

A COMPARATIVE AGRONOMIC ANALYSIS OF SUBSURFACE DRIP  
IRRIGATION AND OVERHEAD IRRIGATION IN GEORGIA COTTON

by

JARED WHITAKER

(Under the Direction of Craig Bednarz)

ABSTRACT

This study was conducted to investigate agronomic effects of subsurface drip irrigation (SSD) in comparison to overhead irrigation in Georgia, such as maturity, lint yield and components, fiber quality, soil moisture, and water use. Studies were located at two Southwest Georgia locations in 2004 and 2005. Treatments included overhead irrigation, dryland, subsurface drip matched to overhead (SSD-matched), and subsurface drip based on soil moisture (SSD-fed). The SSD-fed treatment matured quicker than the overhead treatment. Lint yield from SSD was comparable to overhead irrigation in all environments, with yield distribution trending lower on the plant in the SSD treatments than the overhead treatment. SSD provided adequate soil moisture control while saving water when compared to overhead irrigation. Fiber quality data showed no difference between irrigation treatments. We conclude SSD irrigation provides the same positive effects as overhead irrigation while reducing water use, shifting yield distribution, and increasing maturity rate.

INDEX WORDS: Cotton, Subsurface Drip, Irrigation, Water Use, Soil Moisture, Yield, Yield Distribution, Maturity

A COMPARATIVE AGRONOMIC ANALYSIS OF SUBSURFACE DRIP  
IRRIGATION AND OVERHEAD IRRIGATION IN GEORGIA COTTON

by

JARED WHITAKER

B.S. in Biology, Georgia Southern University, 2000-2004

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial  
Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE

ATHENS, GEORGIA

2006

© 2006

Jared Whitaker

All Rights Reserved

A COMPARATIVE AGRONOMIC ANALYSIS OF SUBSURFACE DRIP  
IRRIGATION AND OVERHEAD IRRIGATION IN GEORGIA COTTON

by

JARED WHITAKER

Major Professor: Craig Bednarz

Committee: Jim Hook  
Marshall Lamb

Electronic Version Approved:

Maureen Grasso  
Dean of the Graduate School  
The University of Georgia  
May 2006

## ACKNOWLEDGEMENTS

There are many people I would like to thank for support during my time at the University of Georgia. First, my sincere thanks to my family, for supporting in every way throughout my life, without them I would have never gotten this far. I am very thankful to Shellie, for putting up with me, being so supportive, and listening to my endless talk about cotton. I would like to thank Jay Holder for getting me interested in the field of agriculture, for a great job, and for helping me realize what I wanted to do in life. My sincere thanks to Dr. Bednarz for giving me this wonderful opportunity and for his unconditional support. Sincere thanks to Dr. Hook and Dr. Lamb for their constructive criticism and for serving on my committee. I am especially thankful for my fellow graduate students who have become friends I will have forever, Glen, for his continual help and friendship throughout the whole process and for his opinion on everything, Cory for his friendship and comradeship (also for help in understanding Glen), and Rob for his never-ending knowledge. I would also like to thank everyone else who helped me during my time at the University of Georgia, Lola Sexton, Rad Yager, Sidney Cromer, Ivey Griner, and Ben Mullinix. I would like to thank Cotton Incorporated and Ed Barnes for their generous financial support. Without the help of everyone I mentioned and even those I forgot, my success would not be possible.

## TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS .....	iv
LIST OF TABLES .....	vii
LIST OF FIGURES .....	x
CHAPTER	
1 INTRODUCTION .....	1
OVERVIEW .....	1
LITERATURE REVIEW .....	2
Advantages of overhead cotton irrigation .....	2
Losses associated with overhead irrigation .....	4
Adverse effects from overhead sprinkler irrigation to cotton .....	6
Subsurface drip irrigation in other crops .....	7
Previous studies of subsurface drip irrigation of cotton .....	7
Objectives and Hypotheses .....	8
Literature Cited .....	9
2 MATERIALS AND METHODS .....	12
Cultural Practices .....	12
Treatments .....	12
Defoliation .....	14
Soil Moisture Monitoring .....	15
Maturity .....	16
Yield data .....	16

