South Carolina Cotton Board
South Carolina State Support Committee
Research Projects

Summary Reports

1997 to 2004

Edited by
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Summary Reports (1997 to 2004)

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Market Risk Management for South Carolina Cotton

South Carolina Cotton Board Grant (1999)
South Carolina State Support Committee (2000)
Awarded To: Kandace Kahl and Charlie Curtis, Clemson University

The South Carolina cotton industry faces significant risks from year to year due to varying prices and yields. Appropriate risk management is important to the sustainability and profitability of the farms and agribusinesses in this industry. Futures and options markets provide opportunities for cotton producers to reduce price risk. However, to be useful, both require knowledge of the basis (cash – futures). This research will provide growers information on the basis to make informed risk-management decisions.

The monthly cotton basis was calculated for each of the seven production regions of the United States, i.e., the Southeast, North Delta, South Delta, Desert Southwest, San Joaquin Valley, East Texas-Oklahoma, and West Texas regions, with USDA supplying the data necessary. The basis was calculated as the average monthly cash price in each region (provided by USDA) minus the average monthly settlement price for the July cotton futures contract (provided by the New York Cotton Exchange). The basis was calculated for ten recent crop years, August 1988 through July 1998.

The statistical results are consistent with economic theory. The basis is found to be strongest, i.e., the cash price is largest relative to the futures price in consumption regions, as expected. Consumption regions are those that either consume cotton in a mill or consume cotton for export. This finding was not unusual because there would be no incentive to ship to a region consuming cotton from a region producing cotton if the cost of transporting the cotton to the consuming region did not allow a higher price to be earned by a producing region. The basis is found to get weaker, i.e., the cash price gets smaller relative to the futures price, as the distance to these consumption regions increases. In other words, the transportation costs associated with shipping cotton further will extract more of the price received as distance to consuming region increases. This will give producers less incentive to ship cotton if the costs of doing so are not profitable for them.

The basis in those production regions that supply the relatively stable demand of domestic textile mills is found to follow a significant seasonal pattern. However, no evidence of a significant seasonal pattern in the basis is found for production regions that supply the cyclical export demand. The seasonality of the basis was found to be less pronounced as the regions marketed more of their cotton to the export market. Work for 2001 will investigate the causes of the seasonality of the basis, as well as the marketing alternatives available for South Carolina producers.

A-index and Loan Deficiency Payment Level Prediction…

South Carolina Cotton Board Grant (2000)
Awarded To: Charles Curtis and Kandace Kahl, Clemson University

The purpose of this research was to develop a predictive relation ship for the A-index and it's subsequent derivation of the adjusted world price (AWP) in order to better predict LDP levels at future points in time and to refine market strategy selection in light of market loss assistance program revenues for cotton. Figure one shows the performance of various available strategies and farm level returns in absence of LDP payments for the 2002 crop as of Friday, February 15, 2002.

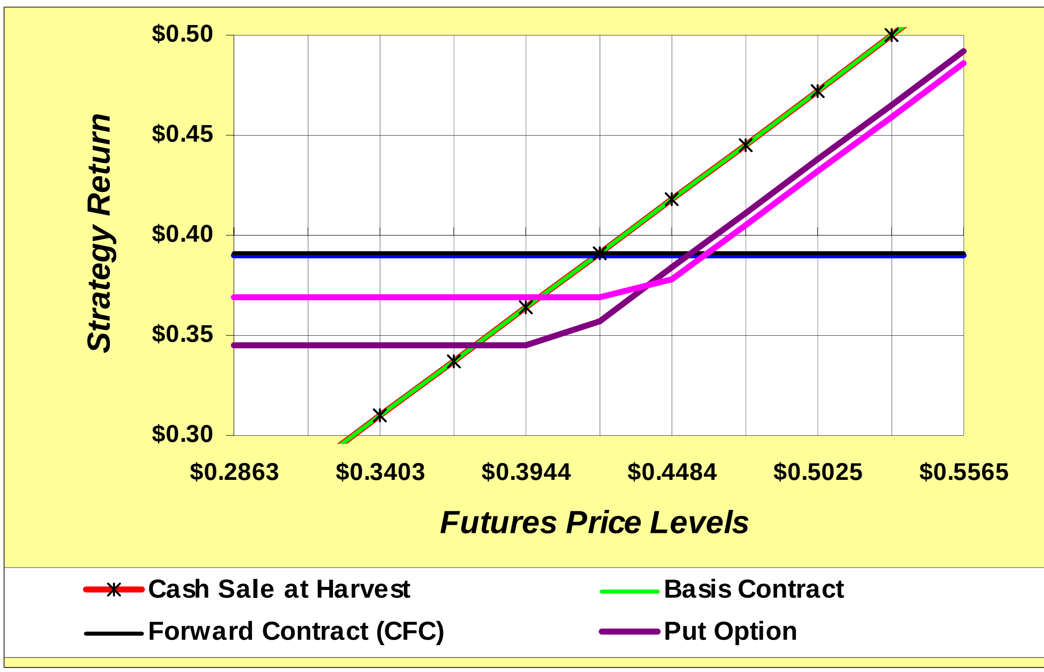


Figure 1: Performance Of Various 2002 Cotton Marketing Strategies, 2/15/02

Project findings lead to the ability to predict forward the potential LDP's available at various potential futures price outcomes. Table one indicates the AWP basis relative to US futures by month and contract. Table two displays the resultant LDP predicted for harvest 2002. Figure two indicates the resultant farm level revenues from the combined cash cotton marketing and the prospective LDP level for the 2002 crop.

Table 1: Cotton, Adjusted World Price Basis (AWP less Futures)

Months	Futures Contract Month	1996/1997	1997/1998	1998/1999	1999/2000	2000/2001	98 to 00 Average
Aug	Oct	-10.8920	-6.7875	-19.56	-15.13	-15.33	-16.67
Sep	Oct	-13.7825	-7.0175	-19.99	-14.89	-15.56	-16.81
Oct	Dec	-13.1280	-6.7980	-21.11	-19.39	-16.21	-18.90
Nov	Dec	-12.4750	-7.8000	-21.63	-18.27	-15.51	-18.47
Dec	Mar	-11.4650	-6.4180	-19.28	-19.31	-12.98	-17.19
Jan	Mar	-9.2750	-8.0375	-17.63	-22.69	-9.78	-16.70
Feb	Mar	-7.8000	-10.2475	-17.51	-17.71	-10.71	-15.31
Mar	May	-7.5325	-14.5075	-20.81	-17.60	-8.76	-15.72
Apr	May	-6.6425	-11.6920	-16.26	-11.33		-13.80
May	Jul	-6.6660	-15.9650	-12.21	-14.01		-13.11
Jun	Jul	-6.6950	-21.2075	-11.16	-9.92		-10.54
Jul	Oct	-7.5960	-21.1960	-9.96	-11.81		-10.88

Table 2: Predicting The LDP At Various Harvest Futures Price Levels

Crop:	Cotton	AWP Basis:	-$0.16	Harvest	
Loan Rate:	$0.52	Increment:	$0.01	Futures:	$0.30
Harvest Futures	**Predicted LDP**	**Harvest Futures**	**Predicted LDP**	**Harvest Futures**	**Predicted LDP**
$0.30	$0.38	$0.44	$0.24	$0.58	$0.10
$0.31	$0.37	$0.45	$0.23	$0.59	$0.09
$0.32	$0.36	$0.46	$0.22	$0.60	$0.08
$0.33	$0.35	$0.47	$0.21	$0.61	$0.07
$0.34	$0.34	$0.48	$0.20	$0.62	$0.06
$0.35	$0.33	$0.49	$0.19	$0.63	$0.05
$0.36	$0.32	$0.50	$0.18	$0.64	$0.04
$0.37	$0.31	$0.51	$0.17	$0.65	$0.03
$0.38	$0.30	$0.52	$0.16	$0.66	$0.02
$0.39	$0.29	$0.53	$0.15	$0.67	$0.01
$0.40	$0.28	$0.54	$0.14	$0.68	$0.00
$0.41	$0.27	$0.55	$0.13	$0.69	$0.00
$0.42	$0.26	$0.56	$0.12	$0.70	$0.00
$0.43	$0.25	$0.57	$0.11	$0.71	$0.00
$0.44	$0.24	$0.58	$0.10	$0.72	$0.00

The results of this study have been heavily utilized in Southeastern US cotton producer meetings to provide more concise management information in low price markets.

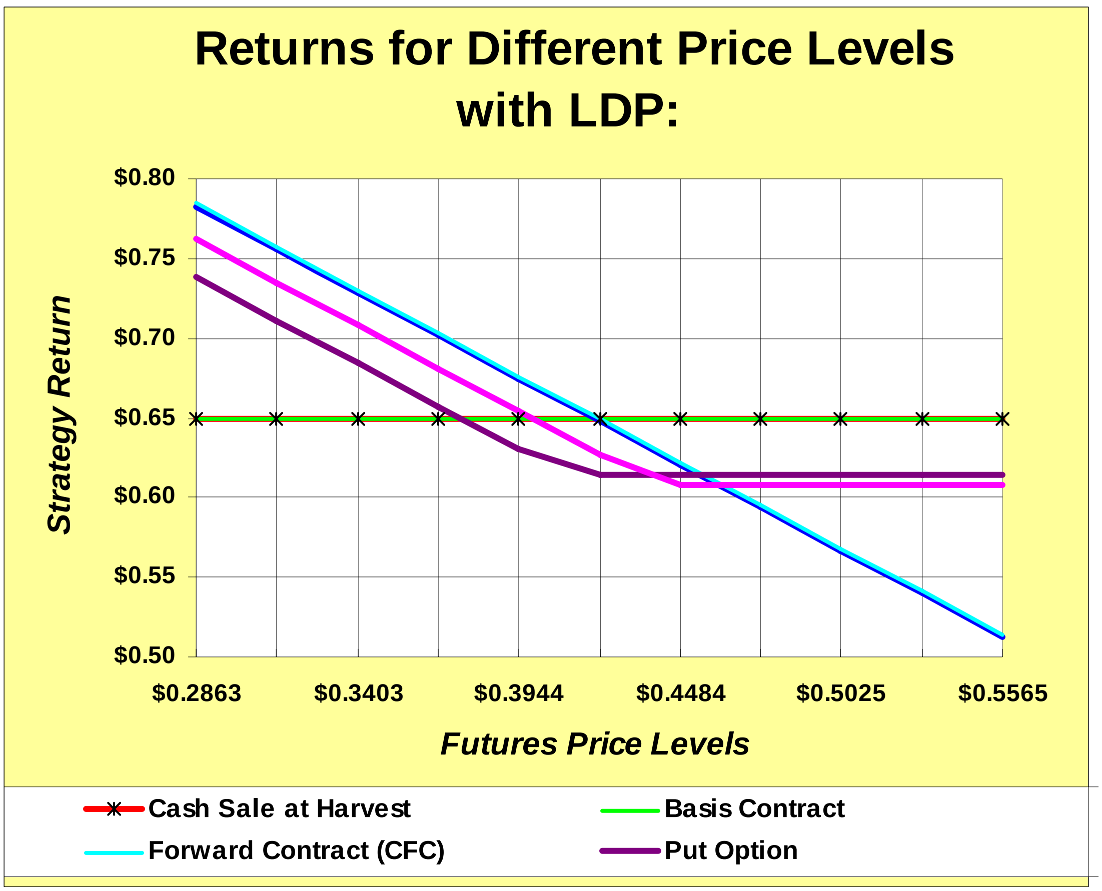


Figure 2: Cotton Market Strategy Results With Ldp Revenues Considered For The 2002 Crop, 2/15/02

Comparative Profitability of Ultra Narrow Row Cotton (UNRC) Production Technology for South Carolina

Core Program Grant – Crop Improvement (2000)
Awarded To: Charlie Curtis, Clemson University

Ultra Narrow Row (UNR) production technology and practices have gained significant attention from the cotton industry in the Southeastern U.S. Coastal Plains in the past few years. The production practice involves planting cotton in 7-10 inch rows rather than traditional 30-plus inch conventional rows.

One often cited benefit is that UNR cotton is harvested with a stripper rather than a spindle picker. Strippers are significantly less expensive to purchase and operate. Yield benefits may also be possible with UNR cotton. Trade-offs include increased seed and plant growth regulator costs. Further, stripper-picked cotton may contain more trash, which could increase ginning cost and reduce market value. Many gins are reluctant to handle this type of cotton.

This study was performed to examine costs and returns of UNR cotton and established conventional technology benchmarks as observed from Experiment Station trials planted at Clemson University's Pee Dee Research and Education Center in Florence, SC for the 2000 crop year.

Cost	Seed	Conventional	UNR	Difference
Variable	Non-Transgenic	$450.12	$440.20	$-9.92
Total	Non-Transgenic	$601.34	$566.49	$-34.85
Variable	Stacked	$448.94	$522.04	$73.10
Total	Stacked	$595.97	$654.87	$58.80

In absence of the use of stacked gene seed, UNR technology held a slight cost advantage. The cost of transgenic seed, however, offset any gain observed from UNR cost savings. This appears a crucial element in that South Carolina scientists typically recommend the transgenic varieties for UNR production. Production costs are very similar for non-transgenic plantings. Major shifts to UNR cotton production adoption do not appear to be occurring in South Carolina at this time.

Partial Budget: UNR versus Conventional Cotton **750 Pound Yield – non-transgenic Seed**		
UNR-Increased Variable Costs		
Increased Seed (+20 pounds)	17.60	
Increased Growth Regulator & Defoliation	14.06	
Increased Gin Charges	11.25	
UNR-Increased Fixed Costs		
None	0.00	
Total Increased Costs		42.91
UNR-Decreased Variable Costs		
Reduced Herbicides		
Reduced Insecticides	-12.22	
Reduced Machinery Variable Costs	-11.86	
Reduced Labor (1.64 fewer acre hours)	-18.42	
Reduced Interest on Operating Capital	-9.84	
UNR-Decreased Fixed Costs	-0.41	
Reduced Machinery Fixed Cost		
Reduced Overhead (8% of TVC)		
Total Decreased Costs		-77.70
UNR Variable Cost Advantage (+) or Disadvantage (-)		**34.79**

Partial Budget: UNR versus Conventional Cotton Round-Up Ready/Bt (Stacked) Seed		
UNR – Increased Variable Costs		
Increased Seed (+20 pounds)	89.20	
Increased Growth Regulator	5.86	
Increased Defoliant	8.20	
Increased Gin Charges	11.25	
Increased Interest on Operating Capital	3.11	
UNR – Increased Fixed Costs		
Increased Overhead (8% of TVC)	5.84	
Total Increased Costs		123.46
UNR-Decreased Variable Costs		
Reduced Herbicides	-5.42	
Reduced Insecticides	-11.86	
Reduced Machinery Variable Cost	-16.86	
Reduced Labor (1.73 fewer acre hours)	-10.38	
UNR-Decreased Fixed Costs		
Reduced machinery Fixed Cost	-20.04	
Total Decreased Costs		-64.56
UNR Variable Cost Advantage (+) or Disadvantage (-)		**-58.90**

Agricultural Engineering

Utilization of Precision Farming in Cotton Production

South Carolina Cotton Board Grant (1997)
South Carolina State Support Committee Grant (1998 and 1999)
Awarded To: Ahmad Khalilian, Francis Wolak, and Roy Dodd, Clemson University

The foundation of precision agriculture is based on the ability to continuously monitor yield at harvest. Yield monitoring combined with the ability to establish a geographic reference for these data allows the producer to construct yields maps and track field performance from year to year. Two commercially available cotton yield monitors (Micro-Trak inc. and Agriplan inc.) were tested for three years at research centers and growers' fields. These cotton yield-monitoring systems are similar in design but exhibit some differences. Both systems utilize an infrared sensor method to measure cotton flow. Field trials in 1997 and 1998 showed that the Micro-Trak and Agriplan units would accurately predict cotton weight when they remain clean and free from obstruction. Results also showed that sensors to become dirty and obstructed very quickly under normal field harvesting conditions. As the sensing units became dirty, measurement errors reached up to 107%. Even with cleaning before each load, errors greater than 5% were evident in data. Therefore, a positive air-pressure mounting technique was developed by Agricultural and Biological Engineers at Clemson University to completely enclose the existing sensor and effectively seal it from environmental contamination. The AirBox was pressurized by the picker fan, which forced air across the sensor eyes.

A John Deere model 9900 2-row-picker was utilized for testing at the Edisto Research and Education Center, Blackville, South Carolina. Each picker chute was equipped with the latest versions of the both Agriplan and Micro-Trak sensors using the AirBox mounting technique. The yield monitors were tested in two 10-acre fields at the Edisto REC and a 15-acre field on a grower farm. The yield monitors were cleaned and calibrated prior to data collection. Sensors for both Micro-Trak and Agriplan stayed clean during the test. Measurement errors for Agriplan unit were less than 5% in all three fields. Six yield measurements out of 25 had errors in excess of 5% for the Micro-Track system. The positive air pressure and isolation from dirt, dust, and lint contamination kept the sensing units clean over 25 harvested loads.

During 1999, Micro-Trak sensors with Air-Box mounting systems were evaluated on the Bozard Farms in Cameron, South Carolina. Sensing units were installed on two chutes of a Case-IH 5-row picker model # 2055. The trial began with a cleaning and calibration of the yield monitor. Eight basket loads of cotton were monitored in a 50-acre field. Average error for the loads was less than 1%. However, error ranged from –12% to 7%. Since the sensing units stayed clean during the test, the variation in yield measurements could be because only two out of five rows of cotton were monitored. In addition, sensor calibration was based on a single basket load. Calibrating the sensors utilizing several baskets loads could reduce measurement errors.

The Agriplan system was more accurate in detecting cotton yield levels than was the Micro-Track system especially in smaller fields. In 1999, the Agriplan Inc. adopted the positive air pressure technology to keep the sensing units clean and currently the system is commercially available. Yield maps were successfully produced with both yield-monitoring systems using global positioning systems (GPS) and geographic information systems (GIS).

Application of Composted Municipal Solid Waste in Cotton Production

South Carolina Cotton Board Grant (1997, 1998, and 1999)
Awarded To: Ahmad Khalilian, Mike Sullivan, John Mueller, Francis Wolak, and Robert Williamson, Clemson University

Municipalities are facing a growing problem of how to safely dispose of their solid waste. An environmentally benign and affordable solution to this problem is composting the organic fraction of municipal solid waste. The largest potential user of MSW compost is the agricultural industry. Application of MSW compost usually increases yields of agronomic and horticultural crops, under both field and greenhouse conditions.

Composted MSW is high in organic matter content and has the potential to increase organic matter content of sandy coastal plain soils. Higher organic matter content tends to increase the populations of many soil microorganisms, including those that are naturally antagonistic or parasitic to plant-parasitic nematodes

Equipment was developed and tested for broadcast, banded and injected applications of municipal solid waste (MSW) compost at selected rates to agricultural land for cotton production. Replicated tests were conducted for four years to determine the effects of compost on soil parameters, plant growth, and pest populations. Soil type in the test field was Faceville loamy sand. Injected & broadcast application of compost significantly reduced soil compaction in the E- and B-horizons (6-18 in.). Preventing soil compaction means fewer deep tillage operations and an $8 to $10 savings per acre each year. All rates of banded applications of compost significantly reduced early season thrips populations. Columbia lance nematode densities decreased in all compost-treated plots during all four years of study. Several plots treated with compost had nematode densities comparable to those found in the plots treated with Temik 15G nematicide ($18/acre savings). Compost application significantly increased the soil organic matter content and soil nitrogen content at 6 and 14 weeks after planting. However, the compost did not affect the leaf nitrogen content of the cotton plant during the same sampling periods. MSW compost (broadcast or injected) significantly increased plant N, P, and K contents compared to no compost application. All rates of MSW compost significantly increased seed cotton yield. Yield increase was proportional to application rate. For the 12-tons/acre-application rate, yield increases were 30%, 23%, 24%, and 44% in 1996, 97, 98 and 99, respectively compared to no compost application. There were very few carry-over compost effects from each previous year's treatments on soil organic matter, soil nitrogen, or seed cotton yield.

Subsurface Drip Irrigation Systems for Cotton Production

South Carolina Cotton Board Grant (1998)
South Carolina State Support Committee Grant (1999)
Awarded To: Ahmad Khalilian and Mike Sullivan, Clemson University

Subsurface drip irrigation (application of water below the soil surface through emitters) is proving to be an economical method of water application to agronomic row crops such as corn, peanuts and cotton. A drip irrigation system installed under each row is estimated to cost $750-$1,000/acre and for alternate row middles about $500 to $750/acre. Operating cost for either system is estimated to be between $1.50 and $2.00/acre-inch of water applied. Once installed and with proper management the irrigation system should last longer than ten years.

Replicated tests were conducted with cotton for three years to determine the effects of subsurface drip irrigation on soil compaction (deep tillage vs. no-till) and to determine optimum depth and spacing of drip lateral placement in coastal plain soils. The irrigation plots were established at the Edisto Research and Education Center at Blackville, SC on a Varina loamy sand soil. Drip irrigation tubes were installed 8, 12, and 16 inches below the soil surface under each cotton row and under alternate row middles. These three depths were selected to place the tubes above, within, and below the hardpan layer to determine the optimum depth for installing the irrigation tubes in coastal plain soils. This system consists of a 4-in well plus a 2-HP electric pump, sand media filtration system, electric control valves, and a programmable controller for turning the system on and off. In 1998 and 99, irrigation plots with tubes under alternate row middles, were split into half. One side was subsoiled prior to cotton planting to determine the effects of subsurface irrigation on formation of hardpan and the need for tillage with irrigated cotton.

Treatments included three drip tube depths (8, 12, and 16 inches), three lateral placements (under every row, under alternate row middles with and without spring deep tillage), and a control (non-irrigated). Plot size was 25 ft. X 70 ft. (40 total plots in each experiment, 10 treatments replicated 4 times). The two middle rows of each plot were machine harvested using a spindle picker for yield response.

The rate of water movement in the soil profile for plots with deep tillage was higher than plots without tillage. Soil surface moisture was higher in plots with laterals buried eight inches deep resulting in higher weed infestation than the rest of the treatments. Tillage significantly reduced soil compaction and increased taproot length in irrigated plots. Taproots in no-till plots were restricted to the depth of the hardpan layer. Keeping this compacted layer wet did not reduced soil strength enough to permit root penetrations into clay. Yield increases due to deep tillage was 4% (about $30/acre). Based on three years data, in coastal plain soils, subsurface tubes should be installed 76 inches apart and 14 to 16 inches deep. Drip irrigation significantly increased lint yields in all three years. Yield increases were 37, 56, and 103% in 1997, 1998, and 1999, respectively, compared to non-irrigated plots. Depth of the drip laterals had an effect on cotton yield, increasing with depth in both every row and alternate row middles. There were no differences in yield between every vs. alternate row installation at any of the three placement depths.

Site-Specific Detection and Control of Nematodes in Cotton

South Carolina State Support Committee Grant (2000)
Awarded To: Ahmad Khalilian, John Mueller, Francis Wolak, and Young Han, Clemson University

The overall objective of this work is to develop and test concepts and technologies for site-specific detection and control of plant-parasitic nematodes with the aim of optimizing farm profit while minimizing the effect of production practices on the environment. Use of soil electrical conductivity to predict soil texture was very successful as was the subsequent use of soil texture to predict the distribution of Columbia lance, spiral, and ring nematodes in a field. The Veris model 3100 Electrical Conductivity Mapping System provided readings from 0.31 to 3.90 mS/M in a ten-acre loamy sand field in Barnwell County, South Carolina. These ratings were able to predict percentage clay in a soil sample with a linear model having a correlation coefficient of 0.915 and predict percentage sand in a field with a correlation coefficient of 0.912. When broken down into four electrical conductivity ranges (0.0 to 1.0; 1.1 to 2.0; 2.1 to 3.0; and 3.1 to 4.0) they showed distinct distribution patterns for Columbia lance, spiral, and ring nematodes. Recovery at planting and at harvest of Columbia lance nematode decreased as soil electrical conductivity increased. An increase of nine percent in clay content of the soil resulted in a 57% reduction in nematode population density. Recovery of spiral nematodes was greater at planting and at harvest from soil types with an EC reading of 2, 3 or 4 than from a soil type with an EC of 1. Recovery of ring nematodes was severely restricted by soil type. No ring nematodes were recovered at planting or harvest from soil types with an EC of 3 or 4, and ring nematode recovery from soils with and EC of 2 were very low. Recovery of ring nematodes from soil types with an EC of 1 was very high, 25 per 100 cm^3 of soil. Nematode distributions are affected by soil particle size. Large nematodes such as sting and Columbia lance cannot move well through soils containing small particle sizes or high percentages of clay. However the degree of difference observed between Columbia lance and spiral nematode distributions was somewhat surprising since these nematodes are relatively similar in size. Soil particle size may have indirect as well as direct effects on nematodes species and their distribution. Plant root growth is less in sandy soils and Columbia lance nematodes may simply out compete other nematode species for the limited number of infection sites on the root. Like wise, where cotton root growth is limited by soil type or feeding by Columbia lance nematodes no canopy closure occurs in the cotton crop and weed species such as yellow nutsedge which are excellent hosts for ring nematodes, will proliferate.

The yield map for the test field was developed and the average yield for each plot was determined using GIS. A yield response was obtained from the 2 lb, but not the 4 or 6 lb rates of Temik 15G. This may be due to delayed maturity on a late-planted crop caused by the nematode control obtained with the 2 higher rates. Columbia lance nematodes were able to increase over the growing season for all rates of Temik 15G. In fact the increase was greater on the higher rates where more root tissue was available for infection.

Using soil electrical conductivity to predict the distribution of soil textures and nematodes with in a field is achievable in a sandy or loamy sand soil type. This will allow placement of nematicides in portions of the field with soil textures that have the highest probability of containing significant levels of specific nematode species, which are being targeted for control.

Spatial Accuracy Evaluation of New Cotton Yield Monitor Technology

South Carolina Cotton Board Grant (2000)
South Carolina State Support Committee Grant (2000)
Awarded To: Ahmad Khalilian, Francis Wolak, Roy Dodd, and Young Han, Clemson University

Two commercially available cotton yield-mapping systems were evaluated at the Clemson University's Edisto Research and Education Center. Four sensors of the new AgLeader Technology cotton yield-monitor and four sensors of the Agriplan Inc. were installed on both the front and rear chutes of a John Deere spindle-picker. Two pickers were used, one for plot work and one for large scale testing. Ground speed and fan speed sensors were installed on both pickers. These sensors are requirements for the AgLeader yield monitor.

Tests were conducted to evaluate the performance of these cotton yield monitors under grower's field environments, and to determine the spatial accuracy of the individual yield data. For spatial accuracy test, 160 plots ranging from 35 to 60 ft were utilized. Yield data were recorded in one-second intervals, which included 8 to 14 data points per test plot. Seed cotton yields were measured using sacking attachment and the yield monitors from 2 rows plots. The mean error from first field (64 plots) was 0.85% for AgLeader and 1.7% for Agriplan. Measurement errors ranged from –7.6 to 7.4% for AgLeader and from –16.9 to 18% for Agriplan. 70% of the test runs for AgLeader and 65% for Agriplan had errors less than 5%. In another field (96 plots), 80% of the data for AgLeader had errors less than 5% with mean error of 0.4% ranging from –8 to 9.3%. Errors for Agriplan in the same field ranged from –20 to 34% with only 30% of runs with less than 5% error. The AgLeader system was more accurate in detecting individual yield data points within a small area than was the Agriplan system.

In addition, the yield monitors were tested in three 15-acre fields at the Edisto REC and a 15-acre field on a growers' field, near Elko, SC, to evaluate the performance of the yield monitors under large field environment. A Trimble Ag132 GPS receiver was connected to the yield monitors for developing yield maps to determine spatial variability of cotton yield within a given area. The yield monitors were calibrated prior to data collection using four basket loads. The sensors were inspected routinely during the harvest and were cleaned as needed.

In growers' field, all measurement errors for both yield-mapping systems were less than 5%. Errors for the AgLeader ranged from –2.9 to 2.8%. Yield maps were successfully produced with both yield monitors using global positioning systems (GPS) and geographic information systems (GIS). The yield maps were similar for this field.

Similar results were obtained in other fields. Measurements errors in both fields for the AgLeader unit were less than 5%. For the Agriplan system, 84% of the basket loads had error less than 5%. The measurement errors ranged from –6.8 to 6.9%. The flush mounting techniques for the AgLeader sensors eliminated the need for manual cleaning. The Agriplan yield monitor required sensor cleaning on daily bases. With proper maintenance both sensors can accurately predict seed cotton yields within an acceptable level. The AgLeader system is more users friendly than the Agriplan mapping system.

Controlling Tillage Depth Based on Geo-Referenced Soil Compaction Data to Enhance Crop Yield and Conserve Energy

South Carolina Cotton Board Grant (2000)
South Carolina State Support Committee Grant (2001 to 2003)
Awarded To: Ahmad Khalilian, Young Han, Roy Dodd, and Francis Wolak, Clemson University

2000 to 2001 An instrumented shank was designed and built to measure mechanical impedance of soil at multiple depths over the entire top 18 in. of soil profile while moving through the soil. GPS-based equipment was developed and tested for controlling the tillage depth "on-the-go" to match soil physical parameters. An electro-hydraulic actuator and proportional directional control valves were used to move the gage wheels on a four-row subsoiler-bedder upward or downward to control the tillage depth.

