicta was evaluated in 14 trials and the other two seed treatments were evaluated in four trials each. In each trial the populations of parasitic nematodes were measured multiple times during the season and yield from all nematicide treatments were compared. Despite assessing the seed treatments at multiple locations across the state, it was difficult to establish the efficacy of these products. In some trials Avicta performed as well as the target of 5.0 lb/A Temik 15G. Unfortunately, in many of these trials, the yields from plots treated with Avicta were not significantly different from plots treated only with the insecticide Cruiser. Because the Cruiser seed treatment is not active against nematodes, it is unclear how to interpret the results with regards to management of nematodes. This was also the case for the abamectin seed treatment from Bayer Crop Science. N-Hibit seed treatment, applied with Temik 15G at 5.0 lb/A, was only better than Temik 15G alone in one out of four trials in which it was assessed.

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 Service, it was found that nearly 70% of the commercial cotton fields included in the survey was infested with some level of 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 2004 growing season, it was estimated that nematodes cost growers approximately $100 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 and 2005. In 2005, research was also conducted to evaluate the efficacy of two additional seed treatments, abamectin 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 and 2005. Only data from 2004 and 2005 will be presented here. An experimental seed treatment from Bayer CropScience was evaluated in two small-plot and two on-farm studies in 2005. The seed treatment from Eden Bioscience, N-Hibit, was evaluated in three on-farm trials and one small-plot study in 2005.

Avicta (abamectin) was evaluated as a component of AVICTA Complete Pak with treated seed provided by Syngenta. AVICTA Complete Pak is a combination of the fungicide seed treatment Dynasty (azoxystrobin, fludioxonil, and mefenoxam), Cruiser (0.34 mg/seed) and abamectin (0.15 mg/seed). Treated seed was provided annually by Syngenta.

The seed treatment from Bayer CropScience was also a formulation of abamectin. Treated seed was provided by Bayer CropScience for use in these studies and also included a treatment for control of thrips.

The active ingredient in N-Hibit from Eden Bioscience is a harpin protein. In three of the trials where this product was assessed in this study, commercial seed was treated at Triangle Chemical in Sycamore, GA 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. In a number of studies, a third Temik treatment was assessed and included Temik 15G, 5.0 lb/A applied both at planting and at side-dress between the 2^{nd} and 8^{th} true leaf stage, but prior to the pin-head square growth stage. In the side-dress application, the Temik was incorporated into the soil with a colter 6-8 inches on either side of the cotton plants to a depth of 2-3 inches.

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, was applied at planting 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 $p \leq 0.05$.

Results and Discussion

The yield results from the field trials are presented in Table 3 and gall ratings from the Gibbs Farm trials are presented in Table 4. The average number of nematodes per 100 cm3 soil collected at harvest from a site is presented in Table 1.

The efficacies of three seed treatments reported to have benefits in the management of nematodes on cotton were assessed in this study. Two of these, AVICTA Complete Pak and N-Hibit, are currently available to growers in Georgia. The third, an abamectin treatment from Bayer CropScience, should be available to growers in the near future.

In the studies presented in this paper, AVICTA Complete Pak was compared to Cruiser-treated seed in 13 trials. Data from two of these studies could be statistically combined. From the resulting 12 data sets, AVICTA Complete Pak out-yielded the Cruiser-treated seed eight times, though none of the differences were significant at the 5% level. Cruiser-treated seed out-yielded AVICTA Complete Pak in four of the twelve trials. Again, the differences were not statistically different.

Thirteen 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 six of these trials; however only in one of the six trials were the yields statistically different. Temik 15G, 5.0 lb/A, out-yielded AVICTA in seven trials; however yields were statistically different in only one of the seven trials.

Five data sets are presented in this paper where AVICTA Complete Pak is compared directly to Temik 15G, 5.0 lb/A at-plant and 5.0 lb/A side-dress, and to Telone II, 3 gal/A. These treatments each out-yielded AVICTA Complete Pak in four of the five studies; however the yields were statistically different only once for two applications of Temik and twice for Telone II. Yields from AVICTA Complete Pak were numerically (and statistically) better than two applications of Temik 15G on one occasion and better than Telone II (numerically only) on a single occasion.