Statistical Analysis.....	16
3 RESULTS AND DISCUSSION .....	18
Applied Water Use .....	18
Soil moisture.....	19
Maturity .....	23
Lint Yield and Gin Turnout.....	25
Seed Cotton Weight.....	26
Percentage of Total Weight.....	26
Percentage of Total 1st Sympodial Position Seed Cotton Weight .....	28
Percentage of Total Boll Number.....	28
Percentage of Total 1 <sup>st</sup> Sympodial Position Boll Number .....	29
Average Boll Weight.....	30
Model of Accumulated Weight .....	30
Fiber Quality .....	32
Literature Cited.....	33
4 CONCLUSIONS.....	66

## LIST OF TABLES

	Page
Table 1: Total irrigation water applied (cm) over all locations and water savings (cm) from the SSD fed irrigation treatment .....	35
Table 2: Nutrient levels in the petiole of uppermost mature leaf from cotton plants at the Lang Farm, Tifton, GA 91 DAP.....	36
Table 3: Lint yield (kg ha <sup>-1</sup> ) and Gin Turnout (%) at all locations .....	37
Table 4: Seed cotton weight (g m <sup>-1</sup> ) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2004.....	38
Table 5: Seed cotton weight (g m <sup>-1</sup> ) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005 .....	39
Table 6: Seed cotton weight (g m <sup>-1</sup> ) at time of harvest at the Lang Farm, Tifton, GA in 2005 .....	40
Table 7: Percentage of total seed cotton weight at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2004 .....	41
Table 8: Percentage of total seed cotton weight at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005 .....	42
Table 9: Percentage of total seed cotton weight at time of harvest at the Lang Farm, Tifton, GA in 2005.....	43
Table 10: Percentage of total boll number (m <sup>-2</sup> ) at each main-stem node and sympodial position at time of harvest at the C.M. Stripling Irrigation Research Park, Camilla, GA in 2004 .....	44

Table 11: Percentage of total boll number ( $m^{-2}$ ) at each main-stem node and sympodial position at time of harvest at the C.M. Stripling Irrigation Research Park, Camilla, GA in 2005 .....	45
Table 12: Percentage of total boll number ( $m^{-2}$ ) at each main-stem node and sympodial position at time of harvest at the Lang Farm, Tifton, GA in 2005 .....	46
Table 13: Average boll weight (g) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2004 .....	47
Table 14: Average boll weight (g) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005 .....	48
Table 15: Average boll weight (g) at time of harvest at the Lang Farm, Tifton, GA in 2005 .....	49
Table 16: Statistical analysis of intercept and linear, quadratic, and cubic functions from Figure 9 from 20, 24, and 22 DAF for the SIRP '04, SIRP '05, and Lang '05 locations, respectively.....	50
Table 17: Fiber quality measurements by high volume instrument (HVI) fiber micronaire, strength, color, length, length uniformity, area percent, and short fiber content at the C. M. Stripling Irrigation Park in 2004 .....	51
Table 18: Fiber quality measurements by high volume instrument (HVI) fiber micronaire, strength, color, length, length uniformity, area percent, and short fiber content at the C. M. Stripling Irrigation Park in 2005 .....	52

Table 19: Fiber quality measurements by high volume instrument (HVI) fiber micronaire, strength, color, length, length uniformity, area percent, and short fiber content at the Lang Farm, Tifton, GA in 2005 .....	53
Table 20: Advanced fiber information system (AFIS) fiber length by weight [L(w)], length by weight coefficient of variation [L(w)CV], upper quartile length by weight [UQL(w)], short fiber content [SFC(w)], fineness (Fine), and maturity ratio at the C. M. Stripling Irrigation Park in 2004 .....	54
Table 21: Advanced fiber information system (AFIS) fiber length by weight [L(w)], length by weight coefficient of variation [L(w)CV], upper quartile length by weight [UQL(w)], short fiber content [SFC(w)], fineness (Fine), and maturity ratio at the C. M. Stripling Irrigation Park in 2005 .....	55
Table 22: Advanced fiber information system (AFIS) fiber length by weight [L(w)], length by weight coefficient of variation [L(w)CV], upper quartile length by weight [UQL(w)], short fiber content [SFC(w)], fineness (Fine), and maturity ratio at the Lang Farm, Tifton, GA in 2005 .....	56