Tests were conducted for the two years on a coastal plain soil to compare variable-depth tillage with the constant-depth tillage and no-till system in terms of energy requirements and effects on soil parameters and crop responses. Intensive geo-referenced soil compaction data was collected using a GPS based tractor mounted, hydraulically operated penetrometer system. Maps showing the depth and thickness of the hardpan were produced using GIS system. Yield maps from previous years, soil electrical conductivity map, and soil compaction map was used to divide the test field into four different management zones. In each area, five replications of the following treatments were applied: 1) constant depth tillage (17 inches); 2) variable depth tillage; and 3) no-till. Variable depth tillage was applied according to application maps generated from soil compaction data. The depth of tillage within a single plot was constant and was calculated using the average predicted hardpan depth for that particular plot. Cotton was planted and crop responses in terms of root weight and length at various depths, plant height and population, and yield were determined. Plant tissues (30 leaves/plot) were collected and analyzed for nutrient.

It was possible to determine the optimum tillage depth using a cone penetrometer, electrical conductivity meter or the instrumented shank. Also, it is possible to control the tillage depth “on-the-go” to match soil physical parameters. Variation in the predicted tillage depths to eliminate the hardpan layer ranged from 10 to 17 inches. Based on penetrometer data, approximately 75% of the test area required tillage operations shallower than the recommended tillage depth for coastal plain soils. There was a strong positive correlation between EC readings and seed cotton yield. Also, the predicted tillage depths were inversely correlated to the soil electrical conductivity. Taproot length was significantly shorter in the no-till plots compared to conventional and variable depth plots. There was no statistically difference in taproot length between conventional and variable depth plots. Soil texture was found to override the effects of deep tillage operation. For sections of the field with high clay contents and depth to B-horizon less than 13 in., there were no differences in yield between variable depth tillage, no-till, and conventional tillage operations. In the sandier part of the field with depth to clay layer more than 13 in., there was a significant difference in yield between no-till and the other two tillage treatments. The energy savings of 42.8% and fuel saving of 28.4% were achieved by variable-depth tillage as compared to uniform-depth tillage.

2002 to 2003 The Clemson instrumented-shank developed in 2002 was evaluated in 2003 to determine if it can predict the depth and thickness of the hardpan layer with similar accuracy as the soil cone penetrometer. This system measures soil compaction at multiple depths over the entire top 18-in of the soil profile while moving through the soil. Tests were conducted to determine the effects of soil moisture on performance of the instrumented-shank. The test field was divided into four sections (block). Three soil moisture levels were assigned at random to plots of each block. The field was irrigated applying two inches of water and tests were conducted two, seven, and 12 days after irrigation. Intensive geo-referenced penetrometer data were collected from a predetermined path in each plot followed by running the instrumented shank in the same path. The penetrometer data was averaged over 3-in depth intervals and compared to the instrumented shank readings at the same depth intervals. Soil Moisture samples were also collected at five depths ranges from each plot. There was a strong positive correlation between soil strength values measured with the penetrometer and the instrumented shank. The correlation was independent of soil moisture. This indicates that it is possible to determine the depth and thickness of the hardpan layers with the instrumented shank with similar accuracy as the soil cone penetrometer. The shank could be used either for real time control of tillage depth or for generating site-specific tillage-depth maps.

An algorithm was developed to determine the optimum tillage depth from soil cone penetrometer data in coastal plain soils. Intensive geo-referenced soil cone penetrometer measurements (1,800 probes) were obtained and each cone index profile was graphically examined. An algorithm was developed to assess and find the optimum tillage depth. After defining the algorithm, a computer program was written to automate the application of the algorithm for large data sets. The results showed 21 different patterns or conditions for the soil cone penetrometer profiles on a Dothan loamy sand soil. The results also, clearly indicated that the thickness and the location of the hardpan can be determined from the soil cone penetrometer data. A great amount of variation was observed in the location and the thickness of the hardpan as well as in the optimum tillage depth.

Also, the effects of soil moisture and temperature on performance of the Veris soil electrical conductivity meter were determined. Use of soil electrical conductivity to predict soil texture was very successful. There was a strong negative correlation between % sand and EC and positive correlation between %clay and EC measurements in each levels of soil moisture content. The soil texture found to be the major factor affecting soil EC. Soil moisture also affected EC values to some degree. However, the effect of soil temperature on EC was insignificant.

Maximizing Cotton Yields by Subsurface Drip Irrigation

South Carolina Cotton Board Grant (2000)
South Carolina State Support Committee Grant (2001)
Awarded To: Ahmad Khalilian, Mike Sullivan, and Brian Smith, Clemson University

Subsurface drip laterals were installed 15 inches below the soil surface under alternate row middles in a two-acre field. The irrigation system had four irrigated zones and one non-irrigated zone. Each zone had eight plots (8 rows by 70 ft). TDT moisture sensors (ESI Gro.point) were installed at two different depths (9 and 14 inches) in the root zone to measure the actual soil moisture content. Four sensors were used in each zone, a total of 20 TDT moisture meters for the test field. The sensors were connected to a microprocessor-based data acquisition/controller system. The controller system transmits the real time data to a desktop computer located at the Ag engineering lab using radio signals. "Aqualink Intelligent Irrigation System" software controlled irrigation valves, filters, injection pumps, etc. and was used for irrigation scheduling. An automatic evaporation pan was developed to measure and record daily evaporation. This system utilizes a load cell, a signal conditioning box, and a Campbell data logger. The unit was calibrated to measure evaporation in mm and transmit the data to the data acquisition/controller unit.

Two irrigation-scheduling styles “A” and “B” were used in 2001. For style “A”, irrigation was scheduled utilizing actual soil moisture content measured with moisture sensors. This system starts irrigation when the soil moisture content drops below a set number. For style “B”, plots were irrigated using pan evaporation data and a crop coefficient. Other factors such as rainfall, temperature, sunlight, and other variables are also entered into the system.

Two fertigation methods were used. For method 1, all fertilizers and micronutrients except phosphorus were injected through the irrigation system. For method 2, only nitrogen was injected though the irrigation system during the growing season. The rest of the nutrients were applied over the top. Also, dry land (non-irrigated plots) received all nutrients over the top (conventional method).

The following treatments were replicated eight times: non-irrigated; irrigation style “a” plus fertigation method "1"; irrigation style “a” plus fertigation method "2"; irrigation style “b” plus fertigation method "1"; and irrigation style “b” plus fertigation method "2".

There was no significant difference in yield between plots irrigated using actual soil moisture contents and those irrigated using pan evaporation and crop coefficient method. Injecting all fertilizers and micronutrients significantly increased seed cotton yield compared to conventional fertilizer application method. All irrigated plots yielded significantly higher than those in dry land area. The yield increase ranged from 25% for “irrigation style B + fertigation method 2” treatment to 43% for “irrigation style A + fertigation method 1” treatment. Injecting all fertilizers and micronutrients significantly increased leaf potassium content. Also leaf nitrogen content in irrigated plots was significantly higher compared to dry land.

Increasing Picker Efficiency By Using A Boll Saver Attachment

South Carolina Cotton Board Grant (1997)
Awarded To: Ahmad Khalilian, Mike Sullivan, and John Mueller, Clemson University

Cotton harvest losses due to delayed picking after defoliation and out of adjustment pickers can be as high as 20%. This study was conducted to determine the effects of a new harvest aid attachment, called the Boll Saver, on harvest losses as affected by cotton variety and adverse harvesting conditions in South Carolina. The Boll Saver mounts under the front drums of the picker, and replaces the bottom ribs of the drum in a configuration that leaves the ribs and Boll Saver in the same line vertically. The Boll Saver attachment redirects the airflow at the picker head, greatly reducing the amount of cotton that falls on the ground, and blows the cotton back around the spindles, giving them another chance to grasp it. Replicated tests were conducted for three years during harvest seasons at the Edisto Research & Education Center. The two middle rows of each plot were machine harvested for yield determinations of eight varieties of cotton, either with or without the Boll Saver attachment. In all three years, stalk and ground losses, percent lint turnout, and yield from each plot were measured. Use of a Boll Saver attachment significantly reduced ground and total harvest losses during the three harvests for all cotton varieties. Savings in lint cotton ranged from 24 to 53 lb/acre. A 53-lb/acre savings on 20 acres will pay for a two-row unit. There were no significant differences in trash content between samples picked with and without the Boll Saver attachment.

Scheduling Irrigation for Cotton Production in the Humid Southeastern United States

Cotton Incorporated Core Program Grant (2004)

Awarded To: Ahmad Khalilian, Young Han, and Tom Owino

Cotton in the Southern United States is generally produced in fields which are known to have a high degree of variability in soil type, topography, water holding capacity and other major factors which affect crop production. Therefore, conventional uniform-rate overhead irrigation systems tend to over-apply or under-apply water to the crop. Recently the scientists at the University of Georgia NASPAL have developed a variable-rate irrigation system for center-pivots which is currently commercially available. However, no commercially available lateral system has been developed. Lateral systems are important to farmers in the Southeast because it is not feasible to use a center-pivot in many fields in this region. Furthermore, lateral systems are important to researchers who wish to lay out plots in rectangular form, as opposed to the odd-shaped, triangular plots associated with center pivots.

The objectives of this study were to : A) Develop and field test equipment for variable-rate application of water on a lateral irrigation system; B) Use the system to determine the optimum irrigation scheduling method for coastal plain soils; and C) Determine crop coefficient for cotton in the humid southeastern United State.

A variable-rate lateral irrigation system was developed for site-specific application of water by modifying a 250-ft existing lateral irrigation system. The lateral has been divided into five sections (five sprinklers in each section) for our research purpose. This system can control each individual sprinkler or a group of sprinklers. All sprinklers are equipped with air-actuated water control valves. The air-actuated valves in each section (group) are controlled by a solenoid valve and pressurized air is supplied using an air compressor and a reservoir tank.

A control and data acquisition (CDA) system acquires information from various sensors and controls the rate of water application in each section accordingly. A solid-state relay board controlled by a computer cycles the sprinklers (on or off) to adjust the rate of irrigation water in each section and also varies the speed of the lateral system. A map-based computer program controls the amount of water applied in each section based on irrigation requirements. A GPS receiver is used to determine the position of the lateral irrigation system in the field. Variable-rate speed control system allows the lateral irrigation system to move quickly over wet spots and slow down over dry spots.

This system could monitor and apply water based on the actual soil moisture content, pan evaporation data, or the U.S. Climate Reference Network (CRN) data. Information from the moisture sensors, evaporation pan and CRN is acquired using wireless technology.

There was a strong correlation between soil electrical conductivity (EC) and soil water holding capacity. Therefore, the EC measurements could be used for irrigation scheduling decisions. The lateral irrigation system could be successfully controlled by nozzle-pulsing technique for variable-rate water application.

Development of Profitable Strip Tillage Systems for Cotton Production

South Carolina State Support Committee Grant (2002 to 2004)
Awarded To: A. Khalilian, M. Jones, M. Sullivan, J. Frederick, P. Bauer and W. Busscher

Soil compaction management in the southeastern U.S. relies heavily on the use of annual deep tillage. The conventional cotton production systems in this area require a minimum of three and often five field operations at a cost of approximately $31 per acre. Strip tillage systems have shown considerable promise for reducing the energy and labor requirement, equipment cost, soil erosion and cotton plant damage from blowing sand. Cost savings of approximately $20 per acre could be achieved by strip tillage compared to conventional methods.

This research was conducted to evaluate the performance of three different strip tillage systems compared to conventional and no-till methods in terms of effects on soil parameters, crop responses, and energy requirements; and to investigate the feasibility of eliminating the need for annual deep tillage by planting cotton directly into the previous years subsoiler furrow and controlling traffic. Replicated field experiments were conducted during the 2002 - 2004 growing seasons at Clemson University's Edisto and Pee Dee Research & Education Centers. Tillage treatments included: conventional tillage, straight shank strip-till, bent-leg shank strip-till (Paratill), bent-leg shank strip till (Terra Max), and no-till. At Blackville, the treatments were compared side by side with and without irrigation. In 2003, the test plots from previous year were split in half to determine the residual effects of different tillage systems. No deep tillage was applied to one-half of the plot while the other half received the same tillage treatment as in 2002. In 2004, again no deep tillage was applied to one-half of the plots (tillage every three years) while the other half received the same tillage treatment as in 2002 and 2003 (annual deep tillage).

Deep tillage significantly reduced soil compaction in crop rows compared to no-till. Strip-till systems utilizing Paratill and Terra Max shanks reduced soil compaction in the non-traffic row-middles. Taproots were significantly longer in deep tillage plots than those in no-till plots in both irrigated and dry land locations. In 2002, irrigation significantly increased cotton yields compared to dry land. There was no difference in lint yield between plots which had deep tillage operation in 2002 & 2003 with those which had tillage operation only in 2002. Therefore, with controlled traffic and planting directly into the previous years subsoiler furrow, the residual effect of deep tillage operations could extend at least for one additional year.

In 2004, there were no significant differences in lint yield between the plots which had annual deep tillage compared to those which had tillage operation only in 2002.

However, when data was analyzed for individual treatments, cotton yields from annual deep tillage in straight shank strip-till and conventional subsoil-bed plots were significantly higher. The yield increase from annual deep tillage was about 100 lbs lint/acre for these two tillage treatments. The results showed that with controlled traffic and planting directly into the previous years subsoiler furrow, the residual effect of deep tillage operations with the Paratill and Terra Max strip-till systems could extend at least for two additional years.

Site Specific Detection and Control of Nematodes in Cotton

South Carolina
Awarded To: Ahmad Khalilian, John Mueller, and Young Han, Clemson University

The overall objective of this work was to develop and test concepts and technologies for site-specific detection and control of plant-parasitic nematodes with the aim of optimizing farm profit while minimizing the effect of production practices on the environment. Nematodes currently are controlled in cotton by the uniform application of nematicides across a field. In this system a significant portion of the nematicide is applied where nematode densities are below treatment thresholds. Replicated tests were conducted in ten farmer's fields in South Carolina to determine whether nematode densities and subsequent crop yield losses can be significantly correlated to soil texture and to determine whether electrical conductivity could be used to map soil texture on a field-wide basis in a timely and economical manner. Use of soil electrical conductivity (EC) to measure soil texture and predict the distribution of nematode species was very successful. EC values were positively correlated with percentage clay and a negatively correlated with percentage sand and were used to develop an accurate soil type distribution map of each field. In South Carolina, recovery at planting and harvest of Columbia lance nematode decreased as soil electrical conductivity increased. Soil texture, especially percentage of sand, was one of the primary factors influencing nematode distribution. A 9% drop in percentage sand resulted in a 57% reduction in nematode population density. Using EC to predict the distribution of nematodes within a field is achievable in a sandy or loamy sand soil type. The % sand was also highly correlated to yield maps generated with a cotton yield monitor. The results showed that the difference in cotton yield between areas treated with Telone II nematicide and non-treated cotton were highly correlated with the root-knot nematode's gall ratings on cotton roots the previous fall. Pre-plat and at planting root-knot population densities were most correlated with yield. Soil texture (%sand) affected root-knot damage potential and environment also affected the relationship between root-knot population densities and cotton yield.

GPS-based equipment for controlling the rates of nematicides (Telone II and Temik 15G) to match the spatial distribution of nematodes were developed and tested under actual field conditions. Both variable-rate applicators closely followed the recommended nematicide application-rate maps with mean measurement error of 1% for Temik 15G and 2% for Telone II. The equipment was used to control applications of Telone II and Temik 15G at varying rates to specific areas of a field to match the spatial distribution of nematodes. Overall, variable-rate applications of both Telone II and Temik-15G increased cotton yields compared to standard uniform-rate applications. Also, nematicides (uniform or variable-rate applications) significantly increased cotton yields compared to no nematicide applications. Yield increases in the sandy portion of the field were significantly higher than in the clay areas. The nematicide rate needed for adequate control of Columbia lance nematode decreased with increasing soil electrical conductivity (EC) and decreasing % sand. Savings in Telone II applications ranged from 53% in sandy portion of the field (85 to 89% sand) to 100% in heavier soil portion (72 to 76% sand) of the field. Reductions in Temik-15G rates ranged from 20% to 50% in the same soil types. On average, the variable-rate Temik -15G system resulted in 7% higher yield and the variable-rate Telone II applications increased lint yield by 5% compared to a single rate application.

Using variable-rate nematicide application systems producers can expect a $38.00/ac return from higher yields compared to uniform application rates. More than 50% of cotton fields in the Southern USA are infested with above damage threshold levels of Columbia lance, reniform or root knot nematodes. All of these acres have potential to be more profitably managed using site-specific nematicide application than with application of a single rate to a whole field. Reduction of costs due to less nematicide applications nationally could result in an additional $35 million in crop revenue. Use of a commercially available soil electrical conductivity meter to detect nematodes has potential to reduce sampling costs by more than 75%.

Development of Sensors and Technologies for Detecting Sucking Bugs Populations in Cotton

South Carolina Cotton Board (2004)

Awarded To: Ahmad Khalilian, Sam Turnipseed, Young Han, and Roy Dodd, Clemson University

The objectives of this project is to develop chemical and physical sensor technologies to detect bug populations as an alternative to current labor-intensive bug detection methodology; construct a hand-held prototype for rapid in-field decision making; and assess its potential for use by farmers/consultants.

Tests were conducted to determine the feasibility of detecting cotton boll infection through electrical properties. A commercially available "Vitel Hydra probe" was modified by replacing the four metal spears with smaller and simpler probes to be inserted into the cotton bolls. The probe had two conducting spears, sharp enough to easily penetrate the cotton boll, separated with a solid insulator and could be connected to the Hydra probe data logger. The probe was used to measure permittivity or “Dielectric Constant” of the healthy and damaged cotton bolls. A standard lab multi-meter was used to measure the resistance of the cotton bolls. Also, the modified probe was used with a TDR sensor.

All three instruments showed that the electrical values of similar cotton bolls were the same. Depth of the probe in the boll changed meter values. This preliminary testing showed the importance of maintaining a constant probe depth. There were differences in dielectric constant values of the healthy bolls with those infected with stink bugs. However, the results were not consistent and further testing is needed. The instrumentation will be modified and the tests will be repeated in 2005.

Use of a portable electronic nose (Cyranose Sciences Inc. 2004) was very successful in identifying stink bug damaged and undamaged bolls (accurate 90 percent of the time). However, this sensor is expensive and a chipper sensor needs to be developed to be used by growers and consultants. Therefore, in 2004, procedures were developed to identify the volatile chemicals produced with sucking bugs themselves and a cotton plant with sucking bug damage to bolls.

The stink bugs were put into a 250 ml Erlenmeyer flask with a Teflon stopper in the top. The inlet air was connected from a cylinder of zero grade medical air through a flow control valve set at .25 L/min and a charcoal filter. The air was passed through the flask for a time period of 4 hours and the stink bugs were excited approximately every 30 minutes. The outlet air from the flask was attached to a collection trap (Super Q). At the end of the sampling period the trapped volatiles were extracted from the collection trap using 0.5 ml of hexane into a 1.1 ml glass vial with a crimp top cap. The chemical samples then were run in a Gas Chromatography/Mass Spectronomy (GC/MS) machine for roughly 3 hours per sample. This system provides a print out of the chemical analysis and a chromotograph showing the peak of each of the major chemicals, which then can be used to determine which chemicals pertain to the stink bug. The chemical composition of the most volatiles released by stink bugs has been identified. However, further testing would have to be done to identify the main chemical for the purpose of developing a low-cost sensor (electronic snifter) for field use.

A Volatile Collection Chamber (VCC) for collecting the volatiles from healthy and damaged cotton plants was developed. The system consists of a 5-galon open chamber (borosilicate glass, Pyrex®), with a "Guillotine" type base. With this type of chamber, it is possible to collect volatiles from only a portion of a plant or specimen. The Guillotine design allows the user to selectively close off a part of a plant in a chamber in which volatiles are to be collected in a clean (neutral) environment while allowing other portions of the plant to be external from this sampling environment for reasons of size limitations, cross contamination or stimulus response testing. The chamber is mounted on an adjustable-height table for sampling cotton plants in the field. The system will be tested in 2005 under laboratory and field conditions.

Maximizing Cotton Yields By Subsurface Drip Irrigation

South Carolina Cotton Board (2002)
Awarded To: Ahmad Khalilian and Mike Sullivan, Clemson University

Subsurface drip laterals were installed 15 inches below the soil surface under alternate row middles in a two-acre field. The irrigation system had four irrigated zones and one non-irrigated zone. Each zone had eight plots (8 rows by 70 ft). TDT moisture sensors (ESI Gro.point) were installed at two different depths (9 and 14 inches) in the root zone to measure the actual soil moisture content. Four sensors were used in each zone, a total of 20 TDT moisture meters for the test field. The sensors were connected to a microprocessor-based data acquisition/controller system. The controller system transmits the real time data to a desktop computer located at the Ag engineering lab using radio signals. "Aqualink Intelligent Irrigation System" software controlled irrigation valves, filters, injection pumps, etc. and was used for irrigation scheduling. An automatic evaporation pan was developed to measure and record daily evaporation. This system utilizes a load cell, a signal conditioning box, and a Campbell data logger. The unit was calibrated to measure evaporation and transmits the data to the data acquisition/controller unit.

Two irrigation-scheduling styles “A” and “B” were used in 2001 and 2002. For style “A”, irrigation was scheduled utilizing actual soil moisture content measured with moisture sensors. This system starts irrigation when the soil moisture content drops below a set number. For style “B”, plots were irrigated using pan evaporation data and a crop coefficient. Other factors such as rainfall, temperature, sunlight, and other variables are also entered into the system.

Two fertigation methods were used. For method 1, all fertilizers and micronutrients except phosphorus were injected through the irrigation system. For method 2, only nitrogen was injected though the irrigation system during the growing season. The rest of the nutrients were applied over the top. Also, dry land (non-irrigated plots) received all nutrients over the top (conventional method).

The following treatments were replicated eight times: non-irrigated; irrigation style “a” plus fertigation method "1"; irrigation style “a” plus fertigation method "2"; irrigation style “b” plus fertigation method "1"; and irrigation style “b” plus fertigation method "2".

There was no significant difference in yield between plots irrigated using actual soil moisture contents and those irrigated using pan evaporation and crop coefficient method in 2001. Injecting all fertilizers and micronutrients significantly increased seed cotton yield compared to conventional fertilizer application method. All irrigated plots yielded significantly higher than those in dry land area. The yield increase ranged from 25% for “Pan evaporation-based irrigation + conventional fertilizer” treatment to 43% for “sensor based-irrigation + injecting fertilizers” treatment. Injecting all fertilizers and micronutrients significantly increased leaf potassium content. Also leaf nitrogen content in irrigated plots was significantly higher compared to dry land.

In 2002, sensor-based irrigation significantly increased cotton yields compared to pan-based irrigation method. Again, injecting all fertilizers and micronutrients significantly increased seed cotton yield compared to conventional fertilizer application method. Also, all irrigated plots yielded significantly higher than those in dry land area.

Matching Soil-Applied Herbicides to Soil Properties in Cotton Production

South Carolina Cotton Board (2002 to 2003)
Awarded To: Ahmad Khalilian, Jason Norsworthy, and Mike Sullivan, Clemson University

There are several herbicides available for weed control in cotton. Roundup Ready cotton varieties have become available in recent years, which allow Roundup to be sprayed over the top. This is probably the simplest way to control major weeds. However, in some cases yields are lower than conventional varieties plus there is about an $8/acre technology fee involved. In addition, Roundup Ready cotton can only be sprayed up to 4-leaf stage. Usually at the recommenced application rates there are number of weeds such as Florida pusley, cutleaf evening primrose, and common purslane that are tolerant to Roundup. Based on Clemson University surveys, about 60% of farmers are still using soil-applied herbicides for weed control even when they plant Roundup Ready cotton.

Soil applied herbicides such as fluometuron (Cotoran) is highly leachable, especially on sandy soils, and has a narrow margin of selectivity in cotton, at times causing injury at a 1X application rate. The injury to cotton plants may be more pronounced in field areas with a high percentage of sand; therefore, use rates must be properly matched with soil properties. Considerable soil variation occurs within and across production fields in South Carolina. However, farmers apply a uniform rate of Cotoran across an entire field (at a cost of approximately $9 to $18 per acre) without regard to in-field variability in soil properties. Matching herbicide application rates to soil properties would reduce herbicide inputs, expenditures, environmental contamination, and yield loss as a result of early-season crop injury.

Tests were conducted during 2002 and 2003 growing seasons in a 6-acre field, with different soil types, near Blackville, SC. The test field was divided into 374 (4-row by 50-feet long) plots. Each plot was identified using a GPS system so that we could return to identical sites for use during the season and the following year. Geo-referenced soil samples were collected from each plot and analyzed for % sand, clay and silt contents. Also, the Veris EC meter was used to identify variations in soil texture across the field.

A soil EC map was developed using a GPS receiver and geographic information systems (SSToolbox). Some farmers are already using EC maps as a nutrient-management tool. Due to the stability of soil texture, and to some degree soil organic matter, a soil EC map can be used for multiple years. The soil texture and EC maps were used to designate three possible soil types. Pitted morningglory and sicklepod were seeded in separate 10 ft^2

sections in each plot immediately following cotton planting. Fluometuron was then applied at nine rates from 0 to 2.0 lbs ai/acre. Each treatment was replicated five times in each soil types.

Plant and weed data were collected 4 weeks after the fluometuron application. Cotton injury was determined visually and also by measuring differences in cotton biomass. Cotton height and density did not vary with fluometuron rates within any block; however, cotton biomass decreased linearly with increasing fluometuron rate, indicating an injurious effect on cotton. At higher rate of fluometuron, there was about 50% reduction in cotton biomass in sandy portion of the field (low EC reading). For the medium and high EC readings the reductions were 44 and 33% respectively. In the sandy portion of the field we were expecting a lot higher reduction in cotton biomass.

The effectiveness of the fluometuron on morningglory biomass varied with soil EC readings. The fluometuron rate needed for adequate control of morningglory diminished with increasing percentage sand as predicted by soil EC. For example to achieve 80% control in sandy portion of the field it required 0.4 kg ai/ha compared to 0.7 kg ai/ha in medium soil type and 1.5 kg ai/ha in heavy soil to achieve the same control. This indicates that geo-referenced soil EC maps can be effectively used to match soil properties with the lowest fluometuron rate needed for effective weed control, in turn reducing fluometuron use and early-season cotton injury. Similar results were obtained with sicklepod except in heavy soil type it required lower rate than for morningglory.

Equipment for site-specific application of soil-applied herbicides was development. This equipment consists of a chemical-injection pump driven by a 12-volt DC motor and controlled by the variable-rate application software Fieldlink (AGRIS), a rate controller (Mid-Tech TASC-6500), and a Trimble GPS receiver. A conventional chemical sprayer, mounted on a John Deere 7300 vacuum planter, applies a predetermined rate of water at constant pressure. The variable-rate equipment injects different amounts of herbicide into the system based on the variation in soil EC.

Agronomy

Residue Management and Soil Type Influence on Yield and Fiber Quality of Cotton With and Without Temik

South Carolina Cotton Board Grant (1997 and 1998)
South Carolina State Support Committee (1999)
Awarded To: Philip J. Bauer, USDA-ARS, Florence
and
James R. Frederick, Gloria McCutcheon, Don Manley, and John DuRant, Clemson University

Differences in cotton growth and productivity occur within most cotton fields in the SE USA Coastal Plain. Many of these differences in non-irrigated fields are due to the amount of water available to the crop during the growing season. Different soil types within a field can hold different amounts of water in the rooting zone, and the lower yielding areas tend to have either too much or too little water than other areas of those fields. Soil-management techniques that increase rainfall infiltration and reduce run-off and soil water evaporation may improve growing conditions in areas prone to water-deficit stress. These techniques may also improve productivity in wet areas of fields by reducing the amount of run-on water from other areas. Since residue-management techniques may influence the variability for yield, they may also have an affect on the amount of variability for fiber properties.

The objective of this study was to determine how cotton yield and quality are affected by residue management systems on different soil types.

SUMMARY OF FINDINGS

The yields of cotton grown with conventional versus conservation tillage averaged over all residue management systems are shown in Table 1. Conservation tillage and conventional tillage did not differ for yield in 1997, which was a good year for rainfall at the Pee Dee Research and Education Center. Conditions were drier in each year thereafter and cotton grown with conservation tillage had higher lint yields than cotton grown with conventional tillage.

Table 1. Effect of surface tillage on cotton lint yield.

	Lint Yield (lbs per acre)	
Year	Conventional Tillage	Conservation Tillage
1997	875	830
1998	574	785*
1999	285	354*
2000	596	687*
2001	551	710*

* Indicates there was a 95% chance that the higher yield with conservation tillage was not due to chance.