In the four studies where they were compared, yields were not statistically different between the AVICTA Complete Pak and the abamectin treatment from Bayer CropScience. In the four 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.

In the studies conducted during 2004 and 2005 in Georgia, it is impossible to determine "how good" AVICTA Complete Pak is in the management of nematodes. 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 was against nematodes. Also, the fact that Telone II and two applications of Temik 15G did not result in consistent significant yield increases over AVICTA Complete Pak also makes it difficult to determine the efficacy of the product.

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.

Although only assessed in four trials, it appears that the abamectin treatment from Bayer CropScience is similar in efficacy to 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 four trials.

Conclusion

After reviewing results from multiple field trials in 2004 and 2005, it is difficult to determine the true efficacy of AVICTA Complete Pak in the management of nematodes on cotton. The product performed as well as Temik 15G, 5.0 lb/A, in most trials. However AVICTA Complete Pak typically produced yields that were similar to Cruiser. Further testing will be needed to differentiate AVICTA Complete Pak as a nematicide.

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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

*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*.

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

Site	Variety	Cruiser	Temik	Temik	Temik	Telone II + Temik	AVICTA Complete Pack*	N-Hibit + Temik	Bayer seed treat**
		0.34 mg/seed	3.5 lb/A	5.0 lb/A	5.0 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	X		
Perryman 05	DP 555	X	X	X	X	X	X	X	
Windhausen 05	DP 555	X	X	X	X	X	X		X
Nugent 04	DP 555	X	X	X	X	X	X		
Nugent 05-1	DP 555	X	X	X	X	X	X		
Nugent 05-2	DP 555	X		X			X	X	X
Gibbs Farm 04	DP 555	X	X	X			X		X
Gibbs Farm 05	DP 555	X	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	X	
Jordan 05	DP 444	X	X	X			X		
Evanson 05	ST 5599	X	X	X	X		X		

*AVICTA Complete Pack is composed of Dynasty CST, Cruiser (0.34 mg/seed) and STAN (abamectin, 0.15 mg/seed).
**The Bayer seed treatment is an experimental formulation of abamectin and other materials.

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

Site	Cruiser	Temik	Temik	Temik	Telone II + Temik	AVICTA Comp. Pack*	N-Hibit + Temik	Bayer Seed Treatment
	0.34 mg/seed	3.5 lb/A	5.0 lb/A	5.0 lb/A +5.0 lb/A	3 gal/A + 3.5 lb/A		3.0-5.0 oz/seed + 5.0 lb/A	
	LINT YIELD (lb/A)							
Perryman 04	642 cd	632 d	678 cd	786 ab	784 ab	727 bc		
Perryman 05	539 a	647 a	803 a	701 a	699 a	612 a	641 a	
Windhausen	1137 a	1086 d	1119 cd	1126cd	1170 abc	1214 a		1199 ab
Nugent 04	779 d	918 b	904 bc	965 ab	1065 a	737 d		
Nugent 05-1	1103 d	1470 b	1283 bcd	1356bc	1752 a	1137cd		
Nugent 05-2	1439 a		1646 a			1327 a	1465 a	1457 a
Gibbs Farm 2004-2005*	1051 a	1086 a	1175 a			1054 a		
Gibbs Farm 2005	1131 a	1184 a	1143 a			1070 a	1208 a	1154 a
Midville 04	1507 a	1446 a	1678 a			1483 a		
Midville 05	997 a	839 a	1018 a			1109 a		1054 a
Storey 05			722 a			755 a		
Green 05	242 a	197 b	223 ab	240 a		258 a	246 a	
Jordan 05	505 a	549 a	526 a			503 a		
Evanson 05	959 a	973 a	940 a	984 a		977 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.

Table 4. Early season gall ratings* from Gibbs Farm trials, 2004-2005**.

Site	Cruiser	Temik	Temik	Temik	Telone II + Temik	AVICTA Comp. Pack*	N-Hibit + Temik	Bayer Seed Treatment
	0.34 mg/seed	3.5 lb/A	5.0 lb/A	5.0 lb/A +5.0 lb/A	3 gal/A + 3.5 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	NA	NA	3.05 ab	NA	NA

*Galls rated on a 1-10 scale where 0 = no observed galling, 1 = 10% galling, 2 = 20% galling, etc.
** 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=0.05 according to Fisher's Protected LSD.