## LIST OF FIGURES

	Page
Figure 1: Soil tension (-kPa) measurements from the SIRP '04 location. Bottom graph represents total accumulated water (cm) from precipitation and irrigation .....	57
Figure 2: Soil tension (-kPa) measurements from the SIRP '05 location. Bottom graph represents total accumulated water (cm) from precipitation and irrigation .....	58
Figure 3: Relative soil water content measurements (%) in the SSD fed treatment from the SIRP '05 location.....	59
Figure 4: Soil tension (-kPa) measurements from the Lang '05 location. Bottom graph represents total accumulated water (cm) from precipitation and irrigation.....	60
Figure 5: Relative soil water content measurements (%) in the SSD fed treatment from the Lang '05 location. ....	61
Figure 6: Maturity measured as main-stem nodes above white flower (NAWF) at approximate cutout taken at 69, 79, and 72 DAP at the SIRP '04, SIRP '05, and Lang '05 locations respectively. ....	62
Figure 7: Percentage of total 1 <sup>st</sup> sympodial position seed cotton weight (g) at each main-stem node at time of harvest .....	63
Figure 8: Percentage of total 1 <sup>st</sup> sympodial position boll number by main-stem nodes at all locations at time of harvest .....	64

Figure 9: Model of percentage of accumulated yield total by days after flowering  
(DAF) assuming 2.5 days for vertical main-stem nodes and 3.8 days for  
horizontal sympodial fruiting positions.....65

# CHAPTER 1

## INTRODUCTION

### OVERVIEW

There are many positive effects from irrigation with overhead sprinkler systems. Overhead sprinkler irrigation of cotton in Georgia has to been shown to increase yields (Bednarz *et al.*, 2002; Bordovsky and Porter, 2003). Irrigation increases lint yield through increased boll production and decreased boll abortion and can alleviate drought and water deficit stress caused by high water demand from the cotton crop and lack of rainfall (Krieg and Sung, 1986). Other advantages of overhead sprinkler irrigation systems are that water can be applied to the crop in a timely matter and the system can be used with little supervision.

There are however, several disadvantages to the overhead irrigation systems. Water can be lost due to spray drift, evaporation from droplets falling in air. With an overhead sprinkler system, water is released from nozzles located above the crop and dispersed as droplets that fall to the crop. Through droplet evaporation, drift, runoff, and deep percolation, water can be lost rendering it unavailable for crop growth. With the properties of a Coastal Plain Soil, the problems of deep percolation become an increasingly important issue (Ocampo *et al.*, 2003).

Acreage under sprinkler irrigation has increased ten-fold since 1970 in the state of Georgia (Harrison and Hook, 2005). There are over 552,000 ha in Georgia watered by overhead sprinkler irrigation (Harrison, 2005). From the Apalachicola, Chattahoochee, and Flint River Basin area perspective, increased agricultural water use has become a major concern in recent years. Georgia's water resources are shared between the highly

populated areas of North Georgia and the Florida Panhandle and the intensely cropped areas of South Georgia and southeast Alabama. To better understand agricultural water use in Georgia, irrigation systems throughout the state have been monitored for the past several years. Water consumption from agriculture irrigation in Georgia in 2002 was 4.86 GL, and accounted for 42% of the total water use for the state (Georgia's Environment, 2003). The significance of the issue is highlighted by the fact that the Environmental Protection Agency of Georgia placed a moratorium on new agricultural-use irrigation well permits from the Floridian aquifer in southwest Georgia in November, 1999 and later in the Upper Floridian in the Coastal Zone in the summer of 2004.

Due to the issues surrounding agriculture water use and the inefficiencies associated with overhead, sprinkler irrigation, new methods of cotton crop irrigation are currently under investigation. Subsurface drip irrigation (SSD) is one such method. Subsurface drip irrigation has been successfully used in other crops in Georgia and elsewhere (Camp, 1998). It has many attributes such as more efficient water delivery and land utilization that make it a feasible irrigation strategy. This study investigated several agronomic effects of irrigation application method on cotton growth, development, and crop maturity, as well as lint yield and fiber quality. Soil moisture and irrigation application were monitored throughout the growing season.

## **LITERATURE REVIEW**

### **Advantages of overhead cotton irrigation**

Adequate soil moisture is necessary to maximize growth and yield of cotton. When rainfall cannot meet the crop's water requirement and maintain soil moisture,

moisture deficit stress will occur. Moisture deficit stress has many negative effects on cotton including reduced overall stature, leaf area index (LAI), and plant development, decreased boll retention and flowering, and ultimately decreased yields (Guinn and Mauney, 1984a; Guinn and Mauney, 1984b; Pettigrew, 2004). Pettigrew (2004) examined moisture deficit stress in a field experiment in the humid Southeastern United States. Cotton grown in non-irrigated, moisture deficit, situations developed several negative physiological effects compared to irrigated cotton. During moisture deficit stress, non-irrigated plants had reduced rate of leaf area expansion and ultimately smaller fully expanded leaves leading to a lower LAI. Non-irrigated leaves had 6% lower CO<sub>2</sub> exchange rates and 10% lower light-adapted photosystem II quantum efficiency than irrigated leaves on irrigated plants (Pettigrew, 2004). Krieg and Sung (1986) also reported decreased overall photosynthesis and translocation activity with increasing moisture deficit stress.