Table 2 shows the effect of the residue-management treatments on conservation-tillage cotton yield for the Bonneau sand and Norfolk loamy sand (data from the Eunola loamy sand were not included because a small number of data points compared to the other two soil types) in the experimental field. The data are averaged over 1998 and 2000 (the two years where cotton was grown following corn). The Bonneau sand is more drought-prone than the Norfolk loamy sand, which explains the lower lint yields of the Bonneau sand. For both soil types, continuous cotton without a winter cover crop (the fallow bar on the graph) had the lowest yield of the three treatments. Continuous cotton grown with a rye winter cover crop had the same yield as cotton rotated with corn (a high residue-producing crop).

Table 2. Effect of Residue Type on Yield of Cotton Grown With Conservation Tillage

	Lint Yield (lb/ac)		
Soil	Winter Fallow	Rye Cover Crop	Rotated With Corn
Bonneau	611	703	724
Norfolk	747	806	809

Least Significant Difference = 61 lb lint/ac

Fiber properties: There was very little response of fiber properties to residue management systems so far in this experiment (data not presented in Tables). Over the first four years of the experiment, cotton grown with conservation tillage had a longer fiber length than cotton grown with conventional tillage when averaged across the three soil types. The increase in fiber length was similar for all three soil types (surface tillage by soil type interaction not significant). Surface tillage had no effect on micronaire. Averaged over tillage systems, the soil types did not differ in fiber length or micronaire.

During the first three years of the study we determined the fiber properties of cotton in the lower, middle, and upper part of the canopy. During the first two years, it appeared that cotton was more uniform throughout the canopy for length and micronaire when grown with conservation tillage. In 1999 (an extreme drought year), there was no difference between tillage systems for within canopy fiber property variation.

CONCLUSIONS

One more year of study is planned before final conclusions from the experimental field can be made. The preliminary findings indicate: Residue management had an affect on cotton yield in drier years, with systems that left considerable amounts of residue on the soil surface resulting in higher yield than systems where the ground was left uncovered. Soil types respond similarly to residue management for cotton yield and fiber properties. This similarity indicates that variability across fields will not be affected when farmers use different residue management systems. This result also suggests that yield maps generated from fields with one residue management system are predictive of the patterns of yield variability that will occur should farmers switch to another residue management system.

Management Systems for Transgenic Cotton in Ultra-narrow Rows

South Carolina Cotton Board Grant (1999)
South Carolina State Support Committee Grant (2000)
Awarded To: Michael A. Jones, Clemson University

One production system that has received increased attention by industry, research personnel, and producers in recent years is ultra-narrow row cotton production. Ultra-narrow row systems consist of planting cotton in narrow rows (15 inches or less) at extremely high populations (approximately 100,000 plants/A) and harvesting with a stripper harvester. Ultra-narrow row systems are attractive to producers because they have the potential to increase yields, reduce production costs and labor, and increase earliness. The purpose of this research was to evaluate the effectiveness of various row spacings, varieties, planting dates, and mepiquat chloride management strategies for transgenic cottons in ultra-narrow row systems.

Several replicated field studies were conducted at the Pee Dee Research & Education Center in Florence, SC, in 1999 and 2000. In the first study, three row spacings (7.5-in., 15-in., and 38-in. rows) and six varieties (Fibermax 832, ST 474, BXN 47, SG 125B/R, PM 1220BR, and NuCotn 35B) were evaluated. A second study evaluated two planting dates (April 20 and June 1), two row spacings (7.5-in. and 38-in. rows) and three varieties (DPL 655BR, PM 1220BR, and FM 832). A third study consisted of three row spacings (7.5-in., 15-in., and 30-in. rows) and five mepiquat chloride applications (untreated check, four applications of 4 oz/A, two applications of 8 oz/A, four applications of 8 oz/A, and four applications of 12 oz/A). Mepiquat chloride applications began at matchhead square and were applied every 10 to 14 days depending on growth conditions. A fourth study consisted of two row spacing (7.5-in. and 15.0-in rows) and six plant populations (75,000 plants/A, 100,000 plants/A, 125,000 plants/A, 150,000 plants/A, 175,000 plants/A, and 200,000 plants/A). Plots were harvested using a finger stripper for the 7.5- and 15.0-inch row spacings and a spindle- picker for the 30- and 38-inch row spacings.

Results

Variety x Row Spacing Study. Results indicated significant differences in seedcotton yield, lint yield, and gin turnout existed among row spacings and varieties. Averaged across years, cotton grown in 7.5- and 38-inch rows (1337 and 1327 lbs/A, respectively) produced more seedcotton than 15-inch rows (1080 lb/A). Suregrow 125BR, ST BXN 47, and DPL 35B produced more seedcotton (1386, 1371, and 1311 lb/A, respectively) than ST 474 (1258 lb/A), Fibermax 832 (1207 lb/A), and PM 1220BR (957 lb/A). However, a significant row spacing x variety interaction was found for seedcotton yield. Highest seedcotton yields were attained for SG 125BR (1757lb/A) and ST BXN47 in 1999, and for ST 474 and Fibermax 832 in 2000 when grown in 7.5 inch rows compared to the other row spacings. Delta and Pineland NuCotn 35B produced more seedcotton in 2000 when grown in 38-inch rows compared to narrower row spacings. Gin turnout was significantly reduced by narrow row spacings, with 7.5- and 15-inch rows averaging approximately 37% lint. Gin turnout for 38-inch rows averaged 41%.

Row Spacing x Planting Date Study. Averaged across years, cotton planted earlier than normal (April 20) produced more lint in 7.5-inch rows (lint yield = 546 lb/A) than in 38-inch rows (lint yield = 464 lb/A). Cotton planted later than normal (June 1) produced more lint in 38-inch rows (lint yield = 658 lb/A) compared to 7.5-inch rows (596 lb/A). No significant row spacing x variety interactions were found with seedcotton, lint yield or gin turnout.

Row Spacing x Mepiquat Chloride Study. Cotton grown in 7.5-, 15-, and 30-inch rows produced 1646, 1227, and 1439 lb of seedcotton/A, respectively, in 1999. However, gin turnout was significantly lower (37 % lint) for 7.5- and 15-inch rows compared to 30-inch rows (41% lint). These differences in percent lint among row spacings negated the potential yield advantage for the 7.5-inch row spacing, resulting in similar lint yields for the 7.5-inch rows (616 lb/A) and the 30-inch rows (585 lb/A) in 1999. Lint yield in 15-inch rows averaged only 457 lb/A in 1999. In 2000, lint yield was higher for cotton grown in 30-inch rows compared to narrower row spacings. No yield advantage was found in applying mepiquat chloride to plants grown in any row spacing.

Plant Population x Row Spacing Study. No significant differences in seedcotton yield, lint yield or gin turnout were found between row spacings or among plant populations in this study. Lint yield averaged 587 and 566 lb/A for the 7.5- and 15-inch row spacings, respectively. Lint yields ranged from a low of 518 lbs/A for the 75,000 plants/A treatment to a high of 600 lb/A for the 175,000 plants/A treatment. Percent lint was extremely low for all treatments, averaging only 35%.

Evaluation of the Efficacy of Boll Opening Materials for Late-season Cotton Management

South Carolina Cotton Board Grant (1999 and 2001)
South Carolina State Support Committee Grant (2000)
Awarded To: Michael A. Jones, Clemson University

Deciding when to defoliate is one of the most difficult decisions producers have to make in cotton management. The process is a balancing act between the weather, crop maturity, and percent open bolls. Since late-season crop management has the potential to cause significant reductions in fiber yield and quality, research into end-of-season management practices is essential in increasing the profitability of South Carolina cotton producers. Common questions often asked by South Carolina cotton producers is how much time is required for bolls to open after boll opening materials are applied, how long is required until a certain percentage of bolls are opened after chemical treatment, and how many unopened bolls should be opened by boll openers in order for the chemical treatment to be profitable. Research has shown that mature bolls usually open 3 to 14 days after application; however, boll opening appears to be highly temperature dependent. This research was conducted to attempt to address many of the questions cotton producers have about the efficacy of boll opening materials and the time requirement necessary for bolls to open after chemical application by relating these events to heat units (DD60's).

Replicated field experiments were conducted at the Pee Dee Research & Education Center in Florence, SC, during the 1999 and 2000 growing seasons. Cotton was planted in 38-inch rows that were 40 ft. long and was grown using standard production practices. Appropriate boll opening treatments were imposed at the 25 and 50% open boll stages by spraying individual plots with a ground sprayer. Boll opening treatments consisted of : a) control - no boll opening materials, b) PREP applied at 1.33 pt/A (low rate), c) PREP applied at 2.67 pt/A (high rate), d) FINISH applied at 1 qt/A (low rate), e) FINISH applied at 2 qt/A (high rate), f) COTTONQUIK applied at 1 qt/A (low rate), and g) COTTONQUIK applied at 2 qt/A (high rate). Defoliation chemicals were not used in this study to avoid confounding the results with boll opening materials.

Surprisingly, the application of all boll-opening treatments resulted in significant leaf removal (57 to 95% defoliation) by 100 DD60s after treatment when applied at the 25% open boll stage compared to the untreated (21-30% defoliation) plots. All boll opening treatments applied at the 50% open boll stage were 64 to 99% defoliated by 133 DD60s after treatment, while the untreated plants were only 26 to 46 % defoliated. Although boll opening rates varied depending on the year and the crop condition, higher rates of boll opening materials usually caused more bolls to open earlier in the season compared to lower rates of the boll opening materials or the untreated check. When applied at 25% open boll, Prep at 2.67 pt/acre increased the number of bolls opening at 141 DD60s after treatment compared to the other boll opening treatments and the untreated check. The application of boll openers at 25% open boll caused more bolls to open between 125 and 145 DD60s after treatment when compared to the untreated plots. When applied at the 50% open boll stage, Finish at 2 qt/acre increased the number of bolls that opened between 54 and 232 DD60s after treatment, but no differences were found among any of the other boll opening treatments and the untreated check when applied at 50% open boll. No differences in lint yield were found among any of the boll opening treatments and the untreated check plots when applied at the 25 or 50% open boll stage. Applying boll openers at 25 and 50% open boll stage reduced boll size of the latest developing bolls. Few differences in fiber properties existed among the treatments and the untreated. However, early applications of boll openers significantly reduced micronaire of late-developing bolls.

Managing Irrigated Cotton For Yield and Fiber Properties Based on Early Season Growing Conditions

South Carolina Cotton Board Grant (2000)
South Carolina State Support Committee Grant (2001)
Awarded To: James R. Frederick and Michael A. Jones, Clemson University
and
Philip J. Bauer, USDA-ARS, Florence, and David McAlister, USDA-ARS, Clemson

The objectives of this project were (1) to compare cotton cultivars differing in genetic background (transgenic versus conventional cultivars) and seedling vigor for yield potential and fiber quality at different full season planting dates; and (2) to determine if yield potential of irrigated cotton can be predicted accurately enough from early season weather to allow for side-dress N management decisions.

Four cotton genotypes were planted at three different times in the spring (mid-April, early May, mid-May) and either 40, 80, or 120 lbs N acre were applied. Early season growth (at match-head size square), mid-season photosynthesis, and yield were measured.

Results

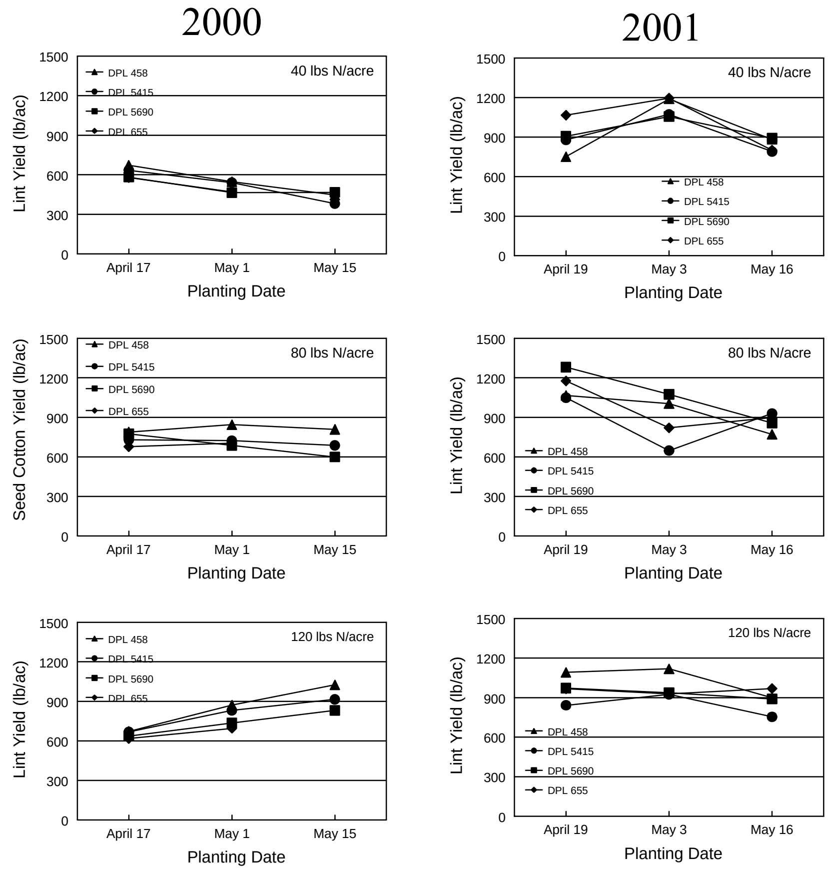
Early Season Growth Conditions. The first twenty days after planting were quite different for the three planting dates each year. In 2000, heat units in the first 20 days after planting were 110, 292, and 357 for the mid-April, early May, and mid-May planting dates, respectively. Total number of days with nighttime lows less than 60 F were 18, 8, and 3 for the three planting dates. In 2001, heat unit accumulations (DD60's) for the twenty days were 119, 235, and 305 for the mid-April, early May, and mid-May planting dates, respectively. The total number of days when the nighttime low reached below 60 F was 19, 12, and 4 for the mid-April, early May, and mid-May planting dates, respectively.

Early Season Growth and Mid-Season Photosynthesis. Samples were collected when plants had reached match-head square size and before side-dress N was applied. There was little difference between planting dates for early season growth. At that time, averaged over both years, DPL 5690 had slightly greater leaf area and dry weight than the other three cultivars (458, 5415, and 655).

The four cultivars did not differ for mid-season canopy photosynthesis rates. Averaged over both years, the late May planting date had higher mid-season photosynthetic rates than the other two planting dates. As was expected, canopy photosynthesis increased with increasing N fertilizer rate.

Fiber properties. We have just finished ginning the cotton samples for this year. Thus, we cannot report the effect of planting date, N, and genotype on HVI fiber properties or fabric quality yet.

Effect of planting date, N fertilizer, and genotype on cotton lint yield.



Yield. Yields for the four genotypes at each planting date in each N rate in both years of the study are given in the figure above. Our original hypothesis was that we could predict yield potential from early season chilling stress and then fertilize with N to match that yield potential. Results from the 2000 crop year looked promising as yields with 40 lbs N/acre decreased with reduced cold stress (earlier planting), there was no difference with 80 lbs N/ acre, but yields increased with delayed planting at the 120 lb/acre N rate. However, in 2001, yields were always high even with early season chilling stress (early planting date). Thus, we conclude that early season chilling stress is not an accurate enough predictor of yield of irrigated cotton to allow for use in optimizing N management

Evaluation of a New, Unidentified Cotton Seed Rot in South Carolina

South Carolina Cotton Board Grant (2000 and 2001)
South Carolina State Support Committee Grant (2001)
Awarded To: Michael A. Jones, John Mueller, and Dan Kluepfel, Clemson University

Monitoring Plots. Plots were established in 4 states at a total of 11 locations to monitor the incidence of seed rot on identical genotypes across a range of environments. Plots were established in Maricopa, AZ, Unadella, GA, Scott, MS, and Hartsville, SC with assistance from personnel of Delta and Pine Land Company. Clemson University personnel established irrigated and non-irrigated early-planted plots and a late-planted dryland plot at the Pee Dee Research and Education Center near Florence, SC, and an early-planted irrigated plus late-planted irrigated and dryland plots at the Edisto Research and Education Center near Blackville, SC. They also established a late-planted, dryland plot in Hampton County, SC. Cultivars tested at each location included 'NuCOTN 35B', 'Deltapine 5690', 'Deltapine 655', 'Stoneville 474', 'ibermax 989', 'Paymaster 1218 BR', and 'Suregrow 501'. At the Clemson University locations 'Sphinx' and 'Maxxa' were added to the trials and at the Delta and Pine Land locations 'Deltapine 458' was included in the trials. Plots consisted of 4 row plots 40- to 50-feet long on conventional row widths with 4 replications of each cultivar. Each location was managed according to local extension recommendations for fertility, nematode control, planting dates, plant population, weed control, PGRs, irrigation, etc. Weekly applications of pyrethroids beginning at first flower and continuing until defoliation were used to minimize insect feeding and damage. Observations for abnormalities in flowering or boll set were begun at early bloom and continued at approximately 2-week intervals. Bolls were rated for seed rot when bolls were at least 21-days old. At each sample date the oldest unopened boll which was 21-days old or older was harvested from 10 to 15 plants per plot. Two transverse cuts were made in each boll resulting in 3 approximately equal width sections. The number of locules containing one or more seeds exhibiting seed rot symptoms was recorded. The lint and seeds were removed from each affected locule and the presence or absence of insect feeding (punctures or warts on the locule wall) recorded. Seed rot was not reported for any locule rated positive for insect feeding. Observations should include seed rot and/or immature seed development, bronze wilt, cavitation, elongation of peduncles, phloem discoloration, root abnormalities, supernumerary carpel, necrotic bracts, and any other plant abnormality found.

Severity of seed rot ranged from none detected at Maricopa to a mean severity (% of bolls affected) across sample dates and cultivars of 34% at Unadella, 18% in the Edisto Research and Education Center early-planted irrigated, 17% in the Pee Dee Research and Education Center early-planted irrigated, and less than 12% in the remaining 7 trials. Mean severity in the Hampton Co. field was 4%. Severity in this field in 1999 had been greater than 60% when planted to a single cultivar (Deltapine 655). Yields in most of the locations were high, between 800 and 1100 lbs of lint per acre, indicating that seed rot can occur in fields with high yield potentials. It was difficult to detect differences in seed rot severity among cultivars across locations, or at a single location. The only cultivar which exhibited a consistently high level of susceptibility was Maxxa when it was planted in the South Carolina locations. Maxxa was not developed and is not adapted to this environment. There were no consistent differences detected among the cultivars commonly grown in the Southeast. High levels of variability among replications prevented detection of differences among cultivars. Severity of seed rot varied from sample date to sample date within locations. It was more severe at certain nodal locations than others. In general it was more severe at the base of the plant than at the top.

Greenhouse and Micro-plots. Bacterial isolates were tested for their ability to induce seed rot symptoms on cotton under greenhouse and field micro-plot conditions. Microbial isolations were made in the summer of 1999 from cotton plants collected from growers' fields, which exhibited seed rot symptoms. Isolations were made from symptomatic and asymptomatic plants. Commonly isolated bacterial genera included: *Enterobacter, Pseudomonas, Bacillus, Pantoea*, and *Cedecea.* In the spring of 2000 24 isolates were tested in the greenhouse trial at the Edisto R.E.C. and 19 in a greenhouse trial at the Pee Dee R.E.C. In each test, the level of seed rot observed was compared to the level occurring in a non-inoculated water check. In the Edisto R.E.C. test plants were inoculated with a 1 ml solution of 10^8 cells/ml placed directly onto the seed at the time of planting. At the Pee Dee and Edisto locations flowers were inoculated when plants were in early- to mid-bloom. One to three flowers per plant were inoculated at the "elongated wick" stage with 300 *ul* of a 10^8 cfu/ml suspension of the strain being tested. Bolls were examined approximately 30 days later for symptoms of seed rot. Forty-one bacterial isolates were tested in a field micro-plot experiment in the summer of 2000 at the Edisto R.E.C. Seed and flowers were inoculated as described previously. Isolates tested included those which appeared to cause seed rot in the Edisto R.E.C. greenhouse test, a sub-sample of the isolates which did not cause seed rot in the greenhouse tests, plus some previously untested isolates.

Eight of the isolates in the micro-plot test produced levels of seed rot of 2X (9% of locules) or greater than the water-treated check (4.5% of locules). In the Edisto greenhouse test 3 of the isolates produced 2X (24%) or greater levels of seed rot for the seed inoculum trial and 12 isolates produced 2X (6%) or greater levels of seed rot in the flower inoculum trial. In the Pee Dee greenhouse test all only flower inoculations were made and 12 of the isolates produced 2X (7%) or greater levels of seed rot. Isolates of a single species varied in their ability to induce seed rot indicating that pathogenicity may be strain specific. Only 2 isolates produced significant levels of seed rot in a greenhouse and the micro-plot test. Isolate #33, *Enterobacter agglomerans,* produced 31% seed rot (% affected locules) in the flower and 20% seed rot in the seed inoculation trial at the Edisto R.E.C. greenhouse and produced 10% seed rot in the micro-plot trial. Isolate #86, *Cedecea neteri*, produced 5% seed rot in the flower and 11% seed rot in the seed inoculation trial at the the Edisto R.E.C. greenhouse and produced 9% seed rot in the micro-plot trial at the Edisto R.E.C.

Impacts on Runoff/Water Quality of Conservation Tillage and Cotton

South Carolina State Support Committee Grant (2000)
Awarded To: John C. Hayes and Stephen J. Klaine, Clemson University

The intent of this project was to measure runoff, soil loss, and nutrient loss from six large plot treatments that were established. In addition, a fallow (bare) plot was established and used for comparison. Increased knowledge of the impacts of conservation versus conventional tillage may make conservation tillage more acceptable and provide knowledge to improve water quality that will increase sustainability of cotton production systems. In 1997, plots were established at Clemson University's Pee Dee Research and Education Center near Florence, SC to determine the effect of soil management on cotton yield and fiber properties. There treatments allow comparison of an entire 3-year cotton rotation to be studied simultaneously with both conventional and conservation tillage methods. The study included three cotton rotations, corn/cotton, rye/cotton, and cotton/cotton. Two different tillage systems were compared, no-till and conventional tillage. A fallow (bare) plot was installed as a control.

Each treatment had an instrumented erosion/runoff plot 4 row wide (approximately 13 ft) and 72 ft long. A border was installed around the perimeter of each plot so that runoff was directed to a collection device, and runoff was measured from the plot at 15-min intervals. Automatic pumping samplers were installed to collect multiple samples during a single storm event. Collected bottles were delivered to the laboratory for analysis of sediment and nutrient concentrations.

The combination of flow rates as a function of time and concentrations allowed computation of runoff and soil and nutrient loss. Spreadsheets were developed to evaluate runoff and chemicals on a mass balance basis for each storm. Totals for longer periods were obtained by summing single storm results to determine totals for the period April through July.

It was anticipated that the fallow plot would have the highest runoff rates of any of the plots. However, the influence of previous tillage practices apparently led the corn/cotton/no-till plot having the highest runoff volume followed by the fallow treatment. All of the no-till plots had higher runoff than did the conventional tillage plots, so it appears that the disking influence had considerable impact on reducing runoff during this period. While these results were surprising, it should be remembered that the period prior to this was dry and storms that occurred during April to July were smaller in magnitude than is typical during this period.

Results from total suspended solids and nutrients showed similar results. This result was not unexpected given the magnitude of runoff and how it controls chemical movement to a large extent. Continued evaluation of the runoff and chemical losses from these plots for additional storms should determine the reason for higher than expected runoff from the no-till plots, but preliminary results indicate that farmers need to recognize that tillage benefits are influenced by weather conditions.

Investigation of the Possible Causes of an Unidentified Cotton Seed Rot

South Carolina State Support Committee Grant (2001)
Awarded To: Michael A. Jones, John Mueller, and Dan Kluepfel, Clemson University

Numerous seed abnormalities have occurred in South Carolina cotton fields during the past three growing seasons. Affected seed are poorly developed and often hollow, while less affected seed are pinkish in color and partially hollow. Some seeds exhibit uneven thickening and development of the seed coat. Bolls in which abnormal seed development is detected do not mature normally and are often hard-locked, i.e. unharvestable with a mechanical picker. The objectives of this research were to evaluate the susceptibility of specific cotton varieties to seed developmental problems, to evaluate the response of this phenomenon to various management inputs, to assess changes in lint quantity and quality associated with this seed problem, to determine the potential economic impact of this disorder, and to identify the causal factor(s) and/or organism(s) associated with this problem.

Five replicated field experiments were conducted at the Pee Dee Research & Education Center during the 2001 growing season. Experiments were designed to determine the impact of the environment, varieties, and management practices on seed abnormalities, as well as the relationships between seed problems, stink bug feeding, and other new cotton disorders. Fifteen cotton varieties representing a range of maturities, seed companies, technologies, and genetic backgrounds were planted in four separate studies. These four variety experiments consisted of early- and late-planted fields grown under irrigated and non-irrigated conditions. A management input experiment was also conducted.

Seed developmental problems occurred in all varieties examined. This list of varieties included a conventional variety released in the early 1920's (Dixie Triumph), conventional varieties adapted to S.C. and developed at the Pee Dee Station during the 1970's (SC 1, PD 1, PD 2, PD 2164), conventional varieties not adapted to the Southeastern U.S. (Maxxa, Sphinx, Tamcot SP21), conventional varieties currently grown in S.C. (DPL 5690 and ST 474), and transgenic varieties currently grown in S.C. (DPL 655BR and PM 1218BR). The only cultivar which was more susceptible than the other varieties to seed abnormalities was Maxxa, a variety which is grown primarily in the Western U.S. Few seed developmental problems were found in bolls younger than three weeks of age. Seed rot symptoms appeared to increase as boll age increased. High levels of seed abnormalities during boll development were generally associated with increased problems with hard-lock cotton at maturity and problems with mechanical picking at harvest. The occurrence of seed abnormalities and seed rot symptoms was unaffected by the various management inputs applied during the growing season: 1) increasing the boll load per plant (Low plant population); 2) decreasing the boll load per plant (early fruit removal with Prep); 3) applying plant growth regulators (Messenger or

PixPlus); 4) increasing the potassium rate by 100 lb/A; 5) increasing the boron rate by 0.5 lb/A; and 6) reducing the nitrogen rate from 90 lb/A to 40 lb/A.

Defining the Potassium Requirements of Cotton

South Carolina Cotton Board Grant (2002 and 2003)
Awarded To: James Camberato and Michael A. Jones., Clemson University

During the past several years, late-season potassium deficiencies have been observed in many cotton fields across South Carolina. Some varieties have appeared to show potassium deficiency symptoms more frequently than other varieties. New, higher-yielding earlier-maturing cotton varieties develop more of their total boll load over a shorter period of time, which can lead to a more condensed boll filling period and an increased demand for the uptake and mobilization of potassium from the soil and leaf to the developing lint. Since Southeastern Coastal Plain soils typically have accumulations of potassium in clayey subsoil layers due to leaching of potassium incorporated into sandy surface soil layers, the extent of downward potassium movement during the growing season and access to subsoil potassium may govern potassium availability in Coastal Plain soils. Current potassium fertilizer recommendations in South Carolina are based on pre-season potassium levels of the topsoil that is adjusted by depth and potassium content of the subsoil. The data establishing the subsoil adjustment to fertilizer recommendations preceded development of these high potassium demanding cotton varieties. Research was conducted to determine if current soil testing procedures and recommendations are valid to optimize yield of modern cotton varieties. Replicated field experiments were conducted in 2002 and 2003 at the Pee Dee Research and Education Center located in Florence, SC, on a Norfolk-Bonneau soil complex identified as potassium deficient during the 2001 growing season. During the 2002 and 2003 seasons, potassium treatments were broadcast applied prior to planting at 0, 50, 75, 100, and 125 lb K_20/acre and five cotton varieties released between the years 1919 and 2001 (Dixie Triumph, DPL 90, DES 119, Paymaster 1218BR, and DPL 555BR) were evaluated.

Cotton growth and development was significantly altered by the various potassium treatments, and visible differences in deficiency symptoms in the field occurred among varieties and potassium rates. Significant premature leaf defoliation occurred at lower K application rates, but varied with variety. Leaf and petiole potassium levels were positively related to the sum of the initial soil potassium level of the A-horizon plus 50% of the potassium fertilization rate. Including E- or B-horizon potassium levels and/or a higher or lower percentage of potassium fertilization rate did not improve these relationships. Leaf potassium appeared to be a better indicator of potassium supply than petiole potassium, but was also more affected by growth stage compared to petiole measurements. Leaf potassium concentrations were low throughout boll development (especially with the low potassium fertilizer treatments), attaining deficiency levels of less than 1.5% at early bloom and less than 0.75% at cutout. All varieties responded favorably to increased levels of leaf potassium, but recently released higher-yielding varieties such as PM 1218BR and DPL 555BR responded more to potassium than older, lower-yielding varieties such as Dixie Triumph, DES 119, and DPL 90. Lint yields increased 400 to 800 lb/acre with each 1% increase in leaf K, with lint yields of newly released varieties increasing more than older varieties.