USE OF THIOPHANATE METHYL AND DICRTOPHOS TO REDUCE HARDLOCK, BOLL DAMAGE AND ROT TO STINKBUGS

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Abstract

A study was conducted in a commercial cotton field in Colquitt County, GA in 2005 to evaluate the effects of multiple applications of Topsin 4.5F (thiophanate methyl) and Bidrin (dicrotophos) on the severity of damage from stinkbugs and the severity of hardlocked cotton bolls. A similar study was conducted at multiple sites in 2004. At that time it was determined that the use of thiophanate methyl did not reduce the severity of hardlock or reduce damage from stinkbugs. However, the trials in 2004 were carried out under low pressure from stinkbugs. The study conducted in 2005 was purposely located in a cotton field immediately adjacent to a production peanut field to insure significant pressure from stinkbugs. In the 2005 study it was found that not only did Topsin 4.5F significantly reduce the severity of hardlocked bolls, but also significantly reduced the internal boll damage associated with stinkbugs during much of the season. Applications of Topsin 4.5F also produced yields that were numerically, but not statistically, greater than the untreated control and not statistically different from plots treated with either Bidrin or Bidrin + Topsin 4.5F.

Introduction

The fungicide thiophanate methyl (Topsin-M) has been reported to reduce the severity of "Fusarium hardlock" on cotton and significantly increase yields in Florida. Hardlock is described as a malady where lint apparently forms normally; however for a variety of reasons, does not "fluff" properly and is difficult to pick with the use of a spindle picker. As hardlocked bolls often appear in fields where damage from stink bugs (*Nezara viridula* and *Euschistus servus*) is severe, the objective of this study was to determine if multiple applications of the fungicide thiophanate methyl, with and without the insecticide dicrotophos, would lead to a reduction in the number of hardlocked cotton bolls. In multiple field trials in 2004, the use of thiophanate methyl and/or dicrotophos did not lead to a significant reduction in hardlock or increase in yield. However, pressure from stinkbugs was not found to be severe in these trials.

A field trial similar to the ones from 2004 was conducted again in Colquitt County. In this study, plots were treated with Topsin 4.5F (thiophanate methyl), Bidrin (dicrotophos), Topsin 4.5F + Bidrin, or left completely untreated. This trial was purposely planted in a commercial cotton field immediately adjacent to a large commercial peanut field in order to maximize pressure from stinkbugs. The objective in this study was to determine if the use of these products could reduce hardlock or other boll damage in the field.

Materials and Methods

A field trial was established in a commercial field planted to DP 555BR in Colquitt County. The experimental design was a randomized complete block with four replications. Each plot was 36 rows wide (36-in. row spacing) by 125 ft. in length. Treatments included a) unsprayed plots, b) plots that received only thiophanate methyl (Topsin 4.5F, 1.25 pt/A), c) plots that received only dicrotophos (8 fl oz/A) and d) plots that received both thiophanate methyl and dicrotophos on each spray date. Treatment applications were begun at first bloom (approximately 50% of the plants in the study had one open bloom) and reapplied on a bi-weekly basis for a total of four spray dates. Treatments were applied by the grower using a high clearance sprayer. During the season 25 bolls were examined from each plot on 12 July, 22 July, 29 July, 5 August, 12 August, and 19 August to evaluate for stinkbug feeding injury. Year end boll damage assessments were also conducted by collecting 100 bolls from each plot which comprised a representative sample of harvestable bolls at first open boll. Bolls were examined for internal bug damage. Bolls were considered damaged if a callous growth or wart was observed on the inner surface of the boll wall and/or stained lint was present. Hardlock was assessed in each plot by removing all of the cotton bolls in 3 linear ft of row immediately prior to harvest and comparing the number of hardlocked locules to the total number of locules from that sample area. Plots were harvested on 5 October and the yield was recorded.