Cotton grown in Georgia requires about 46 cm of water to minimize water deficit stress and maximize yields (Bednarz *et al.*, 2002). Georgia receives an average of approximately 56 cm of rainfall from May 1-September 31 (Southeast Regional Climate Center, 2002). This rainfall, however, is not evenly distributed in time or space. This may result in episodic drought events during the growing season. Precipitation alone often does not meet the crops water requirement during the growing season and may not be synchronized with the crop's changing needs. The timing of the drought event is an underlying influence to the severity of the yield and quality effects from moisture deficit stress. Moisture deficit stress during flowering may result in higher yield losses than the same stress earlier or later in the maturity of the cotton plant.

## **Losses associated with overhead irrigation**

Along with the benefits of overhead irrigation, there are also several disadvantages of this type of system. Water application efficiency with these systems can be low, and in turn result in valuable irrigation water losses. These losses are associated with the delivery of water from the system to the crop. In an overhead sprinkler system water is released from nozzles above the crop. The irrigation water falls as droplets in patterns produced by the nozzle type and system operating pressure. Water may be lost through several paths before reaching the root zone including droplet evaporation, drift, runoff, and deep percolation.

Droplet evaporation has been found to result in significant water losses (Ocampo *et al.*, 2003). There are two types of evaporative losses that occur with overhead irrigation systems: above canopy spray evaporation losses and canopy evaporation. Above canopy spray evaporation loss is droplet evaporation that occurs in the time that water leaves the system and before it reaches the canopy. This time period can differ based on nozzle placement on the irrigation system. In overhead irrigation systems, above canopy spray evaporation loss is usually the major portion of the losses that can occur (McLean *et al.*, 2000). It has been reported that above canopy spray evaporation losses could reach 30% during highly unfavorable conditions (i.e., hot, dry, and windy) (Spurgeon *et al.*, 1983). Harrison (1993) reported that on average 17.2% losses in WAE from overhead sprinkler irrigation in South Georgia's humid environmental conditions.

When water falls from the overhead irrigation system the water has to pass through the canopy of the cotton crop to be utilized. In Kansas, losses from evaporation due to plant-intercepted water has been documented to be about 2-4% (Steiner *et al.*,

1983) This alone may result in a loss of approximately 603 liters of water for every cm per ha of irrigation water applied.

With overhead irrigation, a large amount of water is delivered to the soil in a small amount of time which is particularly true at the ends of center pivots. As water droplets reach the soil in large application rates, surface runoff may occur. Surface runoff occurs when irrigation or precipitation application rates exceed soil infiltration rates and water moves off the field completely (Ben-Hur and Assouline, 2002). Sloping land can result in increased rates of runoff.

Non-uniform irrigation applications can be a problem associated with overhead irrigation. This occurs when excess irrigation water accumulates in locations in the field, which may result in lower yield at those locations. The causes for this problem are due to package and sprinkler design, and may cause water to accumulate where it is not needed, such as off crop beds, down wheel tracks, and low spots in the field.

Excessive delivery of water to the soil may also cause the soil to become saturated and consequently percolate deep into the soil past the crop root zone. The soils of the Coastal Plain have a moderate to low water holding capacity and surface layers of 20 to 30 cm deep (Calhoun, 1983; Stoner, 1986). This low water holding capacity may result in severe water deficit stress during periods of low rainfall, but may also result in deep percolation during periods of excessive water delivery (Campbell *et al.*, 1974).

Water use efficiency (WUE) is a measure that is computed by dividing crop yield by the amount of irrigation water applied (Bordovsky and Porter, 2003). A study in Turkey examining WUE between irrigation systems found WUE's of 4.87, 3.87, and 2.36 kg ha<sup>-1</sup> mm<sup>-1</sup> for SSD, furrow, and sprinkler irrigation respectively in cotton (Cetin

and Bilgel, 2001). A study in Texas also investigated WUE for sprinkler, low energy precision application (LEPA), and SSD irrigation systems. Over a three year period with cotton, SSD increased WUE by an average of 30% over sprinkler and 16% over LEPA (Bordovsky and Porter, 2003). From these two studies there is evidence that SSD is more efficient than overhead sprinkler irrigation.