Evaluation of Nitrogen Rates, Sources, and Application Methods in Irrigated and Dryland Cotton in South Carolina

South Carolina Cotton Board Grant (2002 and 2003)
Awarded To: James Camberato and Michael A. Jones., Clemson University

A 2001 grower survey conducted by the South Carolina Cotton Board and Clemson University Cooperative Extension Service revealed that many cotton growers in South Carolina still have questions and concerns regarding the appropriate rates, timings, sources, and placement of nitrogen fertilizers on their farms. Grower concerns about proper nitrogen fertilization techniques are understandable, especially since nitrogen is considered by many cotton experts to be the second most limiting factor in cotton production following water and the price of nitrogen has steadily increased over the last few years due to inflated oil prices. Therefore, proper nitrogen management represents one of the most critical and important cotton production decisions facing South Carolina cotton growers. The objectives of this study were: to evaluate the effect of various nitrogen rates, nitrogen sources, and methods of application on cotton growth, lint yield, and fiber quality under irrigated and dryland conditions in South Carolina; to determine the optimal nitrogen fertilization techniques for irrigated and dryland cotton; and to determine if current nitrogen fertilization recommendations are still valid. Two replicated experiments were conducted at the Pee Dee Research and Education Center in 2002 and 2003. One experiment was conducted under a center pivot irrigation system and watered to alleviate any drought stress symptoms occurring throughout the season. The other experiment was conducted under dryland (rain-fed) conditions. Thirty pounds of nitrogen per acre was applied broadcast prior to bedding and planting. Additional nitrogen (NH_4NO_3 and UAN sources) was applied either broadcast or banded beside the row at various rates according to treatment schedules. Layby nitrogen rates were 0, 25, 50, 75, 100, and 125 lb N/acre.

Irrigated lint yields ranged between 770 and 848 lbs/acre in 2002. Highest yields were attained at a side-dress nitrogen rate of 25 lbs/acre (55 lbs total N/acre). No differences in yield or fiber quality were found among side-dress nitrogen sources or application methods. No differences in lint yield or fiber properties were found among any of nitrogen rates, sources, or application methods in the dryland study in 2002. Cotton was drought-stressed from May to late-August, and lint yields only averaged 540 lbs/acre. It appears 30 lbs of total N/acre applied preplant was sufficient under these harsh environmental conditions.

Comparison of Newly Released Cotton Cultivars to Older Established Cultivars in South Carolina

South Carolina Cotton Board Grant (2002 to 2004)
Awarded To: Michael A. Jones., Clemson University

Cultivar selection is the first and perhaps the most important management decision a grower makes each season. Cultivar decisions are now more complex due to the fact that numerous new cultivars have been introduced to the market by seed companies during the last few years, and are now offered for sale with fewer years of public testing than most growers, consultants, and university personnel need for proper evaluation. One way to increase the number of environments or evaluations of a new cultivar is to increase the number of locations within a given year. Increasing the number of locations within a given year will expose a new cotton cultivar to as many different growing conditions, management inputs, soil types, and environmental stresses as possible, and hopefully expose any problems associated with the performance of a cultivar before it reaches growers' fields. Eight to ten replicated cultivar trials were conducted at three to four different locations (Florence, Dillon, Lee, and Calhoun Counties) throughout South Carolina during 2002, 2003, and 2004 growing seasons. Trial locations were on growers' farms and each trial consisted of between 30 to 40 cultivars. Trial locations were selected based on previous and projected cotton acreage in a given area and differences in soil types and management inputs. An effort was made to evaluate cultivars under as many different environments as possible within areas of high cotton acreage. New cultivars were chosen based on projected planted acreage in the state and the potential for the cultivar to perform in South Carolina. New transgenic siblings were compared to their parents in order to determine similarities or differences among these lines. Trials were located in areas of high visibility and marked with signs so growers can evaluate cultivars throughout the season. Results from these ten trials were presented at grower meetings, state meetings, regional meetings, newsletters, production guides, and electronically on the web.

Determining the Potassium Requirements for Modern Cotton Cultivars

South Carolina Cotton Board Grant (2004)
Awarded To: James Camberato and Michael A. Jones., Clemson University

During the past several years, late-season potassium deficiencies have been observed in many cotton fields across South Carolina. Some varieties have appeared to show potassium deficiency symptoms more frequently than other varieties. New, higher-yielding earlier-maturing cotton varieties develop more of their total boll load over a shorter period of time, which can lead to a more condensed boll filling period and an increased demand for the uptake and mobilization of potassium from the soil and leaf to the developing lint. Since Southeastern Coastal Plain soils typically have accumulations of potassium in clayey subsoil layers due to leaching of potassium incorporated into sandy surface soil layers, the extent of downward potassium movement during the growing season and access to subsoil potassium may govern potassium availability in Coastal Plain soils. Current potassium fertilizer recommendations in South Carolina are based on pre-season potassium levels of the topsoil that is adjusted by depth and potassium content of the subsoil. The data establishing the subsoil adjustment to fertilizer recommendations preceded development of these high potassium demanding cotton varieties. Research was conducted to determine if current soil testing procedures and recommendations are valid to optimize yield of modern cotton varieties. A replicated field experiment was conducted in 2004 at the Pee Dee Research and Education Center located in Florence, SC, on a Norfolk-Bonneau soil complex identified as potassium deficient last growing season. Potassium fertilization rates were 0, 50, 85, 120, 155, 190, and 225 lb K_20/acre applied broadcast to a sandy Norfolk-Bonneau soil prior to planting. Five modern cotton cultivars, DPL 555BR, ST 5599BR, FM 989BR, DPL 444BR, and PM 1218BR were evaluated. The experimental design was a split-plot with potassium fertilization rate as the whole plot (20 rows wide by 40 foot long) and cultivar as the split plot (4 rows wide by 40 foot long) and three replications. Only the center two rows were used for plant tissue and lint harvest. Leaf and petiole samples were obtained July 14 (2 weeks after first flower) and July 27 to monitor potassium status of the cotton plant. The sap from 20 petioles was squeezed out, and potassium determined with a Cardy K^+ meter. Leaf tissue was dried, ground, and analyzed for nutrient content by standard laboratory procedures. Defoliation was visually estimated on August 12 and 26.

Results: Soil test K levels in the Ap-horizon ranged from 15 to 135 lb acre^{-1} Mehlich I extractable K dependent on prior year K application rates and differences in soil properties. Defoliation, leaf and petiole K, and lint yield were strongly correlated with soil test K in plots receiving no K fertilizer. Potassium fertilization decreased premature defoliation and increased tissue K levels and lint yields. Defoliation was nearly 100% on August 12 for low soil test K without fertilization in contrast to nearly 0% defoliation in K treatments receiving K fertilizer ∃120 lb acre^{-1}. Leaf K ranged from 0.4 to 1.59% on July 14 and was highly dependent on soil test K and fertilizer K rate. Petiole sap K ranged from 2100 to 9500 ppm on July 14 and was also highly dependent on soil test K and fertilizer K rate. Due to premature defoliation, leaf and petiole K levels on July 27 did not reflect soil test K and fertilizer K rate as well as the earlier sampling date. Seed cotton yields ranged from 72 to 3734 lb acre^{-1}. The response of the cultivars to soil test and fertilizer K differed to some extent and will be discussed in the annual report.

Summary: Increasing soil test and fertilizer K dramatically decreased premature defoliation of cotton and increased leaf and petiole K levels, thereby substantially increasing seed cotton yield. Cultivars had somewhat different responses to K supply.

Determining the Cause of Seed Rot

South Carolina State Support Program Grant (2004)
Awarded To: Michael A. Jones and John Mueller, Clemson University

A major cause of hard lock and subsequent reduced yields in South Carolina is seed rot. This malady of unknown origin was first observed in 1999 and in some fields caused yield losses of more than 25%. Initial studies in 1999 and 2000 showed that seed rot was occurring throughout the cotton growing counties of South Carolina. It has also been reported in Georgia. Previous work has helped to characterize seed rot. It occurs on transgenic and conventional cotton cultivars. It occurs sporadically both within a field and among fields. Symptoms within a boll are fairly well defined. Seed appear to stop development at approximately 21 days after fertilization and often are hollow. In spite of the name no true rot occurs. Lint appears to be unaffected. The exact cause of seed rot is unknown. Two major theories are often proposed. The first is that a pathogenic agent, such as a bacterium, enters very young bolls either systemically or through wounds, nectaries, or insect feeding sites. The second theory is that a genetic predisposition to seed rot exists which is triggered either by unfavorable weather or other stress related conditions. Very little data exists to support either theory. Survey data collected in 1999 and 2000 were collected only from bolls which showed no signs of insect feeding. However, in some cases such feeding is difficult to see and the possibility exists that insects, especially piercing/sucking insects, may be involved. This is the basis for **Objective 1. Objective 2** stems from observations by Dr. Jones and others that seed rot is more severe on plants with excess N or in fields with poor stands. **Objective 3** investigates one of the most consistent observations on seed rot: that Maxxa grown in South Carolina shows a higher incidence and severity of seed rot than other cultivars when planted in the same field. Maxxa was developed for use in the San Joaquin Valley and apparently exhibits no seed rot when grown there. One theory is that it has much larger nectaries than cultivars normally grown in the Southeastern United States. These large nectaries could be the portals for infection and in addition to Maxxa nectariless cultivars will also be studied for seed rot in **Objective 3.**

Objective 1: The role of insects in seed rot was examined using rigorous insecticide spray programs in field plots. The incidence of seed rot on two cultivars, Maxxa and Deltapine 555, was compared with and without insect feeding. Three treatments of each cultivar were created: 1. Nontreated-check; 2. Vigorous spray program (as many as twice a week), for all target insects including lepidopteran caterpillars, thrips, stink bugs, plant bugs and other piercing sucking insects; and 3) Vigorous spray program up to peak bloom. Plots were 20 rows 100 ft long on 38-inch centers.

<u>Results</u>: The use of a weekly insecticide spray program significantly increased lint yields in both Maxxa and DPL 555 BR and reduced insect damaged bolls compared to the untreated plots in Maxxa in 2004. However, the use of insecticides had no impact on the occurrence of "Seed Rot" damaged bolls in either variety. Damage caused by insects (mainly worms and stinkbugs) could easily be distinguished from "Seed Rot" damage during the boll sampling procedures. Minor differences in fiber quality occurred due the use of insecticides.

Objectives 2: The effects of stand and nitrogen fertilization rates on seed rot were also examined. Four treatments were established on Maxxa and Deltapine 555. Treatments created different plant populations and levels of N stress and fruit loss. Treatment 1 was a normal plant population of 10 - 12 plants per square meter and Treatment 2 was a low plant population with 2 plants per square meter. Treatment 3 involved the removal of the first position square at nodes 5 - 10 before 1st bloom to create a heavier late fruit load. Treatment 4 was be a low nitrogen treatment with the only N applied being 30 units at planting.

Results: Removing early-season squares up to node 10 increased the lint yield of DPL 555BR and decreased the % hardlock found at harvest in both DPL 555 BR and Maxxa. Reducing the plant population, N rate, and early-season fruit load decreased the amount of "Seed Rot" damage found during the boll development period in DPL 555BR.

Objective 3: The variety aspect of why Maxxa always exhibits consistently higher levels of seed rot than other cultivars in a Southeastern-growing environment was examined. Fourteen cultivars were grown in replicated plots to make specific comparisons. These are (1) Maxxa Acala vs (2) Phy 72 Acala to determine the impact of the Acala trait on seed rot. (3) MD-51 ne vs (4) an okra-leaf isoline of MD-51NE vs (5) MD-51 okra-leaf to determine if the presence of nectaries and/or leaf morphology has an affect on seed rot. Likewise, (6) FM 832 okra-leaf, (7) FM 832 okra-leaf nectariless, and (8) FM 832 normal-leaf was compared and (9) DPL 5415 and (10) DPL 5415ne nectariless varieties and (11) DES 119 and (12) DES 119ne nectariless varieties were compared. (13) DPL 555BR and (14) DPL 458BR or DPL 655BR which is a cultivar many individuals believe is very susceptible to seed rot were compared**.**

Results: Both the Acala varieties evaluated (Maxxa and PHY 72) exhibited higher levels of "seed rot" damaged bolls during the boll development period and hardlock bolls at harvest than the other twelve varieties in this study. Although Maxxa continues to exhibit higher levels of seed rot than other varieties, it is obvious that PHY 72 Acala also is significantly affected by causal agent of "seed rot". Few consistent differences were found among the numerous isolines for leaf morphology or nectaries studied for lint yield, "seed rot", hardlock, or fiber quality in this study.

Economic, Environmental, and Ecological Assessment of Cotton Conservation Tillage Systems

South Carolina Cotton Board Grant (2002 and 2004)
Awarded To: James Frederick, Bruce Fortnum, Don Manley, Sue Robinson (Clemson University) and Phil Bauer, Jeff Novak, Warren Busscher (USDA-ARS)

The objective of this study was to quantify on a large, field-size basis the economic, environmental, and ecological benefits of using conservation tillage to produce cotton on the Coastal Plain. A 14-acre field was divided in half in both years, with the division made so that both halves had similar soil types. Traditional practices were used on one side of the field (centered on disking and cultivating) and new production practices and technologies on the other (Innovative side). The cotton production practices used on the Innovative side included conservation tillage, strip deep tillage, precision P application, and planting a transgenic variety. A traditional versus Roundup Ready weed management system was also used. Soil samples at depths of 0–3 inch and 0-6 inch were collected in the early spring using a grid-sampling method. Samples were also collected at depths of 0-1inch and 1-6 inch using a zone-sampling method. Fire ants and nematode populations were measured on both sides of the field. Lint yield and quality were determined at the end of the growing season on a site-specific basis. Water, nutrient, and sediment runoffs were monitored throughout the year.

Because of the severe drought in 2002, cotton lint yield only averaged 219 lbs/acre on the traditional side of the field and 210 lbs/acre on the innovative side (no difference). In the first year of the study (1998), growing conditions were near normal and cotton yields averaged 530 lbs/acre and 682 lbs/acre for the traditional and innovative production systems, respectively. In 2004 (wet year), yields for the traditional and innovative production systems were similar. Thus, it appears that the greatest benefit from conservation tillage is in years of near normal rainfall. Fiber quality was also similar for the two production systems in all years.

Soil P was the only nutrient found that could be precision applied. Soil P levels varied by about 100 lbs/acre across the field. Soil P levels were higher near the soil surface for both soil tillage treatments. Soil P values for the 0-3 inch samples were about 20% higher than the 0-6 inch samples for both the traditional and innovative systems. The 0-1 and 0-3 inch samples had similar soil P values. Soil pH varied little by sampling method, surface tillage, or sample depth. This supports our previous small-plot research that showed little impact of surface tillage on soil pH if soil pH is maintained near optimum. Although somewhat mobile in Coastal Plain soils, we found soil K to accumulate near the soil surface on both sides of the field. Much of this response may have been due to K leaching out of the vegetation of the previous corn crop during the winter months. Both Ca and Mg were higher near the soil surface, especially with conservation tillage. Soil organic matter was higher near the soil surface with the innovative system, but less at the 1-6 inch depth, compared to the traditional system.

After planting, fireant mound numbers averaged 73 and 13 mounds per acre for the traditional and innovative systems, respectively. In contrast, mound numbers averaged near 40 mounds per acre for both of the tillage systems in the fall after harvest. Thus, conservation tillage appears to enhance ant mound construction during the growing season, but traditional tillage appears to favor mound construction during the winter months. Tillage affects on nematode numbers depended on the species of nematode and soil type.

Rainwater runoff amounts were greater with the traditional production systems than with the innovative production system in all 3 years. The amount of nutrients that moved off site in surface runoff water was much less with the innovative production system.

Entomology

Development of Treatment Thresholds for Stink Bug on Transgenic Bt Cotton and Evaluation of Treatment Effects on Non-Target Species

South Carolina Cotton Board Grant (1996 and 1997)
Awarded To: Sam Turnipseed , Clemson University

Objectives of this project are to establish treatment thresholds for the phytophagous stink bug complex on transgenic Bt cotton, and examine effects of insecticide treatments on insect pests (stink bugs and bollworms) and beneficial arthropod predators.

Plant-feeding stink bugs are not affected by the bacterial toxin expressed in Bt cotton for budworm/bollworm control. Also, reduced insecticide applications for the budworm/bollworm complex in Bt cotton allow stink bugs to move into Bt cotton earlier, and densities can increase significantly. Therefore, the development of thresholds for insecticide treatment of stink bugs on Bt cotton will provide growers with the ability to effectively manage these pests. Data indicate that insecticide treatment at a density of one bug per two meters of row and/or prior to20% ball damage by stink bugs will adequately protect Bt cotton from stink bugs.

Cage studies of phytophagous stink bugs (Hemiptera: Pentatomidae *Nezara viridula*) on Bt cotton were conducted during the 1997 growing season to address specific questions and to provide valuable information concerning producer actions during critical periods of cotton growth and with data about the damage potential of stink bugs at various stages of cotton and insect development. The following questions were addressed:

1) Which stages of developing stink bugs cause significant damage to cotton bolls?
2) How long is a boll susceptible to stink bug damage?
3) Can plant bugs significantly damage young cotton bolls like stink bugs?
4) How does number of feeding sites per boll relate to yield loss?

During the blooming stage of cotton development, large field cages (4m long, 2m high, 2m wide) were placed over 2 rows of cotton to enclose experimental plants and prevent undesired damage to developing bolls. White blooms were tagged with the date so that a range of bolls of known ages was present in each cage. Small boll cages (made of Styrofoam cups, pantyhose, and rubber bands) were secured over bolls, bugs were placed inside the cup cages according to treatment protocol (various stages of bug development or various stages of boll development), and damage levels to bolls were recorded.

Experiment 1: The first experiment focused on the stages of stink bug development and their damage potential to developing bolls. A completely randomized design with 6 treatments and 20 replications per treatment was utilized. The bugs remained caged on bolls for 3.5 days. Bugs were then removed from the cages, and bolls were examined for stink bug damage 4 days following bug removal. Number and severity of feeding sites on each boll were recorded by examining inner boll walls for puncture wounds/warts. There were 6 treatments: 2^{nd} to 5^{th} instar, adult, and no bug (check), Results: 5^{th} instars caused the most damage, followed by 4^{th} instars, 3rd instars, adults, and 2^{nd} instars.

Experiment 2: The results from the first experiment suggested that late instars cause the most damage and should be used in experiment #2 with boll age. In this experiment, boll age (from first bloom) varied as exposure to bug damage remained constant (late 4^{th} early 5^{th} instar). There were 5 boll-age treatments: 4 days old, 8 days old, 15 days old, 18 days old, and all ages with no bugs. Again a completely randomized design was used with 20 replications per treatment. The bugs fed for 5 days. A destroyed boll was assigned the value of 30 warts. Results: a linear response was observed, with older bolls damaged less than younger bolls; bolls 18 days old were not damaged significantly.

Experiment 3: Adult plant bug, *Lygus lineolaris*, damage to young cotton bolls was examined. There were 3 treatments: adult plant bug, 5^{th} instar-stink bug, and no bugs (check). There were 10 replications per treatment in a completely randomized design. Bugs fed for 8 days on 9-day-old bolls. A destroyed boll was assigned the value of 30 warts. Results: both stink bugs and plant bugs significantly damaged very young bolls, but stink bugs caused significantly more damage than plant bugs.

Experiment 4: Feeding site number per boll and a corresponding seed cotton yield loss per boll were examined in a completely randomized design. The experiment was halved, with half of the bolls examined for feeding warts and the other half taken to yield. There were 10 replications for each treatment in each half of the experiment. Treatments were: 5^{th} instar and no bug (check). Bugs fed for 7 days on 14-day-old bolls. A destroyed boll was assigned the value of 10 warts. Results: about 8.5 warts per boll roughly corresponded to a 54% reduction in seed cotton yield per boll.

Management of Bollworms in Bt Cotton and the Importance of Beneficials in Reducing Their Impact

South Carolina Cotton Board Grant (1997 and 1998)
Awarded To: John DuRant, Sam Turnipseed, Mitchell Roof, Mike Sullivan, and Tommy Walker, Clemson University

At the PDREC in 1997, three applications of Orthene to NuCOTN 33B prior to initiation of oviposition by second-generation moths of the bollworm reduced population densities of beneficial arthropods**,** resulting in increased survival of bollworm and fall armyworm larvae and increased damage to bolls. Data on densities of bollworm and fall armyworm larvae and resulting damage to bolls indicated that egg thresholds were superior to larval thresholds for managing these pests, but following these thresholds did not result in significantly better yields.

Geocoris spp. (big-eyed bugs) adults and larvae and *Notoxus* spp. (hooded beetles) were the most abundant predators in 1998. Combined, these two groups comprised 80.3, 69.3, 81.2, 91.5, 40.5, and 32.2% of all predators observed on 30 June, 8 July, 14 July, 21 July, 27 July, and 3 August, respectively. Coccinellidae (lady beetle adults and larvae) was the most abundant group on 27 July and 3 August, comprising 51.6 and 53.7%, respectively, of all predators observed. Densities of ants, which are excluded from the data on total predators because the distribution of ants often is highly clumped and often appears unrelated to treatments, were unusually low throughout the season. Ants never exceeded 5.5% of the total predators observed. Densities of *Geocoris* spp. were reduced significantly by the Egg X 2 threshold (two applications of Karate beginning at peak oviposition) compared with the untreated threshold. Orthene produced a sizeable, although non-significant decrease in densities of *Geocoris* spp. The Scheduled, Egg X 1, and Egg X 2 thresholds significantly reduced densities of *Notoxus* spp. and total predators compared with the larval thresholds, which had not yet been treated with Karate, and with the untreated threshold. Orthene appeared to have no effect on densities of *Notoxus* spp.

Heavy oviposition by bollworm moths in 1998 failed to produce high populations of larvae in NuCOTN 33B. Damage to bolls and squares remained extremely low throughout the season and yields were not affected by Orthene or by the thresholds. Timely applications of Karate provided excellent control of stink bugs. The effects of Karate and Orthene on predators appeared less pronounced than results from similar studies had indicated.

Development of Use Recommendations for New Classes of Insecticides in Bt and non-Bt cotton South Carolina

South Carolina Cotton Board Grant (1997 and 1998)
Awarded To: John DuRant and Mitchell Roof, Clemson University

This project gave us the opportunity to determine the effectiveness of some new insecticides against the cotton insect pest complex, and to compare these with pyrethroids that were being widely used in South Carolina. In 1998, the pressure from bollworm/budworm was relatively light at the PDREC, so there wasn't too much to be gleaned from the data. This is always a potential problem when you depend upon Mother Nature to deliver insect pest numbers in economic quantities. In 1997, moderate to heavy infestations of bollworms, allowed us to get a good look at the chemicals in that test. Tracer, Proclaim, Intrepid and Larvin were compared to the pyrethroids. We found that Tracer and Larvin compared quite well to the pyrethroids, somewhat better than would have been predicted based upon work in other states. And as we have found many times before, you can't always go by results from other states, because we are somewhat different in terms of the environment and our complex of insects. The "new insecticides" were generally better than pyrethroids in conserving beneficials. Studies of this kind are essential for us to develop workable recommendations that will allow us to economically control insect pests. There is no way we can recommend a new insecticide without evidence that it will work in the field. Ideally, as in this study, research will be conducted at both Florence and Edisto, as well as to look at the materials in some on-farm locations when opportunities arise.

Bollworm/Tobacco Budworm Eggs in Bollgard (*Bt*) and Non-*Bt* Cotton: Relationships Among Plant Phenology, Egg Location on Plants, and Parasitism

South Carolina Cotton Board Grant (1997 and 1998)
Awarded To: John DuRant and Mitchell Roof, Clemson University

The 1998 study confirmed the results of a 1997 study. Second-generation bollworm/tobacco budworm moths laid eggs primarily on terminal growth and older leaves of both cultivars, but a small but relatively consistent percentage of the eggs were observed on fruiting structures, where larval survival likely is higher than survival from eggs laid in terminals and on leaves. Several studies have indicated that the concentration of the *Bt* toxin, delta-endotoxin, is lower in tissue of fruiting structures than in leaf tissue. The low numbers of eggs collected for the parasitism study combined with the failure of many of these eggs to develop and hatch successfully made accurate determination of the effects of cultivar and location of the eggs on the plant on percent parasitism impossible.

Since the cotton blooms and pollen have lower concentrations of the toxin than terminals, oviposition preference of the moths directly affects the efficacy of the *Bt* cotton against bollworm larvae. In recent years, as *Bt*-cotton has been more widely grown, there has been a consistent problem with eggs being laid in the middle part of the plant and larvae becoming established in blooms and bloom-tagged bolls. We needed to know more about where the moths were actually laying their eggs in July. It is apparent from this study that most of the problems with bollworms in *Bt*-cotton happen as a result of that small percentage of eggs that are laid on fruit on or near fruiting structures. Information on parasitism by *Trichogramma* would be important as well, but there were insufficient numbers of eggs available in this study to determine their relationship to bollworm management in *Bt*-cotton. This study was important in the development of recommendations to deal with the bollworm problem in *Bt*-cotton, as well as improving scouting techniques.

Monitoring of and Management Strategies for Pyrethroid Resistance in the Budworm/Bollworm Complex in South Carolina

South Carolina Cotton Board Grant (1997 and 1998)
South Carolina State Support Committee Grant (1999)
Awarded To: Sam Turnipseed, Mitchell Roof, Thomas Brown, Mike Sullivan, and Tommy Walker, Clemson University

Resistance to synthetic pyrethroid insecticides was found in bollworm in 1996 in Hampton County. Pheromone trapping of adult male bollworm moths was initiated in 1997 and continued through 2001. Resistant individuals were found below the lakes the first year of trapping, 1997; in 1998 resistant individuals were found above the lakes for the 1st time. Subsequent years data indicate resistant individuals statewide; however, levels of resistance were not high enough to cause widespread field failures with pyrethroid insecticides.

Vial testing and larval collections from field failures indicate resistance in BOTH bollworm and tobacco budworm. In 1998 and 1999, the pyrethroid Karate gave excellent control of bollworm in Bt cotton but not conventional cotton.

A resistance management strategy was formulated and implemented for South Carolina growers; it stresses the use of Bt cotton in areas prone to resistance, the use of alternative chemistries, and no early season (June) applications of "hard" insecticides, particularly pyrethroids.

Doublecropping, Conservation Tillage and Rotation Effects on Population Dynamics and Management of Arthropods and Nematodes in Cotton in the Southeastern Coastal Plain

South Carolina Cotton Board Grant (1997, 1998 and 1999)
Awarded To: John A DuRant, Don Manley, Gloria S. McCutcheon, Bruce A. Fortnum, James R. Frederick, and Dewitt T. Gooden, Clemson University
and
Phil J. Bauer, USDA-ARS, Florence

The objective of this project was to determine the combined effects of doublecropping (growing cotton after a rye winter cover crop), conservation tillage, and rotation on population dynamics and management of arthropods and nematodes in cotton in the southeastern Coastal Plain.

Cotton was grown in plots that were 400 to 700 feet long with conventional (double-disking) and no-tillage, with and without Temik (7 lbs 15G/acre), and following a rye cover crop (1997-1999), no cover crop (1997-1999), or rotated with corn (1998). A 50-foot section of each plot was left untreated for bollworm control so that treatment effects could be evaluated on pest and beneficials with and without worm control insecticides. Soil samples were collected from throughout the experiment to evaluate the effect of treatments on pest nematode populations.

Results

Thrips. Conservation tillage significantly decreased the density of adult and immature thrips and thrips injury to plants compared to conventional (disking) tillage, especially when cotton was grown without Temik. The effect of tillage and Temik on adult thrips at the end of May each year are shown in the table below. The effect of residue type (winter fallow, rye, or corn) on thrips populations was inconsistent.

Effect of Temik and tillage on adult thrips at the first sampling date each year.

	With Temik			Without Temik		
	Date					
Tillage	5/20/97	5/26/98	5/24/99	5/20/97	5/26/98	5/24/99
	Thrips per 10 plants					
Disk	4.8	3.8	1.3	24.5	47.0	10.7
No-Tillage	2.3	2.8	1.5	9.0	17.2	6.0

Nematodes. Treatments had no effect on nematodes. All species were below threshold values for control.

Bollworms/Budworms. Bollworm and budworm counts were made weekly throughout the summer each year. In general, neither tillage nor residue type nor Temik application had an impact on the populations of these pest insects in any year.

Predators of the Bollworm/Budworm Complex. The most abundant predator was the red imported fire ant. The ants were more abundant in the plots following a rye cover crop that did not have Temik applied than in any other treatment combination. Other major predators included big-eyed bugs and lady beetles. More big-eyed bugs were observed in the disked treatments than in the conservation tillage treatments (possibly because of more red imported fire ants in the conservation tillage treatments). The most lady beetles were found in plots that were continuous cotton with winter fallow and disking. Other beneficial insects detected were hooded beetles, lacewings, spiders, and pirate bugs. Soil management treatments did not affect populations of these insects.

Summary

Cotton grown with conservation tillage had significantly lower densities of adult and immature thrips and injury to cotton plants from thrips than did cotton grown with conventional tillage. Although the reduced thrips populations and injury were probably not consistent enough to warrant not using Temik in present-day systems, the findings will be useful in designing new management systems and can be used by growers using alternative production systems (such as organic production). Cropping systems did not have a significant effect on bollworms/tobacco budworms or damage to fruit by these pests.