Results

The results from this study are presented in Table 1 and Table 2. Use of Bidrin (8 fl oz/A) or a dual applications of Bidrin and Topsin 4.5F (1.0 pt/A) significantly reduced internal boll damage from stinkbugs throughout the season, reduced the incidence of hardlock, and improved lint yield over the untreated control. Applications of Topsin 4.5F without Bidrin significantly reduced incidence of hardlock, numerically reduced the internal damage from stinkbugs, and numerically increased lint yield over the untreated control. However, these numerical yields were not statistically significant. For the first four dates of boll assessment (12 Jul, 22 Jul, 29 Jul, and 5 Aug), the differences between internal damage in samples treated with Topsin alone and a combination of Bidrin + Topsin were not significantly different. However, differences were significant later in the season. The levels of year-end boll damage as measured as % internal damage, % lint stain, and lint yield were not significantly different between plots treated with Topsin, Bidrin, or Bidrin + Topsin.

Discussion

In numerous field trials conducted in 2003 and 2004, the use of Topsin fungicide could not be correlated with a reduction in hardlock of cotton. In these earlier trials, stinkbugs were either controlled in the plots with insecticides, or damage from the insects was low in both treated and untreated plots. In the study conducted in 2005, damage from stinkbugs was severe in untreated plots, in large part due to the close proximity of a peanut field.

In the 2005 Colquitt County trial, use of the fungicide Topsin 4.5F consistently reduced the internal damage from stinkbugs. Although this reduction was not typically statistically different from the untreated control, the trend was very interesting. From this data, it appears that use of a fungicide reduced damage attributed to an insect pest. It may be that application of Topsin to the developing bolls reduces introduction of fungal pathogens through the puncture wound, or perhaps the Topsin affects the feeding behavior of the stinkbugs.

Use of Topsin 4.5F significantly reduced the severity of hardlock in this study. Though not statistically significant, less hardlock was found in plots treated with Bidrin and Bidrin + Topsin than in plots treated with Topsin alone. Based upon the data, there was no significant difference in hardlocked bolls in plots that were treated with Topsin and Bidrin or Bidrin alone. Therefore, it appears that the reduction in hardlocked bolls in this study was a result of management of damage caused by stinkbugs rather than the additive control of damage from stinkbugs and some other cause, perhaps of fungal origin.

Although Topsin 4.5F seemed to be an effective means for reducing hardlock and improving yields in fields where significant damage occurs from stinkbugs, the control was not as good as that provided by Bidrin. Additionally, applying both Topsin and Bidrin to a plot did not improve yields of reduction of hardlock over Bidrin alone. Finally, because use of Bidrin is less expensive for the grower than use of Topsin, there appears to be little incentive to use this fungicide for control of hardlock that is associated with stinkbugs.

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Table 1. Measure of internal damage from stinkbugs, 2005.

Treatment	Internal boll damage from stinkbugs per sample of 25 bolls					
	12 July	22 July	29 July	5 August	12 August	19 August
Untreated control	3.0 a	6.75 a	14.0 a	8.25 a	17.25 a	16.0 a
Topsin 4.5F (1.0 pt/A)	1.5 ab	4.25 ab	6.25 b	1.75 ab	11.5 a	10.5 a
Bidrin (8 fl oz/A)	0.25 b	1.5 c	2.75 b	2.5 ab	1.75 b	2.25 b
Topsin 4.5F + Bidrin	1.0 b	2.25 bc	1.0 b	0.25 b	1.5 b	1.75 b

Numbers within the same column followed by the same letter are not significantly different at p≤.05 as determined with Fisher's protected LSD.

Table 2. Year-end boll damage and lint staining from stink bugs, percent hardlock, and lint yields 2005.

Treatment	Year-End Stink Bug Damage			
	% Internal damage	% Stain/rot	% Hardlock 3-ft of row	Yield lb/A
Untreated control	52.3 a	30.5 a	61.5 a	625 b
Topsin 4.5F (1.25 pt/A)	26.5 ab	12.2 ab	26.1 b	886 ab
Bidrin (8 fl oz/A)	7.1 b	4.2 b	18.8 b	1108 a
Topsin 4.5F + Bidrin	8.5 b	6.0 b	14.8 b	1021 a

Numbers within the same column followed by the same letter are not significantly different at p≤.05 as determined with Fisher's protected LSD.