An inverse relationship appeared to exist between densities of ants and densities of some other species of predators, indicating that conditions which favor an increase in densities of ants may result in decreased densities of big-eyed bugs, lady beetles, and possibly other species. The role played by ants in determining the total composition of predator species and the resulting impact of the predator complex on pest species merits further study. Yields were increased significantly by no surface tillage compared with disking, and by aldicarb compared with no aldicarb, indicating that thrips may have a significant impact on yield. Densities of all species of nematodes were below economic thresholds.

Rapid Diagnostic Test for Pyrethroid-resistant Tobacco Budworms Infesting Cotton

South Carolina Cotton Board Grant (1999)
Awarded To: Thomas M. Brown, Clemson University

Probes were designed and purchased for quickly finding resistant tobacco budworms. These probes glow brightly under a blacklight when they bind to genes for resistance. The probes worked as predicted with the synthetic genes, but did not work well with DNA from budworms. The probes, called molecular beacons, are detected by increased fluorescence when hybridized to specific complementary nucleic acids. We are continuing attempts to detect the probes with real samples in collaboration with a private company, which manufactures a very sensitive fluorometric detector.

Monitoring Techniques for Stink Bugs in Cotton

South Carolina Cotton Board Grant (1999 and 2000)
Awarded To: Mitchell Roof, Clemson University

1999. Consultants and scouts report often finding damage in cotton fields where no stink bugs have been found after conducting their normal scouting routines. Finding the insects has been a weakness in developing management techniques for stink bugs. Sticky traps were tested as monitoring tools, but they were unsuccessful in capturing green or southern green stink bugs. The beat-cloth method has been recommended as a monitoring tool ever since we first included stink bug control in our cotton insect control recommendations. Although the beat cloth seems to work fairly well under some conditions, there are situations where it seems to be less than effective. In 1985, my scouts started using a plastic pan (11 x 13.5 x 5.5 inches deep) to check cotton fields for beneficial arthropods. This method has also worked well for lygus bugs and stink bugs. For the second part of this study we compared the plastic pan to the beat cloth in 111 different cotton fields in 5 counties. We found that when utilizing the plastic pans scouts collected nearly twice the number of stink bugs as were collected with beat cloths in about the same amount of time. However, at times neither method was successful in finding stink bugs, despite the fact that direct examinations of the bolls indicated there was a considerable amount of damage. In 2000 our stink bug threshold was changed somewhat to reflect this inconsistency, as the treatment threshold was lowered from 20% to 15%, conditional upon the presence of adult stink bugs, and/or large nymphs. This study showed that the plastic pan would be a good tool for farmers, consultants and other field workers to use in determining if stink bugs are present in a field when deliberating about whether or not to apply an insecticide treatment. This is very important in *Bt*-cotton because an insecticide treatment may eliminate beneficials that are important in regulating populations of bollworms or armyworms.

2000. It would be of great benefit for farmers, consultants and scouts to know when stink bugs were moving into an area, and when their cotton fields were at risk of infestation. In this study, different trap designs were tested for that might be used to attract and capture stink bugs. Each boll weevil trap was modified for use as a stink bug-trap by enlarging the opening in the wire cone and cutting out pieces of plastic at the top of the cup. I also investigated the use of sticky-boards and modified bucket traps (of the type used to collect beet armyworms and fall armyworms). Since there is no pheromone presently available for stink bugs, a 2.3 cm-wide flourescent tape produced by Neoglow Company was utilized to attract stink bugs to the traps, since it is known that stink bugs are attracted to light traps at night. For the six modified boll weevil traps used in this test, two six-inch tapes were placed in diagonal positions on each cup which was oriented to the afternoon sun. Exposure to the sun charges the tape and according to Neoglow representatives would allow the tape to glow for up to 8 hours. There was also a possibility that the trap color (saturn yellow) would be attractive to stink bugs. I looked at the effect of height by placing some traps on cane poles one meter above the ground and some 1.5 meters above the ground. I also looked at bucket traps and "sticky traps" in combination with the flourescent tapes. Traps were set out during the last week in August. From 10 September to 20 September, three green stink bugs were captured using modified boll weevil traps. One capture was in a cotton field and two were in an adjoining soybean field. Weekly beat-pan samples showed that substantially more stink bugs were in the soybean fields where plants were loaded with half-grown pods. No stink bugs were captured with the sticky-board traps that were placed on the edges of the soybean field. The bucket traps with flourescent tape captured two stink bugs (a green stink bug and a brown stink bug) during the period from 1 September to 10 September. Many stink bugs were observed feeding on pigweeds in the vicinity of the traps. In summary, some traps captured stink bugs, but insufficient numbers were collected to be useful in making control decisions. Three of the stink bug captures were in traps containing filter paper that had been used to collect the excrement of several stink bugs confined in a jar for a day prior to being placed in the traps. This suggested that a "pheromone" may be contained in the excrement of the green stink bug. If so, this chemical substance could possibly be used to prepare baits for use in trapping green stink bugs.

Preliminary Investigations of Insect Infestations in Ultra-Narrow-Row Cotton

South Carolina Cotton Board Grant (1999)
Awarded To: Mitchell Roof and Michael A. Jones

We monitored both pest insects and beneficials in two ultra-narrow-row tests at the PDREC. In one test, designed by Mike Jones to investigate plant population, cotton was planted in 7-in. rows and 15-in. rows with plant populations of 75,000, 100,000, 125,000, 150,000, 175,000 and 200,000. The second test incorporated DPL-655 B/R, PM-1220 B/R, and Fibermax 832 planted on either April 20 or June 1, and in 7.5-in rows or 38-in rows. Insect numbers were monitored on a weekly basis from June 27 to August 8.

On July 14, egg counts reached as high as 36 per 100 plants, and the first insecticide treatment was applied (Karate was used at 2 oz/ acre) on July 15. Since the primary objective of these tests was to determine the effects of row width, genotype, plant population and planting date on yield, the decision was made to protect both tests with weekly applications of Karate. No significant differences were observed in numbers of bollworms infesting UNR or conventional cotton. The weekly applications of Karate probably prevented insect infestations from reaching sufficient levels to see differences between treatments. Very few stink bugs were observed and bollworm numbers and damage levels never reached economic proportions. Beneficial numbers were not particularly high, and they did not differ significantly between treatments.

We were interested in looking at insect numbers in UNR cotton, because from past experiences with UNR it had appeared likely that bollworm thresholds and perhaps other insect-pest thresholds could be increased somewhat without sacrificing yields. This would of course reduce the number of insecticide treatments that would be needed. Catchot and Reed (2001) reported at the Beltwide Insect Research and Control Conference that more insecticide treatments were needed for budworm in wide-row cotton than in UNR.

Assessment of Suspected Field Failures of Pyrethroids for Bollworm/Budworm Control by Determining Susceptibility of Field Collected Larvae

South Carolina Cotton Board Grant (1999, 2000 and 2001)
Awarded To: Mike Sullivan, Mitchell Roof, Tommy Walker, and Sam Turnipseed, Clemson University

This project was an outgrowth of Monitoring and Mgt. Strategies for Pyrethroid Resistance etc. Budworm and/or bollworm larvae were collected from fields with suspected pyrethroid resistance beginning in 1998. In 1998, larvae were collected from 8 locations below the lakes; survival of bollworm at all locations was above 30% at the 5ug dose (Table 1) indicating the potential for field failures. Indeed, bollworms did survive 2-4 pyrethroid treatments in some locations. In 1999, only one field failure was reported, that being in Allendale County. Resistance was confirmed in larvae collected from that field through LC 50 studies; these same studies indicated no resistance to the alternative chemistries, Tracer and Steward. No field failures were reported in 2000 or 2001.

Table 1. % Survival of Bollworm Moths Reared from Larvae Collected in Fields with Reported Failures. 1998. Various Locations.

	% Surviving moths/location		
Vial Dosage	Cameron(July 28)	Brubaker Farm(July27)	Reevesville(July 23)
0 ug	100	100	100
5 ug	35	30	43
10 ug	29	5	0

Cameron treated with pyrethroid 7, 14, 21 July.
Brubaker treated with pyrethroid 6,14,21 July.
Reevesville treated with pyrethroid 18, 25 June and 9, 17 July.

Treatment Thresholds for Tarnished Plant Bugs in a Low Insecticide Environments of Bollgard II Cotton Genotypes

South Carolina Cotton Board Grant (2000 and 2001)
Awarded To: Mike Sullivan and Sam Turnipseed, Clemson University

This project supported ½ of a graduate assistantship (MS). Small, individual styro-foam cup cages were utilized to study damage from tarnished plant bugs and false chinch bugs to squares of Bollgard II cotton in 2000. Tarnished plant bugs caused much higher damage than the false chinch bug (Table 1).

Table 1. Tarnished Plant/False Chinch Bug Damage in Small Cages. EREC. 2000.

No. Bugs/Cage		Duration	% Blasted Squares Trt.	% Blasted Sqs. Control
TPB	1	2 days	83	0
	3	2 days	79	0
	1	4 days	80	0
	3	4 days	56	0
FCB	15	4 days	10	0
	15	4 days	17	13

These data are the first reported indicating that little damage results from high numbers of false chinch bug.

Tarnished plant bugs did not occur in sufficient numbers in 2001 to be collected for use in cage studies. However, false chinch bugs did occur in high numbers in June and further small cage studies were conducted. When caged in high numbers on squares and terminals, they did not cause much damage to either plant structure (Table 2).

Table 2. Damage from False Chinch Bug (FCB) on 1st/2nd Position Squares After 4 Days Feeding (20 bugs/cage). EREC. 2001.

		% Squares	
		Healthy	Missing
Test 1	W/FCB	78	22
	WO/FCB	100	0
Test 2	W/FCB	79	21
	WO/FCB	79	21
Test 3	W/FCB	88	12
	WO/FCB	94	6

W/FCB = cages with 20 bugs.
WO/FCB = control cages with no bugs.

Establishment of Treatment Thresholds for Lepidopterous Pests in Bollgard II Cotton

South Carolina Cotton Board Grant (2000)
South Carolina State Support Committee Grant (2001)
Awarded To: Sam Turnipseed and Mike Sullivan, Clemson University

Bollgard II cotton contains two strains of Bt (Cry 1Ac and Cry 1Ab) compared to the one strain (Cry 1Ac) present in currently available varieties. Current Bt varieties provide excellent control of tobacco budworm and fair control of cotton bollworm. Researchers in SC developed bollworm thresholds for Bt cotton; these established thresholds are currently being used throughout the southeastern cotton-growing region. These are 75 eggs OR 30 small worm OR 4 escaped worms over ¼ inch long/100 plants. With Bollgard II cotton, we initially tested these thresholds for bollworm control.

During the 2000-2001 growing seasons, NO lepidopterous pests (bollworm, fall/beet armyworm, soybean looper) were a problem in Bollgard II cotton, even in plots treated in early season (June) with "hard" insecticides to disrupt beneficial arthropod populations (Table 1). It is important to remember that Bollgard II , like the original one gene Bollgard, is not effective on the stink/plant bug complex or aphids.

Table 1. Bollworm, looper, and fall armyworm in conventional, Bollgard, and Bollgard II Cotton. EREC. 2000.

	Number of Larvae/3 Meters of Row				
Cotton Type	Cotton Bollworm			Looper	Fall AW
	7/21	7/31	9/5	9/5	9/5
Conventional	31.8	7.3	13.8	16.5	1.0
Bollgard	0.5	7.3	0.5	15.3	5.3
Bollgard II	0.3	0.3	0.0	0.3	0.0

Laboratory studies have confirmed field data in that lepidopterous insects pests do not survive on Bollgard II cotton genotypes. Projected for release to growers within the next two years, Bollgard II will not need thresholds for budworm, bollworm, loopers, or fall/beet armyworm. We will need reliable thresholds for the stink/plant bug complex and aphids.

Effects of Variety, Planting Date, and N Level on Stink-Bug Infestations and Seed Rot in Cotton

South Carolina Cotton Board Grant (2000 and 2001)
Awarded To: Mitchell Roof, Clemson University
and
Phil Bauer, USDA-ARS, Florence

Stink bugs were seldom a problem in cotton fields prior to the Boll Weevil Eradication Program, which was initiated in 1983. Back in the days when boll weevils were economic pests throughout the state, efforts to control them with multiple applications of organophosphate insecticides usually served to hold stink bugs in check as well. Damaging infestations of stink bugs were first observed in 1985 (the final year of the Boll Weevil Eradication Program), and by the early 1990's, problems were occurring in most cotton growing regions of South Carolina. Since 1999, growers have planted an average of better than 75% of their acreage with Bt-cotton varieties. During that period, less than two insecticide applications were applied in Bt-cotton, compared to four or more in conventional varieties. The low spray environments created in Bt-cotton fields have probably resulted in more stink bug problems. Although stink bugs are now considered a major insect pest of cotton, little is known about factors that might influence their selection of cotton plants as hosts. This study provided an opportunity to measure damage caused by natural infestations of stink bugs to different cotton varieties, grown under different levels of N and planted on different dates.

There were no real differences in the amount of stink bug damaged bolls in the different varieties (DP 5415, DP 5690, DP 458BR and DP 655BR). Planting dates were 15 April, 1 May and 15 May. There was a tendency for stink bug damage to be lower in the later plantings, and damage was significantly lower in 2001. We saw a little more damage in the plots with 80 lbs N than at the 40 lb or 120 lb rates, but the differences were not significant. The majority of stink bugs found during the weekly field monitoring were green stink bugs, *Acrosternum hilare.* In 2000, the average boll damage rating of 6.3% was below Clemson's economic threshold of 15%. None of the treatments significantly affected the appearance of seed rot, although fully enlarged bolls would have been more apt to exhibit the symptoms than the quarter-sized bolls examined in this study. There was no significant relationship between seed rot and stink bug injury in 2000 or 2001.

Stink bugs are rarely distributed uniformly within a field. They are usually found in greater numbers in certain areas. For example, numbers of stink bugs often tend to be higher next to wooded areas where some of their wild host plants may grow. They also will feed on soybeans, corn and other cultivated hosts and when they start moving to cotton they may tend to become more numerous in those areas adjoining cotton fields that are closest to their former hosts. Stink bugs may be more numerous in areas of fields where plants are somewhat larger than the average sized plants in that field. Furthermore, it appears that stink bugs may often leave cotton fields to search for other hosts or perhaps to find cooler temperatures during the heat of the day. They may return to the cotton fields the same evening, or sometime later. There is no data to confirm this, but it would help to explain why scouts often find substantial amounts of boll damage, but they have great difficulty in finding stink bugs.

Activity of New Classes of Insecticides Against the Insect Complexes of Conventional and Bt Cotton in South Carolina

South Carolina Cotton Board Grant (1999, 2000 and 2001)
Awarded To: Sam Turnipseed, Mike Sullivan, Tommy Walker, and Mitchell Roof, Clemson University

Potential pyrethroid resistance caused our research/extension team to look at alternative chemistries that would control bollworm and other cotton insect pests, particularly stink bugs and aphids. Two of these, Tracer (Dow) and Steward (DuPont) have been found to effectively control the bollworm (Table 1). Tracer did not impact beneficial species; Steward was "hard" on ants; and the pyrethroid (Karate)controlled bollworms and stink bugs but flared aphids and was detrimental to beneficials. It is important to note that neither of these alternative chemistries is effective against stink bugs; Steward has been shown to have some activity on tarnished plant bug.

Table 1: Activity of Tracer, Steward, and Karate on Bollworm, Ants, and Minute Pirate Bugs. Blackville, SC. 2000.

Treatment/Rate(lbs. AI/Ac)	Mean number/4 beats (July 26) 6 DAT (2nd application)		
	Bollworms	Ants	Minute PB
Tracer/0.08	1.0	49	12
Steward/0.11	2.3	3	20
Karate/0.03	1.3	15	5
Control	4.5	46	15

Ants were mostly red imported fire ant.

Two new neonicotinoid compounds have been tested for aphid control, Centric (Syngenta) and Assail (Bayer); both provided excellent, extended aphid control (Table 2). Preliminary data of effects on beneficials indicate Assail to be "easier" on these beneficial arthropods.

Table 2. Activity of Neonicotinoid Insecticides on Aphids and Beneficials. EREC. 2001.

	Mean no. live aphids/5 leaves		Predator mortality
Treatment/Rate (lbs. AI/Ac)	July 20(2DAT)	July 24(6DAT)	
Assail/0.03	2.9	5.8	High
Centric/0.047	0.8	0.8	Very low
Provado/0.04	6.5	5.5	Moderate
Bidrin/0.5	2.9	5.8	High
Control	54.8	33.7	None

Treatments applied July 18.
These are preliminary data from one test (Turnipseed/Sullivan).

Tracer and Steward have been included in our SC Grower Recommendations for bollworms and other lepidoptrous pests; both are an integral part of pyrethroid resistance management. Centric will probably be included in 2003 recommendations for aphids and plant bugs.

Controlling Thrips in Cotton with Seed Treatments, Foliar Sprays and In-furrow Insecticides

South Carolina Cotton Board Grant (2001)
Awarded To: Mitchell Roof and Mike Sullivan, Clemson University

In 2001, thrips control tests were conducted at the EREC and the PDREC. Thrips infestations were at levels that we considered potentially of economic importance (one thrips per plant in the early seedling stages and/or the presence of abundant numbers of immature thrips) at both locations. Seed treatments with recommended rates of Adage and Gaucho were compared with Adage + one foliar Orthene spray, two foliar treatments with Orthene, two foliar treatments with Karate, Temik in-furrow, and an untreated check. Temik provided the most consistent control of thrips in terms of immature counts and damage ratings at both locations. Adage + one foliar treatment with Orthene showed promise at both locations in terms of reductions in thrips numbers. Adage + Orthene controlled thrips as well as Temik at EREC and it did well at PDREC, although there was more variability in thrips numbers, and no statistical differences in nymphs of adults were found between treatments. Foliar sprays with Orthene alone compared well with Temik in reducing numbers of nymphs and adults at EREC and PDREC, and Karate looked good at the EREC location, but not as good at the PDREC. Measurements of plant height were conducted at both locations. At the EREC, plants treated with Temik were significantly taller on 12 June than plants in all other treatments, but on 7 June there were no significant differences in plant height between treatments at the PDREC.

Damage was rated on a scale of 1-5 at EREC and 1-6 at PDREC, where 1=no damage and 5 or 6 is extreme damage or plant death. Damage was significantly lower on the plants treated with Temik (2.6) and Adage + Orthene (3.0) on 1 June than in other treatments at the EREC. The untreated cotton had an average rating of 3.9. At PDREC, there was very little damage to Temik treated plants (1.5) on 30 May, but it was not significantly less than the damage to plants in the following treatments: untreated check, 4.1; Adage (new formulation), 2.9; Orthene, 2.1; and Karate, 3.0.

There were no significant differences in yields between treatments at either location. Yields in the untreated checks were statistically as good as any of the treatments (833.5 lbs lint at the EREC and 683.3 lbs at the PDREC). Temik treated cotton had a numerically higher yield (1037.2 lbs lint) than all other treatments at the EREC, however, at the PDREC, two foliar treatments of Karate provided the highest yield (Temik = 797.7 lbs/A and Karate = 847.4 lbs/A).

Evaluation of New Insecticides for Emerging Pests in Conventional and Bt Cotton; Effectiveness of New Insecticides for Piercing/Sucking Bugs and Bollworm/Armyworms in Conventional and Bt Cotton

South Carolina Cotton Board Grant (2002 to 2004)
Awarded To: Mike Sullivan and Sam Turnipseed, Clemson University

At Planting Insecticides—Various seed treatments were compare to various rates of Temik 15G; in all studies, the seed treatments were not as efficacious as Temik (the 5.0lb/ac nematicide rate was used most often). Residual of the seed treatments was not as long as Temik.

In 2004, a new granular material (KC 791230) was compared with Temik. Rates of 3.5, 4, and 5 lbs. of KC 791230 were used; Temik at 3.5, 5, and 6 lbs. were used. The new material gave comparative initial and residual control compared to Temik.

Neonicotinoids—Assail, Trimax, and Centric have been tested for control of both pests and beneficial species during the past 3 growing seasons. These materials were developed to control soft bodied sucking bug pests. With aphids, Assail and Centric provided the best control. With cotton flea hopper and lygus bugs, 1 application of Assail and Centric was adequate; 2 applications of Trimax were needed. None of these neonicotinoids are strong stink bug control materials; pyrethroids and organophosphates continue to be good stink bug materials.

There were differences in overall predator mortality. Trimax resulted in 55-60% reduction compared to 30% with Assail and Centric. An organophosphate (Bidrin) caused a 70% reduction in predators compared to the neonicotinoids.

Insect Growth Regulators(IGR)—A new material, Diamond, has been tested for conrol of both piercing/sucking bugs and bollworms. This material provided adequate control of lygus bugs and some suppression of bollworm. Multiple applications were necessary for bollworm efficacy.

Pyrethroids—Two materials have been tested for bollworm control; XDE-225 (now labeled as Prolex) and CU-J0-44 (combination of acephate and cypermethrin). Prolex provided bollworm control comparable to currently labeled pyrethroids. The other material is not adequate to control bollworm. Both materials were effective on lygus bugs.

Significance of Findings: With thrips, we continue to recommend Temik 15G at planting; usually at least 5.0 lbs/ac due widespread nematode problems. Seed treatments are not effective on nematodes and not as effective as Temik on thrips.

All three neonicotinoids (Assail, Centric, and Trimax) are currently labeled and recommended in SC for aphid control. Centric and Trimax are also listed for lygus and cotton flea hopper control. Both Diamond and Prolex are labeled for use in cotton and are listed in SC recommendations.

Research conducted within the context of these projects has assisted in the labeling of the above mentioned products and has provided rates listed for control of various insect pests. Neonicotinoid beneficial species research was among the first conducted

Evaluation of Trap Crops in Management of Sucking Bugs in Cotton

South Carolina Cotton Board Grant (2004)
Awarded To: Mike Sullivan and Sam Turnipseed, Clemson University

Three trap crops were evaluated in replicated field trials for their respective effectiveness for piercing/sucking insect pests that attack cotton. Trap crops utilized in the 2004 studies were soybean (early maturity Group IV), peanut, and sorghum. Two fields were established at the Edisto REC; field 1 was planted May 5 & 6 and field 2 was planted May 14. Trap crops and cotton was planted at the same time. Cotton variety was ST 4646 BG2R. Trap crops were planted (12 rows on both sides of cotton) in 75 ft. plots. Cotton plots were 75 ft. X 36 rows in field 1 and 32 rows in field 2. Insect samples were taken using the beat cloth sample method. Sampling dates for field 1 were July 9,16, 24, and Aug. 3; for field 2, June 28, July 7,15,22, and Aug. 2. Piercing/sucking bug species sampled, included lygus bugs and the three major stink bug species (green, southern green, brown).

The primary objectives of this study were to determine which trap crop would attract the most piercing/sucking bugs and time of growing season they moved into the trap crop.

Data collected in 2004 indicated that none of the three trap crops were effective in attracting lygus bugs. In field 1, lygus numbers were highest in cotton plots on July 9 when 10-12/4 meters of row were found in cotton. Lygus numbers were consistent in cotton adjoined by all three trap crops. Lygus numbers remained at 10/4 meters in cotton on July 16; on July 24, these populations started to decline in cotton (< 7/ 4 meters) and were essentially nonexistent on Aug. 3. Sorghum was the only trap crop which attracted lygus (< 2/4 meters on all sample dates except Aug. 3 when 5/4 meters were found). Both soybean and peanut failed to attract lygus bugs. Field 2 had only soybean and peanut as a trap crop. As in field 1, neither of these crops attracted significant numbers of lygus. These data indicate cotton is a preferred host vs. soybean, peanut or sorghum.

Stink bug numbers were low in both study areas in 2004; therefore all 3 species were combined for data analysis. All three trap crops did serve as a reservoir for stink bugs with soybean being the most attractive. In field 1, stink bug populations were highest in the soybean trap on all sample dates (14/4 meters on July9, 20/4 meters on July 24, and 12/4 meters on Aug. 3). Numbers in peanut and sorghum never exceeded 2/4 meters during the sampling period. The increased stink bug numbers in soybean did not carry over to an increased number in the adjacent cotton. Stink bug numbers in cotton were highest in those cotton plots adjacent to peanuts; on July 24, 14/4 meters were found, only 4/4 meters were collected in the peanut trap crop. In field 2, soybean was again the preferred trap crop compared to peanut. Stink bug numbers were highest on the last sample date of August 2 when 12/4 meters were found in soybean; adjacent cotton only had 4/4 meters. The highest number in peanut was 4/4 meters on Aug. 2.

In addition to the above replicated field trials, 2 grower locations were established with a trap crop of soybean (Group IV maturity) planted on either one side or both sides of a cotton field. In the Still field, 16 rows of soybean were planted on either side of a 40 acre cotton field and in the Bamberg field, 24 rows were planted on one side of a 30 acre cotton field. Neither area had significant populations of stink bugs. Although soybeans were sampled in a timely fashion, stink bugs never established in either location.

Conclusion and Remarks: Data collected in the replicated studies conducted at Edisto REC show that early maturity soybean varieties will attract and hold stink bug species. Most soybean varieties planted in SC are in Maturity Groups VI, VII, and VIII. Additional studies at Edisto in 2002-2004 indicate that Group IV soybean will attract stink bugs. The plot size used in the 2004 tests was too small. This was very obvious in the 2 off station field sites used in 2004.

Piercing/sucking bugs (both lygus and stink bug species) prefer to feed of plants that have developing fruit structures. This offers some explanation as to why early maturing soybean was the most attractive trap crop in these studies. Our general research indicates that stink bugs may or may not move into these types of crops. We have seen substantial populations of stink bugs move into cotton and not establish themselves in an adjacent trap crop of soybean or peas. The objective of this research was to determine if we could attract these piercing/sucking bugs into a trap crop, treat the trap crop to eliminate potential bugs moving into cotton, therefore reducing the need to treat the cotton for these insects. The studies conducted in 2004 indicate that at this time, trap crops do not appear to be a feasible alternative to controlling these pests.

The Stink Bug/Plant Bug Complex: Development of Treatment Thresholds for Early, Mid, and Late Season; Development of Dynamic Sucking Bug Thresholds That Respond to Within Season and Different Degrees of Bug Pressure

South Carolina State Support Grant (2002 to 2003)
South Carolina Cotton Board Grant (2004)
Awarded To: Mike Sullivan and Sam Turnipseed, Clemson University

Numerous studies have been conducted during the 2002-2004 seasons. In all studies, Bollgard II cotton varieties were used to avoid overspraying the stink bug plots for "worms". In most tests, early maturing soybeans and/or field peas were planted as a trap crop in an attempt to increase stink bug pressure. All tests had a minimum of three treatments: completely treated (sprayed weekly beginning at bloom for a period of 4-6 weeks, treated based on current threshold of 20% boll damage, and completely untreated.

In 2003-2004, we increased numbers of treatments to include: beginning at bloom treated weekly for 7 weeks, and then each week thereafter we initiated an additional treatment for a period of 6 weeks. After the initial treatment, the respective plots were treated weekly. All treatments were Bidrin at 0.5 lb/ac AI and applied by Hi-Cycle. Plots were sampled using the beat cloth sample method to count insects, boll damage was determined, and final yields were taken with a mechanical picker.

Another set of studies were set up to determine if various rates of insecticides affected initial and residual control. Both stink bugs and lygus bugs were utilized in these tests.

General Results: As would be expected, populations of stink bugs and lygus varied from year to year. When compared to the existing treatment threshold of 20% boll damage, none of the additional treatments provided consistently better yields in 2004.. The beginning at bloom followed by weekly treatment for 6-7 weeks was not better than the threshold treatment. Depending upon stink bug pressure, yields in the untreated were significantly lower than any treatment only when bug pressure was high (exceeded current thresholds). In 2003 studies, only 3 treatments were used(completely treated, threshold, and untreated) in 3 separate tests. In 2 early planted tests, the completely treated was sprayed 6X and threshold 2X; yields were increased 187 & 224 lbs. respectively from no treatment to threshold (2X) and 304 & 315 lbs. from threshold (2X) to completely treated (6X). Stink bug pressure was higher in 2003 than 2004.

With the insecticide studies, we found the following: 1) Pyrethroids commonly used for "worm" control are effective against stink bugs. This is particularly true when the higher rates are used; these higher rates are initially as effective as Bidrin and have a longer residual. 2) Lower rates of pyrethroids or Bidrin applied in two applications 7-10 days apart are no better than a one time application of the higher rates. 3) A combination of pyrethroid and Bidrin at reduced rates is no better than an initial 1 time higher rate. 4) Pyrethroids were as effective if not better that Bidrin when either is used alone at higher rates. 5) We have not seen significant numbers of brown stink bugs left after using a pyrethroid at a higher rate.

We have conducted studies that have determined that the red plant bug does damage bolls in a similar manner to stink bugs or lygus. This was done using small Styrofoam cages. These preliminary studies also indicate that although the red plant bug can and will puncture bolls, the damage is not as great as lygus or stink bug.

Data collected from numerous studies has provided a seasonal abundance profile for the piercing/sucking bug complex. Lygus bugs are the first species to establish a presence in SC cotton fields. This starts at squaring (June) and continues through mid-late July. Most initial boll damage in our studies was caused by lygus. Stink bug species (green, southern green, and brown) do not establish in cotton until bolls are set. Dependent upon location, populations begin to build in late July and continue through early September.

Significance of findings: The numerous studies conducted using different treatment regimes (ie. at bloom and weeks 1-6 following bloom) did not provide better yields than the current boll damage threshold of 20% boll damage. Therefore we are keeping this 20% threshold in our cotton recommendations.

The pyrethroid insecticide chemistrys continue to control all three stink bug species, especially when used at the higher labe

Development of Treatment Thresholds for Aphids in Cotton Production in South Carolina

South Carolina Cotton Board Grant (2002 to 2003)
Awarded To: Mike Sullivan and Sam Turnipseed, Clemson University

Three neonicotinoid compounds were evaluated over a two year period for efficacy against aphids, cotton fleahopper, lygus, and non-target beneficial species in cotton. These were acetamiprid (Assail), thiamethoxam (Centric), and imidacloprid (Trimax); a standard was used in all studies, dicrotophos (Bidrin). Numerous trials (7) were conducted in 2002 & 2003; all were replicated small plot trials where applications of insecticides were made using a CO_2 backpack sprayer.

With aphids, Assail and Centric were the most effective control measures. Trimax was intermediate in control with Bidrin actually causing an increase in aphid numbers after 2 applications. See Table 1.

Table 1. Control of aphids with Assail, Centric, Trimax and Bidrin. Sandifer Farm-2002.

Treatment	Rate (kg/ha)	Mean Number Aphids, top 3 leaves of 25 plants* July 2	July 8
Assail	0.05	75	87
Centric	0.05	93	156
Trimax	0.05	465	166
Bidrin	0.05	1298	2552
Untreated		1428	1301

*All treatments applied as foliar sprays on June 19, Trimax and Bidrin on June 26, and all treatments again on July 3.

Other pest species were found in some tests. Cotton flea hopper and lygus bugs were controlled by Assail, Centric, and Bidrin after 1 application. Two applications of Trimax were needed to control lygus. Bidrin was the best material in controlling green stink bugs.

Efficacy of these neonicotinoids was determined for major predator species found in cotton. Minute flower bugs were reduced by all treatments except Trimax. Big-eyed bugs and red imported fire ants were reduced by Centric and Bidrin. The spider complex was unaffected by any of the neonicotinoids; Bidrin does cause significant reductions. The range in overall predator mortality was substantial; 70% with Bidrin, 55-60% with Trimax and 30% with Assail and Centric.

Significance of Research: These studies have resulted in all three neonicotinoids being placed in SC Grower Recommendations for aphid control. Centric and Trimax are also listed for lygus and cotton flea hopper control.

This project supported 50% of an MS graduate student, Amy Kilpatrick. She reported results of this project at the Beltwide Cotton Conferences in 2002 & 2003; she won 1st place in the MS student competition both years. Amy graduated in 2004.

NOTE: All studies in both years confirmed previous research results; namely, the aphid fungus will control existing aphid populations when they are left untreated without yield loss in 99% of SC cotton fields.

Assessing the Impact of Stinkbugs on Yield and Fiber Quality Variability in South Carolina Cotton

South Carolina State Support Grant (2002 to 2003)
Awarded To: Mitchell Roof and David McAlister, Clemson University
And
Phil Bauer, USDA-ARS

Stink bugs have become a major insect pest on cotton in in the Southeast, following eradication of the boll weevil (in 1985 in SC). Before eradication, 12 to 14 insecticide treatments directed at weevils, bollworms and budworms served to keep stink bugs in check. With the increase in acreage planted to Bt-cotton (about 75% in 2001) insecticide treatments have been reduced even more, and stink-bug problems have increased. Research efforts during the past several years have provided some information about the relationship between stink-bug numbers and damaged bolls, and yield. Relatively little is known, however, about the impact of stink bugs upon fiber quality.

Mill operators have suggested that the variability of cotton quality has increased in recent years, increasing with the rise in popularity of transgenic cotton cultivars. It is conceivable that the damage caused by stink bugs to developing bolls is part of the cause of this increase in variability. Therefore, it is imperative that we determine the impact of stink bugs on cotton yield and quality in order to develop optimum control thresholds.

Six cotton varieties were grown with and without stinkbug protection in replicated plots in 2002 and 2003 at the Pee Dee Research and Education Center in Florence. The cultivars were Stoneville 474 and the five transgenic sibs of 474 (BT, RR, BTRR, BXN, and BTBXN).

We did not find a relationship between stink bug damaged bolls during August and lint yield. This may partially be due to the low amount of stink bug pressure in the experiment. The amount of damaged bolls was low, ranging from 9 to 21% for the control plots and 2 to 4% for plots protected with insecticides. In 2002, average lint yield for the control was 718 lb/ac while cotton treated with Bidrin for stinkbugs averaged 639 lb/ac. These relatively low yields were partially due to excessive rainfall (over 6 inches) that occurred during late August and early September. The rainfall occurred just as bolls were opening and resulted in a large amount of hard locked bolls and bolls that rotted. Lint yields in 2003 were much higher, averaging 1420 lb/ac for the control and 1443 lb/ac for the plots treated with Bidrin.

All fiber, spinning, and fabric tests from the 2002 crop have been completed. Fiber spinning tests are currently being conducted on the lint from the 2003 crop. Waste during cotton fiber processing, spinning efficiency, yarn quality, and knit fabric quality are being evaluated. The data from both crops will be analyzed together once all data is collected.

<u>Extension</u>

Pilot Project to Establish a 1-800 Hotline for the Dissemination of Timely Information on Cotton Pest, Production Practices, and Farm Management Records

South Carolina Cotton Board Grant (1999)
Awarded To: Mitchell Roof and Toby Boring, Clemson University

We obtained funding from the SC Cotton Board to develop a Cotton Insect Hotline for the 1999 crop year. We were unable to get the Hotline up and going during the growing season, but by late September Toby Boring was able to find a computer software program that provided the service that was needed. The hotline system was in place for the 2000 and 2002 growing seasons, and we started making recordings on Tuesdays and Thursdays during the first week in June. Each time a cotton grower called the Hotline they heard a 1.5 to 3 minute message concerning such timely topics as the cotton insect situation, scouting procedures, insect management strategies, pyrethroid resistance and other items pertaining to the production of cotton. Each message acknowledges the support of the SC Cotton Board by indicating that “the following message is sponsored by the SC Cotton Board.”

Validation of COTMAN Expert System in South Carolina

Cotton Incorporated Core Projects (1999 to 2000)

Awarded To: Michael A. Jones, Mitchell E. Roof, Charles Davis,and Vic Bethea, Clemson University

COTMAN (COTton MANagement) is an expert system computer software program developed by the University of Arkansas and Cotton Incorporated, which uses plant monitoring to adjust crop management based upon plant response to pests and environment. One potential advantage of the COTMAN system is that it provides a continuous in-season crop monitoring to assist growers in making key decisions which can influence crop earliness by giving growers timely feedback on plant development and by detecting early plant stress based on the growth of a particular crop compared to the target development curve. Another potential advantage of the COTMAN system is that it identifies cutout dates for individual fields, which could be used to help make insecticide termination decisions and help plan defoliation and harvest schedules based on crop maturity. Since the COTMAN expert system computer program currently costs less than $2.00 per acre per season to collect data and produce weekly reports using the program, there is a considerable opportunity for growers to benefit from this crop management tool.

The COTMAN expert system has been evaluated in Alabama, Arkansas, Georgia, Louisiana, Missouri, Mississippi, Tennessee, Texas, and Virginia; however, little information exists on the validity of this computer program on the soils of the Southeastern Coastal Plain. Because there is the potential for economic benefits with this system, research evaluating and validating COTMAN is desperately needed by South Carolina cotton producers. Therefore, several studies were conducted to determine the feasibility of using COTMAN expert system as a crop management tool in South Carolina, and to validate the system for South Carolina cotton producers.

1999. The validation effort consisted of a combined effort between extension personnel and consultants/growers in two locations in South Carolina. Two fields in the northern (Dillon county) and southern (Calhoun county) regions of the state were identified and used as the experimental units. Each experimental unit was split in half, and the COTMAN computer program was used to follow the development of the chosen fields. Management decisions for half of each field was based on the COTMAN expert system model, while the other half of each field was based on grower/consultant recommendations. The Calhoun county site was located near Cameron, SC, and >Suregrow 125' was planted on 16 May. The Dillon county site was located near Dillon, SC, and >DPL 655BR@ was planted on 11 May. The soil type for both locations was a Norfolk sandy loam. Unfortunately, test fields in both Calhoun and Dillon counties encountered severe weather problems during the growing season (Hurricane Floyd and extreme drought), which resulted in poor crop development at both locations and the abandonment of the Dillon county field. Therefore, yield and cost of production information from the experimental units was not gathered. Plant growth and development data was collected from each experimental unit through mid-season, which allowed the extension specialists, extension agents, cotton consultants, and growers involved with the project to gain valuable experience with the SQUAREMAN AND BOLLMAN portions of the computer program and the data collection process involved with the system.

2000. One field in the northern (PDREC, Florence, SC) and southern (Cameron, SC) regions of the state were identified and used as the experimental units. Each experimental unit was split in half, and the COTMAN computer program was used to follow the development of the chosen fields. Management decisions for half of each field was based on the COTMAN expert system model, while the other half of each field was based on grower/consultant recommendations. The Calhoun county site was located near Cameron, SC, and 'Suregrow 125BR' was planted on 16 May. The Florence site was located at the Pee Dee Research & Education Center, and 'DPL 458BR" was planted on 11 May. The soil type for both locations was a Norfolk sandy loam. Unfortunately, test fields in both Cameron and Florence encountered severe drought during the growing season, which resulted in poor crop development at both locations and the abandonment of the Cameron field. Results at the Florence location indicated no significant yield advantage to using the COTMAN expert system. The COTMAN side of the field averaged 2564 lbs/A of seedcotton, while the grower recommendation side averaged 3210 lbs/A. No differences were found in gin turnout (39.6% for the COTMAN, 39.1% for the check side) or any of the lint quality parameters measured.

Possible advantages for the COTMAN side included potential savings associated with the recommendation by the program for one less pyrethroid application and earlier defoliation based on gathered heat unit information. A late application of Karate was made to the check plots based on scouting recommendations. The COTMAN side recommended defoliation on Sep. 11. The check plots were not defoliated until Sep. 27. This resulted in earlier harvesting for the COTMAN side (Sep. 28) compared to the check side (October 9).

Redevelop a State Cotton Conference for South Carolina
Continued Support for the South Carolina Cotton Growers' Annual Meeting

South Carolina Cotton Board Grant (2001 to 2004)
Awarded To: Michael A. Jones, Clemson University

South Carolina is one of the few cotton producing states in the Southeast and Mid-South that does not have an annual conference devoted entirely to bringing cotton industry personnel together in a single forum to discuss emerging cotton issues, research, and new technologies. Presently, important cotton research and production issues are addressed at several smaller venues, such as the South Carolina Ag Expo, county production meetings, field days, and through publications and newsletters. But these venues are often associated with other commodities and are limited in their focus on cotton issues in the state. A state cotton conference would bring together people from all aspects of the cotton industry (cotton producers, processors, scientists, extension personnel, and agribusiness representatives), and hopefully foster face-to-face dialogue among these people to help solve emerging problems and speed the transfer of new technology to the growers of South Carolina. A state cotton conference would provide researchers receiving funding from the South Carolina Cotton Board a forum to present their research findings, and would help promote the Board's efforts by increasing the awareness among cotton producers in the state the importance of the South Carolina Cotton Board to the cotton industry of the state.

The objective of this project was to provide South Carolina cotton growers, extension personnel, researchers, dealers, and other agribusiness personnel interested in cotton a forum for in-depth discussions of production issues and other concerns related to the cotton industry.

Results. The first three annual South Carolina Cotton Growers' Meetings were held in February of 2002, and 2003 at the Pee Dee Research & Education Center in Florence, SC and in 2004 and the Edisto Research & Education Center in Blackville. The Fourth annual South Carolina Cotton Growers' Meeting is scheduled for February 24, 2005 at the Pee Dee Research & Education Center in Florence, SC.

Genomics

Serial Analysis of Gene Expression (SAGE) in Floral and Leaf Abscission Zones

Cotton Incorporated State Support Program (1997 to 1998)
Awarded To: Rod A. Wing, Clemson University

The discovery and implementation of agriculturally important genes is paramount to our understanding of cotton biology with the goal of applying this information toward the development of superior cotton cultivars and fiber products. Traditional, "one gene at a time" approaches have been found to be extremely costly in both time and funding. Alternatively, scientists are now focusing on the discovery of all plant genes up front which can then be sorted into functional groups and pathways using sophisticated biochemical, genetic and bioinformatics tools. Two general approaches for global gene discovery are: 1) serial analysis of gene expression (SAGE), and 2) expressed sequence tags (ESTs). Early attempts to establish the SAGE technique for gene discovery of cotton flower abscission zone tissue with Cotton Incorporated funds failed at the CUGI, and we therefore resorted to an EST approach.

We have sequenced over 2,000 cDNA clones (i.e., copies of genes) from a cotton white flower abscission-zone cDNA library and identified hundreds of novel genes, which partial sequences have been deposited in the GenBank (accession number: AI054442-AI055745). Among the DNA sequences obtained that have significant similarity to other genes in the GenBank, three major classes of gene functions were identified: cell wall metabolism, cell signaling, and cell defense and stress.

Over 40 of our cDNA clones have been requested and sent to laboratories from Israel, in Europe, and from universities across the nation. Preliminary analysis using high-density arrays indicated that as many as 40% of the 1,500 clones are associated with cotton fiber development. This detailed analysis of cDNAs will be part of our continued efforts in establishing high throughput methods for cotton gene discovery, which is now supported by funds from the National Science Foundation.

Development of a Transformation Core Facility for Cotton

Cotton Incorporated State Support Program (1998 to 1999)
Awarded To: Chun-Hua Wan and Rod A. Wing, Clemson University

One of the techniques that plant biologists use to identify the functionality of a particular piece of DNA is called transformation, which is the process of transferring recombined DNA to cells in an attempt to recover plants that have new traits conferred by the engineered DNA. We have used this technique to study plant abscission, a process by which plants shed organs, such as fruits, flowers, and leaves. It has been known that changes in the activity of abscission zones (the cell layers where abscission takes place) in response to stress, both biotic and abiotic, can have a profound impact on crop production in terms of both yield and quality. Therefore, study of cotton floral abscission has implications for control of boll dropping and mechanical harvesting.

In our research on gene expression in cotton floral abscission, we have identified a promoter (a piece of DNA) that has the potential to direct specific expression of any genes in floral abscission zones of cotton. To identify the exact function of the promoter, a test gene was constructed and introduced to tobacco, a "model" plant that is related to cotton and much easier to transform. Several plants (lines, F0) containing copies of our test gene were recovered from test tubes, and their selfed seeds (F1) were allowed to grow to maturity in the greenhouse and were used for analysis. In total, four independent lines, each with at least three transgenic F1 plants, were analyzed for the presence of the test gene activity. All plants showed the expected activity only in floral abscission zones and pollen, and not in other tissues tested, including leaf abscission zones, flower parts, and immature seeds. Ethylene treatment did not alter the pattern of the gene expression. In addition, it was occasionally found that some floral abscission zones, particularly the young ones, did not have any detected gene activities, suggesting a possible temporal regulation of the promoter.

This finding of the promoter activity in tobacco suggests that it may function in cotton in a manner specific to floral abscission zones. We have developed all the necessary means for transforming cotton with the promoter. This part of research will be continued in the second year of the project.

Development of a Cotton Genome Center at Clemson University and Analysis of Sequence Tag from Developing Fiber Cells

Cotton Incorporated State Support Committee (1998)
Awarded To: Rod A. Wing and Chun-Hua Wan, Clemson University

Genome is the term used to describe the complete set of the inheritable material, namely DNA, in an organism. Several genomics programs have been initiated in our laboratory, with the aim to understand the cotton genome and provide tools for rapid gene discovery. One of the programs is to develop cotton ESTs (expressed sequence tags) which represent portions of genes.

We have sequenced over 2,000 cDNA clones (i.e., copies of genes) from a cotton boll abscission-zone cDNA library and identified hundreds of novel genes. Partial sequences of these genes have been deposited in the GenBank (accession number: AI054442-AI055745). Among the DNA sequences obtained that have significant similarity to other genes in the GenBank, three major classes of gene functions were identified: cell wall metabolism, cell signaling, and cell defense and stress.

The EST clones were used to produce macro-arrays, which are cDNAs arrayed in high density on nylon membrane. When the EST clones are matched with genetic material from specific tissues, it is possible to identify the tissue location of the cDNAs. This set of cDNA clones was also used to match genetic material from mRNA of developing fibers. With the aid of computer software, we have identified approximately 500 cDNA clones that showed an increase in gene expression from the primary cell wall stage to the secondary wall stage, and approximately 100 EST clones that had a decrease in gene expression during the same transition.

Cotton Incorporated funds were instrumental to the CUGI for the establishment of a cotton boll abscission EST database and clone resource and a high-through-put EST sequencing center (http://www.genome.clemson.edu). This foundation has led to the acquisition of significant grant funding from the National Science Foundation to establish a 50,000 EST database for cotton fiber ESTs (Pls: T. Wilkins, A. Paterson, J. Wendel, N. Trolinder, and R. Wing; URL: (http://www.genome.clemson.edu/news_frame.html).

Development of Computational Tools for Efficient Sequencing of Cotton cDNA's

South Carolina Cotton Board Grant (1998)
South Carolina State Support Committee Grant (1999)
Awarded To: Chun-Hua Wan and Rod Wing, Clemson University

Complementary DNA clones (cDNAs) represent a collection of expressed genes. Sequencing the partial or full length of cDNA can result in Expressed Sequence Tag (EST), which has become an important resource for discovery of genes and gene functions. At the Clemson University Genomics Institute, we have produced and deposited in GenBank over a thousand cotton floral abscission EST sequences. This initiative of cotton ESTs, first funded by Cotton Incorporated, is now extended to sequencing 50,000 cotton fiber ESTs, with funding provided by the National Science Foundation, which are to be used to produce gene chips for expression analysis.

One of the difficulties involved in a high-volume sequencing project is monitoring its progress. Because genes that are highly active in transcription are likely to be selected multiple times, continued sequencing from the same pool of random clones may not have the same throughput (the new sequences generated from a certain amount of random clones). The objective of the project is to develop a software solution to the problem.

Using programming language C, we have experimented with different data structures, the methods of organizing data for computing. A linked list was constructed and a program, called "cottoninc', was developed. This program, which is available to the public upon request to the authors, takes in an input data file and produces different output files. One of the output files reports redundant gene copies, and the other contains only clones with unique sequences in a format that can be directly fed to our Oracle database. The resulting software tool is being integrated into our overall data monitoring and processing system.

Research Towards an Integrated Genetic and Physical Map of Cotton

Cotton Incorporated State Support Committee Grant (2000)
Awarded To: Rod A. Wing, Clemson University

Cotton breeding in the past decade has failed to produce varieties that will lift yield from its present plateau. Marker-assisted breeding could provide a method to follow genes, or groups of genes, through various crosses allowing rapid incorporation of new traits without the stigma of genetic modification. The construction of a physical map that can be delineated is the first step in this research effort.

The Maxxa BAC library construction was completed and sent to Dr. Roy Cantrell at New Mexico State University in September of 2000. The library has been made publicly available and may be ordered through the CUGI's website at www.genome.clemson.edu/orders. Currently, a copy has been requested by and received by our collaborator, Dr. Thea Wilkins, UC-Davis. A manuscript has been completed and submitted to the journal "Plant Molecular Biology" for review. The abstract reads as follows:

We have constructed a cotton (*Gossypium hirsutum* L.) BAC library using the elite Acala type cultivar Maxxa. The BAC library contains 129,024 clones comprising 8.3 haploid genome equivalents based on an AD genome size of 2,118 Mb. A random sampling of 435 BACs indicated an average insert length of 137 kb with a range of 80 to 275 kb. Ninety-nine percent of BAC clones in the sample had an average insert length equal to or greater than 100 kb. Contamination of the genomic library with chloroplast clones was low (1.5%). To gain a glimpse into the cotton genome and evaluate the library for sequence-tagged connector (STC) development, 1,536 BAC clones were end sequenced in both forward and reverse. The STCs were queried against the *Arabidopsis* databases and significant hits were sorted according to reported function.

The fingerprinting protocol for cotton BACs has been tested and optimized by our physical mapping group. The laboratory has been set up and is ready to begin fingerprinting the cotton BAC clones. Once R. Cantrell identifies the appropriate BAC clones to be fingerprinted, we will begin that phase of this collaborative project.

Plant Pathology

Enhancing Grower Awareness of Nematode Management Strategies

Cotton Incorporated State Support Committee Grant (1996 and 1997)
Awarded To: John D. Mueller and Ken Lege', Clemson University

No resistance to Columbia lance nematode has been found in cotton. Tolerance, the ability to sustain yields when infected, has proven to be an effective management tool in controlling Columbia lance nematode in soybean but not cotton. The primary objective of this study was to better understand mechanisms of yield loss in cotton due to Columbia lance nematode. Of special interest were effects on the onset of reproductive growth and boll maturity. Plots of Stoneville's LA 887 were established on a grower's field and at the Edisto Research and Education Center. Eight row plots 50-feet long were split with one-half untreated and one-half treated with 6 gal/acre Telone II. Average yield losses of 21% were observed in the 4 tests. A significant cause of yield loss was the delay in the onset of fruiting and maturity of bolls. In fumigated (nematode free) plots more than 55% of lint was available on the first picking date. On the last date almost twice as much lint was still present in the non-fumigated than the fumigated plots.

Year	Location	lbs lint/acre Telone II	lbs lint/acre Check	% Yield Loss
1996	Edisto	926	771	17
1996	Youngblood	938	781	17
1997	Edisto	1,130	863	24
1997	Youngblood	791	594	25

		% of lint picked			
Location	Telone II	First	Second	Third	Fourth
Edisto	Yes	66	13	9	12
Edisto	No	46	14	20	20

Youngblood	Yes	55	18	15	12
Youngblood	No	35	16	24	25

Sequential handpicked yields were collected 2 to 4 consecutive weeks prior to machine harvest. Yield loss was attributed to significant reductions in total harvestable bolls per plant. Total nodes, total fruiting sites per plant, and total number of first position harvestable bolls was not affected. Yield losses were due to a 23% reduction in retention of second position bolls.

Incorporation of Root-Knot Nematode Resistance and Reniform Nematode Tolerance into Agronomically Acceptable Cotton

Cotton Incorporated State Support Committee Grant (1998 to 2004)
Awarded To: John D. Mueller, Clemson University, O. Lloyd May, USDA-ARS, Florence, SC; James L. Starr, Texas A & M University; and C. Wayne Smith, Texas A & M University

This was a multistate project supported by Cotton Inc. as a Core Project. Root-knot nematode is a major pest of cotton in all areas of the U. S. cotton belt. Reniform nematode occurs in most of the areas east of the Rio Grande Valley. Management of both of these pests relies heavily on the use of nematicides and to a limited extent rotation to control reniform nematodes. The objective of this project was to utilize root-knot resistant material such as Auburn 634 RNR and M-75 RNR which are not agronomically suitable to the southern or southeastern United States as sources of resistance to be incorporated into agronomically acceptable cultivars. Tolerance is the ability of a plant to sustain yields even while infected by a pest such as reniform nematode. Material exhibiting tolerance to reniform nematode would be utilized to eventually create genotypes resistant to root-knot and tolerant of reniform nematode.

South Carolina: Efforts in South Carolina have concentrated on the development of recombinant inbred lines derived from a cross of PD 5363 and M-75 RNR. Development was initiated in 1998 by self-pollination of 100 F2 plants from a single cross of PD 5363 and M-75 RNR Selfing of the populations has proceeded through the F8 stage. F8 material will be screened in the spring of 2002 in the greenhouse and in the field for resistance to root-knot nematode and the inheritance pattern will be determined. Lines highly resistant to root-knot nematode will be evaluated for agronomic characters and selections further developed as germplasm or cultivars.

Texas:
1. Segregation for resistance to *M. incognita* in progenies of crosses between the susceptible cultivar Deltapine '90' and the resistant cultivars CPSD's 'Acala NemX' and Stoneville's 'LA 887' were determined. The resistance of both resistant cultivars appears to be variable and controlled by multiple genes. A major portion of the resistance may be due to recessive genes.

2. The advanced breeding line '96F15DD17' was developed and has excellent yield potential but is still segregating for resistance to *M. incognita*.

3. A *G. barbadense* "TX110" line resistant to reniform nematode has been crossed with a G. hirsutum line, M315, resistant to root-knot nematode. F2 progeny have been selected for day neutrality and F3 material screened for resistance to reniform nematode. F3 material are being screened for root-knot resistance. Material resistant to both nematodes will be crossed with advanced breeding lines to improve yield potential and fiber quality.

Managing Cotton Nematodes in Conservation Tillage Systems

South Carolina Cotton Board Grant (2001 to 2003)

Awarded To: John D. Mueller, Ahmad Khalilian, and Charles W. Davis, Jr., Clemson University

OBJECTIVE1: To determine whether nematode populations buildup more rapidly in strip tillage systems than in conventional tillage systems;

OBJECTIVE 2: To determine whether Telone II can be applied effectively in stale seed bed systems;

OBJECTIVE 3: To determine whether Telone II can be applied effectively using a Paratill:

OBJECTIVE 4: Compare the efficacy of a regime including Temik 15G at-plant + Temik 15G side-dressed with a standard Telone II regime.

Summary of Accomplishments

Progress on this project was hindered in the first year by the late arrival of tillage equipment to be used in test plots. In the second year extremely wet conditions prevented the use of grower fields where Telone II was to be applied or where stale seed beds were to be established since planting dates would have been too late to grow a reasonable cotton crop. Most of these results are from the 2002 growing season.

Objective 1. Strip till systems appear to support higher levels of reproduction by Columbia lance and reniform nematodes than conventional and minimum tillage systems. Reproduction of root-knot nematode appeared to be unaffected.

Objective 2. Comparison of 3 dates of Telone II application in March (6, 4, and 2 weeks preplant) showed that all Telone II applications gave a greater yield response than treatments involving only Temik 15G at planting.

Objective 2. Comparison of 3 dates of Telone II application in March (6, 4, and 2 weeks preplant) showed that Columbia lance nematode control levels did not differ among treatment dates. However, reniform nematode control was greater on the last two treatment dates than on the first.

Objective 3. Equipment for this test, an eight row strip tillage rig did not arrive until May, which was too late to apply Telone II for production purposes. It was rigged up with a Telone II unit and tested for use in 2003.
Objective 4. Side dressing Temik 15G was very effective in decreasing nematode reproduction and increasing yields, especially in fields infested with reniform nematode. This may be a suitable alternative to using Telone II preplant in minimum or strip tillage systems.

Objective 4. Reniform nematode continues to spread in its distribution across the upper half of South Carolina. Continuous cotton cropping systems utilizing only at-plant applications of Temik 15G allow production of appropriate yields where reniform numbers have not yet built to high levels. We saw higher infestation levels in such fields this summer than in any previous summer.

RESULTS & DISCUSSION:

Objective 1:We continued to utilize the Center of Excellence and it's set of tillage treatments to compare levels of nematode reproduction in different tillage systems. All three major nematode pathogens of cotton in South Carolina were present. All three tillage systems supported approximately equal levels of reproduction by root-knot nematode. Reproduction of Columbia lance and reniform nematodes were greatest in the strip tillage system. Data from 2003 continues to show that Strip Tillage systems appear to sustain higher populations of Columbia lance nematode than no till or conventional tillage systems.

Objectives 2 & 3: Application of Telone II in stale seed beds was studied on two grower's fields in Calhoun County near Ft. Motte. Telone II was applied on at 2 week intervals in grower's fields infested with root-knot and Columbia lance nematodes. The first field was infested primarily with root-knot and Columbia lance nematodes. Levels of Columbia lance nematode did not vary with date of Telone II application or by treatment applied, i.e. all 4 nematicide regimes gave the same level of control. Yields were slightly lower for the March 29 than for the earlier 2 treatment dates. Telone II treatments yielded 50 to70 lbs/acre more than the treatments with Temik 15G alone. The second field was infested primarily with reniform and Columbia lance nematodes. Recovery at planting of reniform nematode was greater from plots treated on March 1 than plots treated on March 29. Recovery of Columbia lance nematode was not affected by treatment date. Yields were greater for earlier treated plots than those treated on March 29. Plots treated with Telone II had higher yields than those treated only with Temik 15G at planting.

Objective 4: Plots were put out on 3 farms, a total of 12 test sites or fields. Eleven of the 12 fields were irrigated. Each test consisted of paired plots. One set of rows received no side-dress treatment. The second set of rows received 4.5 lbs of Temik 15G per acre.

Two of the three farms were heavily infested with reniform nematode. The third had primarily Columbia lance nematode. Side dressing with Temik 15G provided an average 81 lb/acre increase in lint yield averaged over 12 locations. Yield increases were especially high in fields heavily infested with reniform nematodes. Despite the increase in yields, nematode levels were still very high at harvest and will require management in each subsequent year.