FUNGAL FERMENTATION PRODUCTS FOR CONTROL OF ROOT-KNOT NEMATODES

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Introduction

Nematodes are an increasing problem in all of Georgia's cotton production areas. 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 2004, according to Georgia Cooperative Extension Service estimates, plant-parasitic nematodes caused $40 million in crop losses on cotton, and incurred 82% of the cost of pesticides used for disease control (Pearce, M. A., et. al., 2004). Although average damage levels due to nematodes may be in the 10 % range, these losses are not evenly distributed, and growers with problem fields are experiencing much higher levels of crop loss. Our research on cotton in Georgia has indicated that cotton yield losses due to nematodes may be as high as 60-70% in fields infested with root-knot or reniform (Noe, 1994, 1998), Total crop failures are possible with extreme pest pressures. Populations of these parasitic nematodes may increase 200-300% per year under cotton

A critical need exists for the development of new nematode management options for cotton production. 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 Temic (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

Soil samples were collected from locations in Georgia with differing soil types and habitats. Soilborne fungi were isolated from these samples by dilution-plating and use of selective growth media. Several thousand isolates of fungi were recovered, from which approximately 150 isolates were selected for further evaluation as producers of nematicidal compounds. For evaluation, each fungus was placed in flasks containing nutrient agar and fermented with aeration on platform shakers for 10 days. As an in-vitro assay, liquid cultures were micro-filtered (0.22 μm) and pipetted into sterile microwell plates with freshly-hatched Southern rootknot nematode (*M. incognita*) juveniles. Sterile water was used as a control treatment. Nematode survival rates were determined at 2, 4, 24, and 48 hours after suspension, with 6 replications per isolate. Liquid fungal-culture filtrates also were 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 were also applied. Southern rootknot nematode (*M. incognita*) eggs were added to the pots, and cotton cv. DPL5415 RR was planted in each pot to serve as a susceptible host. Each treatment was applied to 6 replications. Plants were grown on greenhouse benches for 45 days. Plant roots were then removed from the pots and washed, and the nematode eggs were collected and counted. Total numbers of nematode eggs were compared using ANOVA followed by mean separation (LSD) for each fungal-isolate treatment and the controls. After mass screening of the fungal collection, isolates were selected and further evaluated for biocidal production using different evaluation protocols. The methods used were similar to the greenhouse screening, but with different soil types, culture media, and fermentation protocols.

Results and Discussion

After preliminary selection from the several thousand fungal isolates that were recovered from soil samples, approximately 150 fungi were further evaluated for production of nematicidal compounds. Of the 150 that were screened in the laboratory tests, 3 isolates showed enough root-knot nematode control when applied to soil planted with cotton to warrant their selection for phase 3 evaluation and testing. This final phase of testing included repeated greenhouse screens, evaluation of rates and application methods for nematode control, and a determination of the efficacy of heat-killed and dried fermentation residues for nematode control in soil.

Two fungal isolates were tested in three different soil types for efficacy in killing root-knot nematodes on cotton. One soil each from north and south Georgia, and a greenhouse mix were placed in 6" pots and treatments consisting of two candidate culture filtrates, a control fungal culture (no effect on nematodes), raw culture media, and water were applied. There was no significant interaction among the soils and treatments ($P < 0.05$), so results from all three soils were combined, giving a total of 18 replications per treatment. Both of the candidate culture filtrates reduced nematode egg numbers per gram of root weight ($P < 0.05$) across the three soil types, with the nematicidal treatments reducing the number of eggs by an average of 60% compared to the control treatments.

We continue to observe variability in nematode control results from the soil-treatment evaluations, and development of a final product is slowed by the need to evaluate various protocols for stabilizing the nematicidal activity of selected fungal isolates. In one series of experiments, fungal culture filtrates were dried and applied as a powder at varying rates to soil in greenhouse pots, with 6 replications per treatment. Two of the fungal isolates tested reduced root-knot nematode egg numbers by an average of 65% when applied in a powdered formulation ($P < 0.05$). In another experiment, culture filtrates of selected fungal isolates were pH-adjusted to determine the possibility of enhancing the nematicidal formulations by changing the acidity of the solutions. In two trials with 6 replications each, pH adjustment did not significantly enhance the nematicidal activity of any of the culture filtrates tested ($P < 0.05$). Other experimental approaches for evaluation of application rates, methods, and timing of treatments are planned to further the development of an effective and reliable nematicidal preparation.

Acknowledgments

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