Effects of Foliar Fungicides on Leaf Health, Hard Lock and Foliar Diseases

South Carolina Cotton Board Grant (2004)
Awarded To: John Mueller, Michael A. Jones, and John .K. Croft, Clemson University

The objectives were completed as outlined in the original grant proposal. Mr. Jonathan K. Croft, a 2004 graduate of Clemson University with a B.S. in Ag Mechanization, was hired as a graduate research assistant. He planned, coordinated, and conducted plot work at both the Edisto and Pee Dee R.E.C.'s for Objective 2, the comparison of the growth habit and yield of Deltapine 555 versus Paymaster 1218 when treated with various fungicide regimes. He also conducted the fungicide comparison for Objective 1 at the Edisto R.E.C. He has presented these results at the Beltwide Cotton Conference this January in New Orleans as a poster and an oral presentation. He will finish his coarse work in the spring of 2005 and work full time at the Edisto R.E.C. on his research until his projected graduation in 2006.

OBJECTIVE 1: EVALUATION OF FOLIAR FUNGICIDES FOR HARD LOCK CONTROL.

Plots were established at the Edisto R.E.C. to evaluate the efficacy of nine fungicides for controlling hardlock and increasing yields as well as their possible effects on plant growth. Stoneville 5599 was planted on 7 May 2004 and grown using standard production practices including the application of Pix. Plots consisted of 4 rows on 38" centers and were 45 ft long. Plant growth data and leaf areas were recorded on August 3 and September 9. Plots were maintained with a vigorous spray schedule to minimize damage from piercing–sucking insects. Fungicide sprays were initiated at first flowering, which occurred on July 7. A second spray was applied to all plots 2 weeks later. Plots were sprayed using a backpack sprayer delivering 20 gpa at 60 p.s.i. At harvest plants from 1 meter of row were plant mapped and data collected on the height, number of nodes, and the node number of the first fruiting branch. Bolls were divided into five categories: rotten bolls = decayed bolls with little or no lint; 1 = bolls green and immature, not open; 2 = all locules open and with fluffly, pickable lint; 3 = 1 or 2 locules with hardlock, lint in those locules not pickable; 4 = all locules hard locked, no lint pickable.

Overall it was an excellent growing season. Yields were exceptional (Table 1) despite the fact that cloudy wet weather early in the year caused the abortion of almost all fruit in the bottom third of most plants. Although small differences were detected between fungicide treatments no fungicide treatment significantly increased leaf area compared to the check (Table 1). No treatment differed from the check for plant height, number of nodes, position of first fruiting branch, or other plant growth parameters (data not shown). Plants treated with Topsin M 70 WSB at 0.75 lbs/acre had a slightly higher % lint than the check (Table 1). The treatments did not vary among themselves or from the check for yield (Table 1). There was no significant positive effect on the percentage of harvestable bolls as a result of any fungicide spray (Table 2).

OBJECTIVE 2: COMPARISON OF FUNGICIDE EFFECTS ON DELTAPINE 555 AND PAYMASTER 1218.

Plots were established at the Edisto and Pee Dee R.E.C.'s of Deltapine 555 and Paymaster 1218. Plots consisted of 8 rows 45 ft long on 38 inch centers. Four fungicide regimes were established at the PDREC: 1). nontreated check; 2). 3 weekly sprays starting at flowering; 3). Weekly sprays starting at 3 weeks after planting until flowering; and 4) weekly sprays from the start of flowering until the end of flowering. At the EREC a fifth treatment, weekly sprays from 3 weeks after planting until the end of flowering, was added. All sprays consisted of 0.5 lbs/acre Topsin M applied from a tractor mounted sprayer in 20 gpa at 40 psi. Only plots at EREC were treated with Pix.

Yields for both cultivars were exceptional at both the Edisto and Pee Dee RECS's (Tables 3 and 4). No fungicide treatment significantly increased yields above the level of the nonsprayed check. Yield of Deltapine 555 exceeded that of Stoneville 5599 at both locations. The percentage of healthy bolls was not positively affected by fungicide treatment at either location for Paymaster 1218 or Deltapine 555 at the PDREC (Tables 3 and 4). At The Edisto R.E.C. weekly Topsin sprays up to flowering resulted in a higher percentage of healthy bolls than the check. Fungicide sprays had no effect upon plant height, leaf area, bolls per meter of row, the node number of the first fruiting branch, or the ratio of reproductive to vegetative dry matter.

OBJECTIVE 3: EFFECTS OF FUNGICIDE SPRAYS ON SEED ROT IN DELATPINE 555 AND PAYMASTER 1218.

Bolls were collected every 14 days from plots at both locations beginning approximately 21 days after flowering. No significant differences were detected in incidence or severity between cultivars or among fungicide regimes (no data shown).

FUTURE PLANS:

Plant growth and yields were exceptional at both locations due to very favorable weather conditions in 2004. The incidences of hard lock or seed rot were relatively low. We would like to repeat all experiments in 2005 to observe the growth and development of these cultivars in what is bound to be a less favorable environment than was encountered in 2004.

Table 1. Comparison of nine fungicides for control of hardlock and effects on growth and yield of Stoneville 5599 at the Edisto R.E.C., 2004.

Fungicide	rate/acre	August 3 L.A.I.	% Lint lbs	lint/acre
Stratego	7.00 oz	1.81 ab	40.8 bc	1,231 a
Headline	9.00 oz	1.72 ab	40.9 bc	1,225 a
Quadris	13.00 oz	1.53 ab	40.9 bc	1,182 a
Folicur	7.20 oz	1.88 a	41.1 bc	1,175 a
TM 85 WDG	0.62 lbs	1.24 b	41.6 ab	1,161 a
Tilt	3.00 oz	1.96 a	40.5 c	1,126 a
Check	-----	1.56 ab	40.9 bc	1,076 a
Bravo Ultrex	1.40 lbs	1.73 ab	41.0 bc	1,060 a
Topsin M 70 WSB	0.75 lbs	1.57 ab	42.1 a	1,038 a
Topsin M Flowable	1.17 lbs	1.40 ab	41.0 bc	1,038 a

Means within a column with a letter in common are not significantly different according to a DNMR test (*P* = 0.05).

L.A.I. = leaf area index = leaf area (cm^2) of plants in a meter of row / 10,000 cm^2.

Table 2. Percentages of bolls in the following categories: rotten = bolls decayed and nonharvestable; 1 = bolls green and immature; 2 = bolls with lint in all locks fluffed and harvestable; 3 = lint in 1 or 2 locules hard locked and not harvestable; and 4 = lint in 3 or more locules hardlocked and not harvestable.

Treatment	Rotten	1	2	3	4
Topsin M WSB	1.0 a	0.0 a	61.4 ab	14.7 a	22.7 ab
Topsin M F	0.2 a	0.2 a	62.0 ab	14.3 a	23.4 ab
TM WDG	1.3 a	1.3 a	62.3 ab	16.1 a	18.6 b
Bravo Ultrex	1.7 a	1.3 a	60.6 ab	17.5 a	18.2 b
Headline	0.6 a	0.2 a	53.7 b	16.3 a	29.0 a
Quadris	1.2 a	0.7 a	62.4 ab	17.7 a	17.7 b
Stratego	0.3 a	0.0 a	64.0 a	21.7 a	14.1 b
Folicur	0.7 a	0.3 a	59.5 ab	19.9 a	19.0 b
Tilt	0.2 a	0.6 a	61.1 ab	17.1 a	20.8 ab
Check	1.5 a	0.0 a	64.3 a	16.4 a	17.9 b

Means within a column with a letter in common are not significantly different according to a DNMR test (*P* = 0.05).

Table 3. Lint yield and percentage of healthy bolls (all locules fluffly and harvestable) of Deltapine 555 and Paymaster 1218 at the Edisto R.E.C. treated with 5 spray regimes.

	lbs lint/acre		% Healthy Bolls	
0.5 lbs/a Topsin M sprayed	DP 555	PM 1218	DP 555	PM 1218
Wkly, flwrng to end of flwrng	2,112 a	1,476 a	86 b	84 a
Wkly, 3 WAP to flwrng	1,824 a	1,495 a	93 a	86 a
3 wkly sprays starting at flwrng	1,798 ab	1,533 a	88 ab	84 a
Nontreated Check	1,788 ab	1,498 a	86 b	82 a
Wkly from 3 WAP to end of flwrng	1,716 b	1,476 a	86 b	80 a
Mean	1,846 A	1,495 B	88 A	83 B

Numbers within a column with the same letter are not significantly different according to a DNMRT test (*P*=0.05).

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Table 4. Lint yield and percentage of healthy bolls (all locules fluffy and harvestable) of Deltapine 555 and Paymaster 1218 at the Pee Dee R.E.C. treated with 4 spray regimes.

	lbs lint/acre		% Healthy Bolls	
0.5 lbs/a Topsin M sprayed	DP 555	PM 1218	DP 555	PM 1218
Wkly, flwrng to end of flwrng	1,856 a	1,614 a	49 a	54 a
Nontreated Check	1,840 a	1,676 a	47 a	53 a
Wkly, 2 WAP to flwrng	1,832 a	1,606 a	52 a	55 a
3 wkly sprays starting at flwrng	1,695 a	1,605 a	45 a	50 a
Mean	1,806 a	1,626 b	48 B	53 A

Numbers within a column with the same letter are not significantly different according to a DNMRT test (*P*=0.05).

Weed Science

Yellow Nutsedge Control Programs in Cotton Utilizing Roundup Ultra and Staple With and Without Standard Soil-Applied and Postemergence Herbicides

South Carolina Cotton Board Grant (1996 and 1997)
Awarded To: Ed Murdock, Clemson University

This test was conducted to determine if the added cost and inconvenience of using Zorial was justified for control of yellow nutsedge and to compare POST yellow nutsedge control with Roundup Ultra, Staple, and MSMA. A split application of Zorial (2 rate PPI, 2 rate PRE) alone provided 78% control of yellow nutsedge 8 weeks after planting; when followed by (fb) Staple, Roundup, or MSMA control ranged from 81 to 99%. The average lint yield when Zorial was used was 1016 lb/ac. The average lint yield when only POST treatments were used (i.e. no Zorial) was 934 lb/ac. Best yellow nutsedge control was observed with MSMA and Roundup Ultra fb MSMA.

Conclusions:

- The added cost of Zorial can be justified only in fields with high yellow nutsedge populations.

- MSMA provides better yellow nutsedge control than Staple or Roundup Ultra and is considerably more economical.

- Roundup Ultra alone provides marginal control of yellow nutsedge.

Evaluation of Cotton Growth and Development, Weed Control, and Net Profit in Strip-Tillage Cotton

South Carolina Cotton Board Grant (1997 and 1998)
Awarded To: Ed Murdock, Clemson University

Weed management systems were compared in strip- and conventional-tillage. Broadcast and banded applications of Prowl + Cotoran and Prowl + Reflex were compared, and the entire test area (except the untreated check) received a POST application of Roundup Ultra at the 4-leaf stage. Palmer amaranth was the most prevalent weed species present; sicklepod was present at a moderate to high infestation level. Reflex provided more consistent and better control of Palmer amaranth compared to Cotoran, and this was reflected in lint yields. Average lint yields with Reflex and Cotoran were 955 and 816 lb/ac. Average lint yields with banded and broadcast application of soil-applied herbicides were 848 and 923 lb/ac, respectively. Average lint yields with strip- and conventional-tillage were 904 and 689 lb/ac, respectively.

Conclusions:

-Without POST-directed or layby herbicide applications, soil-applied treatments must be broadcast.

-Lint yields with strip-tillage should be equal to and in some years greater than yields attained with conventional tillage.

-Adopting strip-tillage saves on fuel inputs and time, and helps retain soil moisture. Part of these savings are negated by the higher input cost associated with additional herbicide use.

Evaluation of Mid- and Late-season Competitiveness of Okra-leaf Cotton with Weeds and the Potential Need for Additional Herbicide Inputs

South Carolina Cotton Board Grant (1998 and 1999)
Awarded To: Ed Murdock and J. Staples, Clemson University

In this 2-year study, weed management systems were compared in a conventional cotton variety (DP-51) and an okra-leaf variety (Fibermax 832). Weed biomass reductions were similar for all herbicide systems with the two varieties. Treflan alone and Treflan followed by (fb) Meturon + Staple PRE did not provide adequate weed control. However, Treflan fb Meturon + Staple fb Staple + surfactant POST alone and fb Cotton-Pro + MSMA POST-directed or Cotton-Pro + MSMA POST-directed fb Cotton-Pro + surfactant @ layby reduced weed biomass 93 to 100%. Respective average lint yields with these 3 weed systems were 733 and 905 lb/ac for DP-51 and Fibermax 832, respectively.

Conclusions:

-Competitiveness of okra-leaf cotton is similar to that of conventional cotton.

-Necessary herbicide inputs should be similar.

Palmer Amaranth (*Amaranthus palmeri*) Resistance in South Carolina to the ALS-Inhibiting Herbicides

South Carolina Cotton Board Grant (1998)
South Carolina State Support Committee Grant (1999)
Awarded To: Billy J. Gossett, Clemson University

Acetolactate synthase (ALS) – inhibitors are a broad family of herbicides that are widely used in agronomic crops. ALS herbicides used in South Carolina include: Staple®, Scepter®, Pursuit®, Cadre®, Classic®, Pinnacle®, Accent®, Beacon®, Permit®, and

Broadstrike®. One or more are registered in cotton, soybeans, peanuts, and corn; that is, in essentially all major agronomic crops. Many cases of resistance to the ALS herbicides have been reported. An unusual feature of ALS resistance is the unpredictable pattern of cross-resistance. When ALS resistance occurs, it may be limited to only one herbicide; or occur as complete or partial resistance to other ALS herbicides. Such a complex pattern of cross-resistance may occur because six different mutation sites have been reported on the ALS enzyme that can confer resistance.

In 1999 suspected ALS-resistant Palmer amaranth collections from three fields in Clarendon County and one field in Dillon County, South Carolina were confirmed to be resistant to Staple and other ALS-inhibiting herbicides as well. The collections were resistant to the ALS herbicides at up to four-times (4x) their recommended rates, while a susceptible Palmer amaranth was controlled at the recommended rate. Resistance was limited only to the ALS-inhibiting herbicides. Other commonly used herbicides were effective. The Clarendon County ALS-resistant Palmer amaranth seed were collected from three fields that had been treated each year during the previous four to six years with the imidazolinone herbicides, Pursuit® or Scepter®. The Dillon County ALS-resistant Palmer amaranth seed were collected from a field that had been treated each year during the previous four or five years with the sulfonylurea herbicide, Classic®.

Additional cases of herbicide resistance in South Carolina include goosegrass and Palmer amaranth resistant to Treflan® and other dinitroaniline (DNA) herbicides, common cocklebur resistant to DSMA and MSMA, and Italian ryegrass resistant to Hoelon®. Since DNA-resistant Palmer amaranth commonly occurs throughout the Coastal Plains of South Carolina, the first generation (F_1) progeny of ALS-resistant x DNA-resistant Palmer amaranth was evaluated for herbicide resistance. The F_1 progenies were resistant to the ALS-inhibiting herbicides. This demonstrates that the ALS-resistant trait is transmitted by pollen as well as by seed, which will accelerate the spread of ALS-resistance. No DNA-resistance was observed. However, DNA resistance could be a recessive trait and might appear in later generations. No resistance was observed to herbicides with modes of action other than ALS in the tested collections.

Evaluation of Roundup Ready® Cotton Cultivars under Weed Management Programs Based Primarily on Postemergence and Postemergence-Direct Applications of Roundup Ultra

South Carolina Cotton Board Grant (1998 and 2000)
South Carolina State Support Committee Grant (1999)
Awarded To: Ed Murdock, Clemson University

Producers often rely on Official Cultivar Trials (OCTs) for performance data with which to choose cultivars. However, yields of glyphosate [N-(phosphonomethly)glycine]-tolerant (Roundup Ready®) cotton (Gossypium hirsutum L.) cultivars in OCTs may not reflect cultivar variation in tolerance to glyphosate nor do yields reflect the intended production system because all cultivars, transgenic or not, are produced in non-glyphosate herbicide systems. Our objective was to assess main effects and interaction among glyphosate-tolerant cultivars. Herbicide systems were defined as 1) standard, consisting of soil-applied and post-direct-applied residual compounds typically employed in OCTs, but no glyphosate; 2) residual + glyphosate, consisting of soil-applied and post-direct-applied residual compounds combined with a topical application of glyphosate; 3) glyphosate-only. We found a significant (P<0.01) herbicide system main effect for lint yield, but no cultivar x herbicide system interaction. The herbicide system main effect means revealed that the glyphosate-only herbicide system produced significantly (P<0.01) greater yields (597 and 839 kg ha^{-1} earlier-and later-maturity trials, respectively). The lack of cultivar x herbicide system interactions indicate that the yield rank of glyphosate-tolerant cultivars was unaffected by herbicide system, suggesting that data from OCTs can discriminate among glyphosate-tolerant cotton cultivars for relative yield potential. However, the herbicide system main effect demonstrating higher yields of glyphosate-tolerant cultivars produced in the glyphosate-only herbicide system suggests that OCTs can underestimate yield potential of glyphosate-tolerant cultivars.

Conclusions:

- Herbicides system does not affect relative performance of Roundup Ready® cotton cultivars.

- Yields from Official Cultivar Trials where all cultivars are treated alike in a non-Roundup Ultra herbicide system can be used for Roundup Ready® cultivar selection.

- Official Cultivar Trials where standard herbicides systems are used may underestimate yield potential of Roundup Ready® cultivars.

Evaluation of the Relative Yield Potential of Roundup Ready vs. Conventional Cotton Cultivars

South Carolina Cotton Board Grant (1999)
South Carolina State Support Committee Grant (2000)
Awarded To: Ed Murdock and Michael A. Jones, Clemson University
and
Lloyd May, USDA-ARS, Florence

Crop injury, weed control, weed biomass, and lint yield of Roundup Ready and conventional cotton cultivars were compared under two herbicide systems. A standard herbicide program (Prowl + Cotoran PRE, Staple + surfactant POST, Cotton-Pro + MSMA layby) was used on the Roundup Ready and conventional cultivars. In addition, a Roundup Ultra only program (Roundup Ultra POST-4 leaf cotton, Roundup Ultra layby) was evaluated on the Roundup Ready cultivars.

Conventional cultivars evaluated were DP1560, DP90, DP5415, DP5690, and Fibermax 989; Roundup Ready cultivars evaluated were DP5690RR, DP458BG/RR, DP655BG/RR, DP1560BG/RR, and DP5415RR.

Southern crabgrass, Palmer amaranth, and morningglory control 11 weeks after planting (WAP) was excellent, (95 to 100%) with all cultivars and herbicide programs. Sicklepod control ranged from 81 to 100%. Weed biomass 10 WAP ranged from 0 to 79 lb/ac. Average weed biomass for the standard and Roundup Ultra only system was 34 and 28 lb/ac, respectively.

Lint yields were similar for all cultivars and herbicide systems; average lint yield for the conventional and Roundup Ready cultivars was 838 and 790 lb/ac, respectively. Averaged across cultivars, the lint yield for the standard and Roundup Ultra only systems was 797 and 868 lb/ac, respectively.

Conclusions:

-Adequate season-long weed control can be attained with standard herbicides and with Roundup Ultra alone.

-Lint yield of conventional and Roundup Ready cultivars was similar.

Effects of Multiple Applications of Roundup Ultra on Roundup Ready Cotton

South Carolina Cotton Board Grant (2000)
South Carolina State Support Committee (2001)
Awarded To: Ed Murdock and Michael A. Jones, Clemson University

Field experiments were established in 2000 and 2001 at the Pee Dee Research and Education Center, Florence, SC, to evaluate the response of Roundup Ready cotton to multiple postemergence (POST) and POST-directed applications of Roundup Ultra. Six treatments were evaluated both years; four additional treatments were included in 2001. Treatments were replicated six times each year, and plots were maintained weed-free.

Multiple applications of Roundup Ultra did not affect plant population, plant height, picker efficiency, or gin turnout (data not presented). Lint yields are presented in *Table 1*. Lint yields in 2000 averaged 817 to 891 lb/ac, and were similar for all treatments. Treatments that included multiple applications of Roundup Ultra averaged 838 lb lint/ac. Where no postemergence treatment were applied the average lint yield was 862 lb/ac (*Table 1)***.** In 2001, cotton produced 1040 lb lint/ac where no postemergence herbicides were used (*Table 2)*. When multiple POST and/or POST-directed Roundup Ultra treatments were applied cotton averaged 1048 lb lint/ac.

Roundup Ready cotton exhibited excellent tolerance to multiple applications of Roundup Ultra, even when treatments were applied beyond the recommended maximum 4-leaf stage of growth.

Table 1 Effect of multiple applications of Roundup Ultra on lint yields, 2000-01.

		2000	2001
NO POST DP655BR		862	1040
ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA DP655BR	POST-2LF POST-4LF POST-DIR-6LF POST-DIR-8LF	824	1009
ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA DP655BR	POST-2LF POST-4LF POST-DIR-8LF	822	1020
ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA DP655BR	POST-2LF POST-4LF POST-DIR-12LF	891	1081
ROUNDUP ULTRA ROUNDUP ULTRA COTTON-PRO + MSMA DP655BR	POST-4LF POST-DIR-8LF POST-DIR-12LF	817	1032
STAPLE + SURFACTANT COTTON-PRO + MSMA DP35B	POST-4LF POST-DIR-12LF	853	1065
LSD (0.05)		103	
ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA DP655BR	POST-2LF POST-4LF POST-DIR-8LF		1043
ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA DP655BR	POST-2LF POST-4LF POST-8LF POST-12LF		1067
ROUNDUP ULTRA ROUNDUP ULTRA ROUNDUP ULTRA DP655BR	POST-2LF POST-4LF POST-12LF		1082
STAPLE + SURFACTANT FIBERMAX 958	POST-4LF		917
LSD (0.05)			129

Evaluation of Crop Tolerance and Weed Management in Glufosinate (Liberty)-Tolerant Cotton

South Carolina Cotton Board Grant (2001 to 2002)
Awarded To: Edward C. Murdock, Michael A. Jones, Joe E. Toler, and Ryan F. Graham, Clemson University

2001 Three field experiments were established in 2001 to evaluate crop tolerance and weed control with Liberty in glufosinate-tolerant cotton. Plots were 2 to 4 rows, 20 ft long, and were arranged in a randomized complete block design with 3 replications. Plot size was relatively small because only 4 lb of the transgenic seed were allocated for South Carolina.

No crop injury or effects on reproductive development were observed even with 3 postemergence (POST) applications of Liberty. Lint yields could not be obtained since EPA regulations required crop destruction prior to maturity.

In Expt.5C01, two POST applications of Liberty controlled Palmer amaranth, morningglory, sicklepod, yellow nutsedge, southern crabgrass, and Florida pusley 90,97,99,67,58, and 12%, respectively. When preceded by PPI/PRE applications of Treflan,Cotoran,Treflan followed by (fb) Cotoran,Treflan fb Reflex or Treflan fb Reflex + Cotoran, two POST applications of Liberty provided 95 to 100% control of Palmer amaranth, sicklepod, and morningglory. These sequential treatments controlled Florida pusley 93 to 100%, and provided complete southern crabgrass control. Yellow nutsedge control with Treflan fb two or three Liberty applications was 68 to 78%. Other sequential treatments provided 96 to 100% control of yellow nutsedge.

In Expts.F6C01 and F7C01, two POST applications of Liberty controlled southern crabgrass, sicklepod, Florida beggarweed, and morningglory 93 to 100%. When preceded by the same soil-applied treatments used in Expt. 5C01, these weed species were controlled 94 to 100%.

2002 Crop tolerance and weed control in glufosinate-tolerant cotton were evaluated in four field trials established at the Pee Dee Research and Education Center, Florence, SC, and at an on-farm site in Horry County, SC. No crop injury was observed with up to three applications of Liberty. In Horry County, one application of Liberty at 24- to 40-oz/ac applied postemergence (POST) to 4-leaf cotton and weeds that were 2- to 4-inches tall controlled entireleaf morningglory, sicklepod, Florida beggarweed, and common lambsquarters 90 to 100% nine weeks after planting (WAP). Two POST applications of Liberty with and without a preemergence herbicide (Prowl, Cotoran, Prowl + Cotoran) provided 99 to 100% control of the broadleaf weeds present. The use of a PRE herbicide was not necessary to attain complete weed control. In Florence, Liberty was applied POST to 4-leaf cotton and to weeds that were 2- to 3-inches (southern crabgrass, sicklepod, entireleaf morningglory) and 4- to 6-inches (Palmer amaranth) tall. When evaluated 1 week after application, southern crabgrass control was 85 to 96% with a single application of Liberty at 24- to 40-oz/ac. However, most of the southern crabgrass exhibited rapid recovery and regrowth, and poor control (7 to 15%) was observed 16 WAP. Two POST applications of Liberty at 32 oz/ac controlled southern crabgrass 99% 8 WAP, but control dropped to 72% 16 WAP. However, PRE applications of Prowl (2.4 pt/ac), Cotoran (1.25 qt/ac), or Prowl + Cotoran (2.4 pt + 1.25 qt/ac) followed by two POST applications of Liberty controlled southern crabgrass 100%. Palmer amaranth control with a single POST application of Liberty at 24- to 40-oz/ac was generally inadequate and ranged from 47 to 77% 13 WAP. However, when Liberty was applied early–POST followed by mid-POST and a PRE herbicide was used, Palmer amaranth control was excellent (96 to 100%). One POST application of Liberty controlled sicklepod and entireleaf morningglory 83 to 97% and 67 to 97%, respectively. Two POST applications of Liberty with and without a PRE herbicide controlled sicklepod 93 to 100% and entireleaf morningglory 97 to 100% 16 WAP.

NOTE: South Carolina was declared in an extreme-to-severe drought throughout most of the 2002 growing season. Subsequently, there was little or no weed emergence following the early-POST herbicide applications.

Evaluation of Tank-Mix Partners with Roundup Ultra

South Carolina Cotton Board Grant (2001)
Awarded To: Edward C. Murdock, Clemson University

A field trail was established in 2001 at the Pee Dee Research and Education Center to evaluate the additive effects of residual tank-mix partners on weed control and lint yield in Roundup Ready cotton. 'Stoneville 4892 BR' cotton was planted May 24, 2001 at a seeding rate of 4.5 seed/row ft. Plots were four rows, 30 ft long, and were arranged in a randomized complete block design with three replications. No residual herbicides were applied prior to or at planting. The entire test (except the untreated check) received a postemergance (POST) application of Roundup Ultra @ 1qt/ac. POST-directed treatments were none, Roundup Ultra (1qt/ac) alone and tank-mixed with Caparol (1qt/ac), Firstrate (0.3oz/ac), Bladex (0.8qt/ac), Karmex (0.8qt/ac), Roundup Ultra + Goal (1qt + 1pt/ac), Rawhide (a prepackaged mixture of Roundup + Goal-1pt/ac), Staple (0.6oz/ac), and Cotoran (1qt/ac). All treatments (including one application of Roundup Ultra applied POST at the 4-leaf stage with no follow-up treatments) provided good to excellent (84 to 100%) control of Palmer amaranth and excellent (98 to 100%) control of sicklepod and morningglory. The lint yield for the untreated check was 335 lb/ac. Lint yields for all other treatments were similar, and ranged from 495 to 625 lb/ac.

In some fields (and years) Roundup Ultra alone can provide adequate season-long weed control. However, this is highly dependent upon the weed species present and their density, environmental conditions throughout the growing season, and correct timing and placement of herbicide treatments.

Comparison of One vs Two Early-Season Topical Applications of Glyphosate in Roundup Ready Cotton

South Carolina Cotton Board Grant (2002 to 2003)
Awarded To: Edward C. Murdock, Michael A. Jones, Charlie Curtis, Joe Toler, and Ryan Graham, Clemson University

OBJECTIVES:

a) Compare weed control, lint yield, and net profit with systems utilizing one vs. two early-season topical applications of glyphosate;

b) Determine the financial incentive (or disincentive) of using a residual soil-applied herbicide to replace at least one topical or POST-directed glyphosate application.

PROCEDURE:

A field experiment was conducted in 2003 to address the above objectives. The experiment was established on the Pee Dee REC, Florence, SC, in a field with moderate to heavy naturally occurring populations of southern crabgrass, goosegrass, Palmer amaranth, entireleaf morningglory, and sicklepod. Plots were four rows, 30 ft long, and were arranged in a randomized complete block design with four replications.

The row spacing was 38 inches. Treatment factors were PRE herbicide (none and Prowl + Cotoran @ 2.4 pt + 1.25 qt/ac) and glyphosate applications (one to four applications). All glyphosate applications were @ 0.75 lb ae/ac.

'Stoneville 4892 BR' cotton was planted May 1, 2003, at a rate of 4.5 seed/row ft. PRE herbicides were applied May 2, and glyphosate was applied May 20, May 30, June 10, June 20, and July 8, 2003. Crop injury and weed control were recorded 4, 7, 10, and 12 weeks after planting (WAP). Weed control 12 WAP was used for this summary. Cotton was harvested December 3, 2003, with a 2-row spindle picker. Seed cotton was ginned and lint yields were calculated assuming 40% gin turnout.

RESULTS:

Weed control 12 WAP with Prowl + Cotoran applied PRE, and with one and two early-season applications of glyphosate (POST 2-Leaf, POST 4-leaf, POST 2-leaf + POST 4-leaf) with and without a PRE herbicide was generally unsatisfactory . Several of these treatments provided good to excellent control of annual grasses, entireleaf morningglory, and sicklepod, but Palmer amaranth control was poor (23 to 49%). In contrast, weed control with three and four applications of glyphosate with and without the PRE treatment was excellent (95 to 100%) for all weed species present.

Lint yields and net profit above weed management costs generally reflected the observed levels of weed control. Lint yield and net profit with Prowl + Cotoran alone were 168 lb/ac and $90.34/ac, respectively. Average lint yield and net profit with a single glyphosate application at the 2-leaf stage with and without Prowl + Cotoran was 268 lb/ac and $153.67/ac, respectively. Lint yield and net profit with one glyphosate application POST 4-leaf were 681 lb/ac and $431.87/ac. These were similar to the values obtained with three and four glyphosate applications. However, this was unexpected and was likely due to the location of these plots in the field.

This conclusion is supported by the relatively low lint yield and net profit attained with Prowl + Cotoran followed by glyphosate applied POST 4-leaf (341 lb/ac and $192.01/ac), two POST applications of glyphosate (413 lb/ac and $246.89/ac), and Prowl + Cororan followed by two POST applications of glyphosate (562 lb/ac and $324.87/ac).

Lint yields and net profit were similar with three and four glyphosate applicaitons with and without Prowl + Cotoran, and ranged from 696 to 839 lb/ac and $401.20 to $502.23, respectively. Greatest numerical net profit ($502.23/ac) achieved with four applications of glyphosate (POST 2-leaf, POST 4-leaf, POST-directed 8-leaf, and layby).

Weed Management Systems Utilizing Only Glyphosate for Season-Long Weed Control

South Carolina Cotton Board Grant (2002 to 2003)
South Carolina State Support Committee (2004)
Awarded To: Edward C. Murdock, Michael A. Jones, Joe Toler, Charlie Curtis, and Ryan Graham, Clemson University

A field trial was established in 2002, 2003, and 2004 at the Pee Dee Research and Education Center, Florence, SC, to evaluate weed management systems in Roundup Ready cotton. Plots were four rows, 30 ft.long, and were arranged in a randomized complete block design with three replications. Treatments evaluated were one application of glyphosate (POST 4-leaf cotton), 2 applications (POST 4-leaf, POST-directed 6-leaf), 3 applications (POST 4-leaf, layby), and four applications (POST 2-leaf, POST-4-leaf, POST-directed 6-leaf, layby). These treatments were also evaluated following a preemergence (PRE) application of Prowl @ 2.4 pt/ac, Cotoran @ 1 qt/ac, and Staple @ 0.6 02/ac).

2002 No cotton was produced in the untreated check Glyphosate applied POST 4-Leaf controlled southern crabgrass, Palmer amaranth, sicklepod, and entireleaf moringglory 70, 82, 47, and 50% 14 weeks after planting respectively. However, when two or more applications of glyophosate were made these weeds were controlled 95 to 100%. Lint yield with a single application of glyphosate was 111 lb/ac. With two or more applications, lint yields averaged 171 lb/ac. Prowl applied PRE controlled southern crabgrass 97%, but provided poor (0 to 10%) control of the other weeds present. Cotoran provided 88% control of southern crabgrass, but control of the other weeds was poor (10 to 52%). Staple provided poor (20 to 47%) control of all weeds present. Lint yields produced following a PRE application of Prowl, Cotoran, and Staple were 0, 80, and 148 lb/ac, respectively. When a PRE treatment was followed by glyphosate applied POST to 4-leaf cotton, southern crabgrass, Palmer amaranth, sicklepod, and entireleaf morningglory control averaged 95, 93, 88, and 86% respectively. When glyphosate was applied two or more times following a PRE herbicide, control of these weeds averaged 97 to 100%. Average lint yields for the single and multiple applications of glyphosate following a PRE herbicide were 170 and 232 16/ac, respectively.

2003 One application of glyphosate provided poor (25 to 45%) control of all weeds except sicklepod, which was controlled 93% failed to provide adequate weed control. This was reflected in low lint yields ranging from 46 to 111 lb/ac. Control of all weeds present with and without a PRE herbicide ranged from 96 to 100%. Averaged across number of glyphosate applications (2, 3, 4, and 5) lint yields with no PRE herbicide, Prowl, Cotoran, and Staple were 851, 901, 1046, and 862 lb/ac, respectively. When no PRE herbicide was used, lint yield with two and three glyphosate applications was 740 and 721 lb/ac, respectively. Lint yields with two and three applications of glyphosate averaged across PRE herbicides were 976 and 908 lb/ac, respectively. Lint yields with and without a PRE herbicide were similar with four and five glyphosate applications, and ranged from 913 to 998 lb/ac. Greatest net profit above weed management costs ($682.01/ac) was attained with Cotoran PRE followed by (fb) 2 applications of glyphosate. However, net profit with no PRE fb 4 and 5 applications of glyphosate; Prowl fb 2 and 5; Cotoran fb 3, 4, and 5: and Staple fb four and five applications of glyphosate were all similar to the top-ranked treatments. It is interesting to note that four of the top six treatments in terms of net profit above weed management costs included Cotoran PRE (Cotoran fb two, three, four, and five applications of glyphosate). Four and five applications of glyphosate with no PRE herbicide ranked fifth and eighth out of the 24 treatments in terms of net profit.

2004 Southern crabgrass and goosegrass were controlled 100, 51, and 70% 12 weeks after planting (WAP) with PRE applications of Prowl, Cotoran, and Staple, respectively. Roundup Weathermax applied once at the cotton 4-leaf stage controlled annual grasses 71%. PRE herbicides alone provided poor (0 to 21%) control of Palmer amaranth. One Roundup Weathermax application controlled Palmer amaranth 70%. Prowl did not control sicklepod or entireleaf morningglory. Cotoran and Staple applied PRE controlled these weeds 93 to 95%. One Roundup Weathermax application provided 96% control of sicklepod, but controlled entireleaf morningglory only 49%. Annual grasses were controlled 99 to 100% 12 WAP with Prowl and Cotoran followed by (fb) one application of Roundup Weathermax. Control of annual grasses with Staple fb one Roundup Weathermax application was 49%. Palmer amaranth, sicklepod, and entireleaf morningglory were controlled 89 to 99, 99 to 100, and 76 to 99% with one Roundup Weathermax application preceded by a PRE herbicide, respectively. Averaged across two to five Roundup Weathermax applications, Roundup Weathermax alone and preceded by a PRE herbicide provided 94 to 100% control of all weeds present. Averaged across PRE herbicides, two Roundup Weathermax applications provided 91 to 100% weed control. Complete (100%) weed controlled was attained with three or more Roundup Weathermax applications alone or following a PRE herbicide. PRE herbicides alone failed to provide adequate weed control. This was reflected in low lint yields ranging from 553 to 643 lb/ac. Lint yield with one Roundup Weathermax application was 998 lb/ac. Lints yields with two or more Roundup Weathermax applications alone or following a PRE herbicide were similar and ranged from 1224 to 1450 lb/ac. Net profit above weed management costs exceeded $900/ac with Staple fb two Roundup Weathermax applications, three applications of Roundup Weathermax with no PRE herbicide, and Prowl fb four Roundup Weathermax applications. The top 25% (ranked 1 to 6) of the 24 treatments evaluated included four treatments that had a PRE herbicide. The remaining two treatments were three and four applications of Roundup Weathermax alone. The top 50% (ranked 1 to 12) included eight treatments that had a PRE herbicide and four treatments that did not include a soil-applied herbicide.

Response of Round Ready and Conventional Cotton Cultivars to Tillage and Weed Control Systems

South Carolina State Support Grant (2002 to 2003)
Awarded To: Michael A. Jones and Edward C. Murdock, Clemson University

Declining profit margins have caused South Carolina cotton producers to consider conservation-tillage systems as a means of reducing production inputs. Although there are a large number of these systems employed by cotton producers throughout the cotton belt, three common systems practiced in South Carolina are strip-till, stale-seedbed, and no-till. All of these systems substitute herbicides for tillage operations to manage weeds prior to planting cotton. The objectives of this study were to evaluate the response of Roundup Ready and conventional varieties to reduced-tillage systems (no-till, strip-till, and stale-seedbed); to determine the effectiveness of Roundup only weed control programs compared to conventional herbicide programs in these systems, and to assess the effect of these production systems on cotton growth, maturity, lint quantity/quality, and net profits. An irrigated field experiment was conducted at the Pee Dee Research & Education Center in Florence, SC, during the 2002 and 2003 growing seasons. Four tillage systems (conventional-till, no-till, strip-till, and stale-seedbed) were evaluated. These tillage systems were established in the fall of 2001. Five planting systems consisting of a variety x herbicide program combination were planted in four 38-inch rows that were 40 ft. long. The five planting systems consisted of a conventional variety grown without herbicides, a conventional variety grown under a standard conventional herbicide program (Prowl applied preplant incorporated, Cotoran+Staple applied preemergence, and Caparol+MSMA applied post-directed), a Roundup Ready7 variety (the transgenic sibling of the conventional variety) grown without herbicides, a Roundup Ready7 variety grown under a standard conventional herbicide program (Prowl applied preplant incorporated; Cotoran+Staple applied preemergence; and Caparol+MSMA applied post-directed), and a Roundup Ready variety grown under a Roundup only herbicide program (over-the-top at 4 leaf; post-directed as needed). Treatments were arranged in a split plot design with four replications. Main plots consisted of the four tillage systems and subplots consisted of the five planting systems.

In general, differences in lint yield occurred among all variables evaluated. Averaged over years, varieties and tillage systems, lint yield was higher in conventional tillage (750 lbs/a) systems than in strip-till (601 lbs/a), stale-seedbed (563 lbs/a), and no-till (547 lbs/a) systems. In 2003, conventional tillage systems produced more lint (723 lbs/a) than the other three tillage systems (strip-till systems averaged 647 lbs/a, stale-seedbed systems averaged 510 lbs/a, and no-till plots averaged 353 lbs/a) evaluated. In 2002, lint yield was higher in no-till (741 lbs/a) and conventional tillage (723 lbs/a) systems than in stale-seedbed (606 lbs/a) and strip-till (555 lbs/a) systems. Fibermax 989RR produced 20 to 25% more lint yield than FM 989 (the recurrent parent). Hand-weeded plots produced more lint yield than either the Roundup only treatments or the standard herbicide system in 2002, with FM 989RR untreated plots producing 802 lbs/a, the standard herbicide system producing 666 lbs/a, and the Roundup only system producing 720 lbs/a. Few consistent differences in herbicide systems were found in 2003. In 2002, reduced plant stands occurred in the strip-till system, with plots averaging only 5 plants /m^2. No-till, conventional, and stale-seedbed treatments averaged 7, 8, and 8 plants /m^2, respectively. Differences in plant stand were apparently caused by poor soil-seed contact during the planting operation and significant seed/seedling losses after planting in the strip-till system due to problems with subsoil shank slit caving from heavy rains several days after planting. In 2003, plant stand was reduced in all treatments due to extremely wet and cool weather during germination and emergence (4.0 plants/m^2). Dry matter partitioning data collected at peak bloom (July 23rd) in 2002 showed differences in early-season reproductive development of plants occurred among tillage systems, herbicide systems, and varieties. No-till plants developed more early-season bolls (16 to 47%) and partitioned more of their dry weight into reproductive structures (ie. greater Reproductive:vegetative dry weight ratio or RVR) compared to plants grown in conventional, stale-seedbed, or strip-till systems. Plants in hand-weeded and Roundup only plots also had a slightly greater RVR than plants grown in standard herbicide systems, and FM 989RR produced more early season bolls than FM 989. Tillage or herbicide systems had little affect on flower development or fiber quality (micronaire, strength, uniformity and elongation); however, fiber length was reduced slightly with the stale-seedbed system (1.08 in.) compared to the other tillage systems (1.11 in.). Control of Palmer amaranth, morningglory spp., and southern crabgrass ten weeks after planting (WAP) ranged from 94 to 100% for all tillage systems (averaged across weed control systems). When averaged across tillage systems, Palmer amaranth, morningglory ssp., and southern crabgrass control was 93% and 99%, 100 and 100%, and 95 and 100% for the standard and Roundup only systems, respectively. Total weed biomass 16 WAP averaged across weed control systems was 215, 392, 739, and 819 lbs/a for the conventional-tillage, stale-seedbed, strip-till, and no-till systems, respectively. Averaged across tillage systems, the total weed biomass for the standard and Roundup only systems was 670 and 284 lbs/a, respectively.

Early Detection of Glyphosate-Resistant Weed Populations in South Carolina Cotton

South Carolina Cotton Board Grant (2003)
Awarded To: Edward C. Murdock, Michael A. Jones, and Ryan Graham, Clemson University

OBJECTIVES

a) To monitor and follow-up on reported weed control failures with glyphosate;
b) To detect glyphosate-resistant weed populations as early as possible;
c) If the presence of a glyphosate-resistant weed biotype is confirmed, to implement control strategies that would preclude seed production and subsequent buildup and spread of the problem.

PROCEDURE

Seven Birchmeier backpack sprayers were purchased and distributed to each of the Extension districts in South Carolina. A detailed memorandum explaining the project's objectives, what to look for, step-by-step procedures to follow when glyphosate resistance is suspected, and specific weed species considered most likely to develop resistance (Palmer amaranth, goosegrass, Italian Ryegrass) was sent to all Extension Agents with agricultural responsibilities. The memorandum was also sent to the district agents and appropriate administrators and Extension specialists in the College of Agriculture**.**

Contribution of Wild Radish to Cotton Stand Loss and Early-Season Development Programs

South Carolina Cotton Board Grant (2003)
Awarded To: Jason Norsworthy and Michael A. Jones, Clemson University

Wild radish biomass was harvested at biweekly intervals over a 4 week period beginning March 28, 2003. Biomass production increased between the first and second harvest, whereas a small decline was noted at the third harvest as wild radish began to mature (Table 1). Nine glucosinolates were identified in roots and shoots of wild radish (data not shown). Production of these glucosinolates was greater in shoots than roots, with glucosinolate production in both plant parts increasing over time. Interestingly, the glucosinolates produced in the root tissue was often different from ones in the shoots. If the trend in increased glucosinolate production were to continue through early to mid-

May, the effect of the allelochemicals on cotton growth and development would likely be more pronounced.

Table 1. Wild radish biomass, glucosinolate production in roots and shoots, and total glucosinolate production per ground area on various dates and growth stages prior to planting cotton.

Harvest date	Growth stage	Root	Shoot	Total	Root	Shoot	Total
		——— g/m^2 ———			— µmol/g —		$\mu mol/m^2$
March 28	Full bloom	73	215	288	1.69	4.96	1191
April 10	Early podfill	92	266	358	1.74	9.19	2605
April 23	Late podfill	81	253	334	11.63	32.16	8494

Roundup WeatherMax with and without Harmony Extra was applied to test plots 1, 2, and 4 weeks before cotton planting. Visual control estimates at cotton planting revealed wild radish was easily controlled (96%) with Roundup alone (Table 2). Addition of Harmony Extra to Roundup provided minimal increase in control, regardless of application timing. Cutleaf eveningprimrose and Carolina geranium also infested the test site, thus control rating were recorded for these weeds. Control generally improved the earlier the application, and the addition of Harmony Extra to Roundup generally resulted in a marketable increase in control of both weeds, especially evident 2 and 4 weeks before planting.

Table 2. Weed control at cotton planting.

Treatment	Wild Radish	Cutleaf eveningprimrose	Carolina geranium
	——— % control ———		
Rdp 4 WBP	96	68	66
Rdp + Harmony Extra 4 WBP	100	83	93
Rdp 2 WBP	56	28	46
Rdp + Harmony Extra 2 WBP	61	43	60
Rdp 1 WBP	34	6	6
Rdp + Harmony Extra 1 WBP	45	16	15
LSD(0.05)	16	16	17

Abbreviations: Rdp, Roundup WeatherMax; WBP, weeks before planting

Cotton was planted on April 23 and the entire test area was immediately sprayed with paraquat. Due to excessive rainfall amounts shortly after planting much of the cotton rotted and the test had to be replanted on May 9. Therefore, all treatments were 2 weeks earlier than initially intended which is reflected in the below tables. Cotton root and shoot weight along with plant density was similar among treatments (Table 3). Differences among treatments occurred for total plant weight, but cotton plant weight in the non-treated treatment was similar to the weed-free control, indicating wild radish biomass had no effect on cotton, when controlled at least 2 weeks before planting.

Table 3. Root, shoot, total plant weight, and density of cotton 1 week after emergence.

	Root weight	Shoot weight	Plant weight	Density
Treatment	–––––––––––	g/2-m row	–––––––––––	plants/2-m row
Rdp 6 WBP	0.78	1.41	2.19	16
Rdp + Harmony Extra 6 WBP	0.81	1.77	2.58	15
Rdp 4 WBP	0.51	1.47	1.98	15
Rdp + Harmony Extra 4 WBP	0.62	1.42	2.04	17
Rdp 3 WBP	0.65	1.83	2.48	18
Rdp + Harmony Extra 3 WBP	0.71	1.54	2.25	16
Non-treated	0.59	1.30	1.89	13
Weed-free	0.58	1.36	1.94	16
LSD(0.05)	NS	NS	0.80	NS

Abbreviations: Rdp, Roundup WeatherMax; WBP, weeks before planting

Similarly at 4 weeks after cotton emergence no differences were noted in cotton root, shoot, or total plant weight or density (Table 4). Additionally, cotton leaf area and visual injury was similar among treatments along with seed cotton yield. Although never significant, it is interesting that the non-treated treatment (paraquat applied 2 weeks before cotton planting) generally produced the lowest numerical amount of cotton biomass, density, and seed cotton yield. In similar studies in Georgia in 2003, Stanley Culpepper found no differences in root and shoot weights among treatments, but did observe unhealthy plants in plots planted immediately or 1 week after the burndown treatments. At 4 weeks after cotton emergence, stands were negatively impacted when treatments were applied 1 week before planting or at planting compared to the weed-free control. However, this stand reduction did not translate in to reduced yields.

Table 4. Root, shoot, total plant weight, and density of cotton 4 weeks after emergence.

	Cotton root weight	Cotton shoot weight	Cotton total plant weight	Cotton density
Treatment	–––––––––––	g/2-m row	–––––––––––	plants/2-m row
Rdp 6 WBP	2.2	14.7	16.9	15
Rdp + Harmony Extra 6 WBP	2.0	18.9	21.9	16
Rdp 4 WBP	2.0	16.5	18.5	17
Rdp + Harmony Extra 4 WBP	2.1	15.3	17.4	12
Rdp 3 WBP	2.2	17.5	19.7	16
Rdp + Harmony Extra 3 WBP	1.7	14.7	16.4	13
Non-treated	1.9	13.0	14.9	13
Weed-free	2.2	14.5	17.7	15
LSD(0.05)	NS	NS	NS	NS

Table 5. Cotton leaf area and visual injury 4 weeks after emergence and end-of-season seed cotton yield.

	Cotton	Cotton	Seed

Treatment	leaf area cm²	Injury %	cotton yield lb/acre
Rdp 6 WBP	1750	15	2210
Rdp + Harmony Extra 6 WBP	1670	8	2050
Rdp 4 WBP	1900	3	2290
Rdp + Harmony Extra 4 WBP	1680	13	2090
Rdp 3 WBP	1900	6	2140
Rdp + Harmony Extra 3 WBP	1560	14	2300
Non-treated	1470	9	1630
Weed-free	1450	---	2360
LSD(0.05)	NS	NS	NS

Weed Management Systems in Roundup Ready Flex Cotton

South Carolina State Support Committee Grant (2004)
Awarded To: Michael A. Jones, Edward C. Murdock, Joe Toler, and Ryan Graham, Clemson University

OBJECTIVES: a) Evaluate crop injury and weed control with selected weed management systems in Roundup Ready Flex cotton;

b) Determine yield reductions due to early-season weed interference associated with delayed glyphosate applications;

c) Compare lint yields, weed management costs, and net profit for each weed management system.

MATERIALS AND METHODS

Roundup Ready Flex cotton (Monsanto Event MON88913) was planted June 1, 2004, at a seeding rate of 3.25 seed/ft. The relatively late planting date and lower seeding rate were due to an initial planting on May 10 that failed to attain an adequate plant population. Plots were four rows, 30 ft long, and were arranged in a randomized complete block design with three replications.

The center two rows of each plot were harvested with a spindle picker November 11, 2004. Lint yields were calculated assuming 40% gin turnout.

Expt. 5C04-Weed management systems-Roundup Ready Flex cotton.

Roundup Weathermax was applied postemergence @ 22 oz/ac to facilitate evaluations of single and multiple applications. Treatments evaluated included single applications at the 4-, 6-, 8-, 10-, and 12-leaf cotton growth stages; two applications (4- and 8-leaf, 4- and 10-leaf, 4- and 12-leaf, 6- and 10-leaf, 6- and 12-leaf, 8- and 12-leaf; three applications

(4-, 8- and 12-leaf), four applications (4-, 6-, 8-, and 10-leaf; 4-, 6-, 8- and 12-leaf; 4-, 8-, 10-, and 12-leaf); and five applications (4-, 6-, 8-, 10-, and 12-leaf).

RESULTS:

Southern crabgrass and goosegrass were controlled 88 to 100% 12 weeks after planting (WAP) with single applications of Roundup Weathermax (Table 1). Palmer amaranth was controlled 100% with a single application the 4- and 6-leaf cotton growth stage. However, single applications at the 8-, 10-, and 12-leaf stage provided 82 to 87% control. Sicklepod was controlled 97 to 100% with one application at the 4- or 6-leaf stage, and 81% with a single application at the 8-leaf stage. Poor (57 to 60%) control was observed with later applications. Control of pitted morningglory was poor 10 to 47% when one Roundup Weathermax application was made to 4-, 10-, and 12-leaf cotton. One application at the 6- and 8-leaf stage controlled pitted morningglory 90 and 72%, respectively. Lint yields ranged from 1033 to 1389 lb/ac and were similar for single Roundup Weathermax treatments applied to 4-, 6-, 8- and 10-leaf cotton. Greatest lint yield was produced when a single application was made to 6-leaf cotton; lowest lint yield occurred when the single application was delayed until cotton reached the 12-leaf stage. When application was delayed until cotton was in the 12-leaf stage the lint yield was 605 lb/ac. Two Roundup Weathermax applications controlled all weeds 87 to 100% 12 WAP. Three or more applications of Roundup Weathermax provided 99 to 100% control of all weeds present. Lint yields ranged from 1134 to 1334 with two or more Roundup Weathermax applications, and were similar for all multiple applications. They were also similar to the lint yields observed with single applications to 4-, 6-, 8-, and 10-leaf cotton.

Expt. 4C04. Early-season weed interference-Roundup Ready Flex cotton.

Roundup Weathermax@ 22 oz/ac was applied initially to 2-, 4-, 6-, 8-, and 10-leaf cotton. Following the initial application all plots (except the untreated check) were maintained weed-free with additional applications of Roundup Weathermax and handweeding.

RESULTS:

No crop injury was observed. Weed control 12 weeks after planting was essentially complete (98 to 100%) for all weed species present. When the initial application was made at the 2-leaf cotton growth stage the lint yield was 1343 lb/ac. If the initial application was delayed until cotton reached the 4- and 6-leaf stage, lint yields were 1211 and 1238 lb/ac, respectively (average reduction of 9% compared to the 2-leaf application). When the initial application was delayed until cotton reached the 8- or 10-leaf stage, lint yields were 1023 and 1057 lb/ac, respectively (average reduction of 23% compared to the 2-leaf application).

Effect of Palmer Amaranth Stage Growth Stage on Control with Envoke and Liberty

South Carolina State Support Grant (2004)
Awarded To: Michael A. Jones, Edward C. Murdock, Joe Toler, and Ryan Graham, Clemson University

OBJECTIVES: a) Determine the optimum/maximum Palmer amaranth stage of growth that will ensure excellent/acceptable control with Envoke and Ignite;

b) Evaluate the efficacy of Envoke and Ignite on the most troublesome weeds in South Carolina cotton;

Compare net profit (above weed management costs) with weeds management systems using Envoke, Ignite, and/or glyphosate.

MATERIALS AND METHODS:

"Deltapine 555 BG/RR" and "Fibermax 958 LL" cotton were planted May 5, 2004, at a seeding rate of 4.5 seed/ft. Plots were four rows, 30 ft long, and were arranged in a randomized complete block design with four replications. Treatments evaluated were postemergence applications of Envoke @ 0.1 and 0.15 oz/ac, Ignite @ 32 oz/ac, and Roundup Weathermax @ 22 oz/ac. Nonionic surfactant (Induce) was included with the Envoke treatments @ 0.25% v/v. These four treatments were applied when Palmer amaranth seedlings reached 1-, 2-, 3-, 4; 5-, and 6- inches in height. Palmer amaranth control was evaluated 7 days after each application. In addition, all treatments were evaluated 4 weeks after planting (WAP). A salvage application of Roundup Weathermax was applied June 5, 2004 (31 days after planting) to plots where Roundup Ready cotton was planted (Envoke and Roundup Weathermax treatments). Ignite was applied @ 32 oz/ac as a salvage treatment to plots where Liberty Link cotton was planted (Ignite treatments). Palmer amaranth control was evaluated 2 weeks after the salvage treatments were applied. The center two rows of each plot were harvested with a spindle picker November 3, 2004. Lint yields were calculated assuming 40% gin turnout. Crop value was calculated assuming a cotton price of $0.55/lb. Herbicide costs (including cost of application) were subtracted from the crop value to determine net profit above weed management costs.

RESULTS:

Palmer amaranth was controlled 91% one week after application when Envoke @ 0.1 oz/ac was applied to 1-inch seedlings. However, poor (50 to 53%) control of 2- and 3-inch Palmer amaranth was observed and 4- to 6-inch seedlings were controlled only 9 to 28%. Envoke @ 0.15 oz/ac controlled 1-inch Palmer amaranth 94% 1 week after application; 2- and 3-inch weeds were controlled 61 to 66%. Palmer amaranth that was 4 to 6 inches tall was controlled 11 to 25%. Envoke generally provided unacceptable

Palmer amaranth control 4 WAP. However, Envoke @ 0.15 oz/ac did control 1-inch seedlings 80%. Ignite controlled 1-, 3-, and 4-inch Palmer amaranth 99 to 100% one week after application. However, 2- and 5-inch seedlings were controlled only 39 to 56%. Six-inch weeds were controlled 70%. Control 4 WAP was excellent (90 to 92%) when Ignite was applied to 3- and 4-inch weeds. Palmer amaranth control was poor (31 to 54%) when Ignite was applied to 1-, 2-, and 5- inch weeds. Six-inch seedlings were controlled 70%. Roundup Weathermax controlled 1- to 6-inch Palmer amaranth 96 to 100% one week after application. However, control 4 WAP was poor (54 to 55%) when Roundup Weathermax was applied to 1- and 2-inch weeds indicating a lack of residual control. Palmer amaranth was controlled 92 to 99% 4 WAP when Roundup Weathermax was applied to weeds that were 3- to 6-inches tall. Excellent control was observed 1 week after application for several treatments, but control was poor to marginal 4 WAP. This was generally attributed to new weed emergence after the initial application. Palmer amaranth control 2 weeks after salvage applications of Roundup Weathermax was excellent (95 to 100%). Salvage application of Ignite following an initial application to 1-, 3-, 4-, and 6-inch weeds provided 93 to 99 % control. However, when Ignite was initially applied to 2- and 5-inch weeds, the salvage application of Ignite provided only 63 to 65% control. Averaged across Palmer amaranth growth stages (and following the salvage application of Roundup Weathermax), Deltapine 555 BG/RR cotton yielded 1344 lb lint/ac. Averaged across weed growth stages (and following the salvage application of Ignite) Fibermax 958 LL averaged 911 lb lint/ac. Lint yields were especially low (354 to 355 lb/ac) when Ignite was initially applied to 2-and 5- inch Palmer amaranth. Lint yields and net profit following postemergence applications of Envoke to 1- to 5-inch Palmer amaranth were similar. However, lint yields and net profit were generally lower (even with the salvage application of Roundup Weathermax) when Envoke applications were delayed until the weeds were 6-inches tall. Lint yields and net profit with Ignite were generally lower than those attained with Envoke and Roundup Weathermax, and were lowest when Ignite was applied to 2- and 5-inch Palmer amaranth. Lint yields and net profit were generally similar when Roundup Weathermax was applied early-postemergence, however, they were lower with the 4-inch application compared to applications made to 1- and 3-inch weeds. Averaged across Palmer amaranth growth stages, average lint yields with Envoke (0.1 oz/ac), Envoke (0.15 oz/ac), Ignite, and Roundup Weathermax were 1377, 1326, 911, and 1330 lb/ac, respectively.