### **Adverse effects from overhead sprinkler irrigation to cotton**

Cotton pollen is very sensitive to water and can be destroyed when contact with water occurs. As the cotton plant flowers, pollen grains that come into contact with water may rupture and subsequently become sterile, reducing pollination of ovules and possibly causing fruit abortion (Lloyd, 1920). Burke (2003) conducted a greenhouse study to evaluate seed production in cotton bolls with water. Cotton flowers were exposed to 1 mL sprays of water using a hand-held spray bottle. With one spray, seed number per boll was reduced over 50% and with each sequential spray; seed number per boll was decreased further, eventually causing fruit abortion. In a field retention study conducted by Pennington and Pringle (1987), flowers were tagged before morning irrigation. From this study, it was found that sprinkler water applications reduced flower retention 65% compared to non-wetted flowers. In an irrigation system study performed in Turkey, the shedding ratio of SSD and furrow irrigation was lower than that of overhead irrigation (Cetin and Bilgel, 2001). Burke (2003) evaluated sprinkler irrigations at different time intervals to further examine Pennington and Pringle's (1987) study with morning irrigations. In this study, losses of fruit occurred most frequently in the 1200-1400 h irrigation, probably due to the corresponding time in which the flower is most open and

most vulnerable to water. Yield losses were 21% and 13% in 2000 and 2001 respectively with sprinkler irrigation compared to drag sock irrigation (Burke, 2003). These studies suggest that changes in irrigation placement may improve yield and/or fruit distribution.

### **Subsurface drip irrigation in other crops**

Subsurface drip irrigation (SSD) has been successfully used in agricultural crops for approximately 35 years, and has many attributes that make it a feasible irrigation strategy (Grabow *et al.*, 2002). SSD irrigation research has been conducted in over 30 crops. In most cases an equal or positive yield response to other irrigation technologies was reported. Also, many of those studies with SSD have documented reductions in applied water in comparison with other irrigation methods (Camp, 1998).

### **Previous studies of subsurface drip irrigation of cotton**

Subsurface drip irrigation in cotton has been successful in other regions and countries, leading to more evidence for potential success of the system in Georgia. A study was performed in Turkey comparing SSD, furrow, and sprinkler irrigation systems. SSD produced 21% higher yields than furrow irrigation and 30% higher than sprinkler irrigation (Cetin and Bilgel, 2001). Cetin and Bilgel (2001) also showed that drip irrigation produced 1570 kg ha<sup>-1</sup> more seed cotton yields with 509 mm less irrigation water and similar yields with 1045 mm less irrigation water. In Texas, SSD was compared to low energy precision application (LEPA) and spray irrigation for pre-plant irrigation levels and overall seasonal irrigation. In this experiment, SSD yielded better than LEPA and LEPA yielded better than spray (Bordovsky and Porter, 2003). In a

California study on sandy soils, cotton grown under SSD yielded as well as furrow irrigation and saved an average of 44.45 cm of irrigation water (Detar *et al.*, 1994).

Research has been conducted in the Southeastern Coastal Plain with drip irrigation. Surface drip has been used, yet proved economically unviable from a production standpoint because of the drawbacks of removing the system each cropping season (Camp *et al.*, 1997). But it is useful in research where it removes spray drift, droplet and leaf water evaporation, effects of pollen wetting, and possible runoff. Due to this fact, research has turned to subsurface drip irrigation as a more economically viable alternative. The high cost of installing drip tape every row has pushed for ways to find ways to decrease the cost of drip irrigation. A study was conducted examining lateral spacing of the drip tape: every row (1 m) and alternate row (2 m) in the Coastal Plain of Georgia. Camp *et al.* (1997) found no difference in cotton yields between alternate row tape and tape under every row. It has also been found that lateral spacing can be placed wider than 1 m and sufficiently supply water to a Coastal Plain soil (Bauer *et al.*, 1997; Camp *et al.*, 1997). Cotton yield and quality differences between SSD and overhead sprinkler irrigation have been assessed in Georgia and have produced comparable yields 2000 and 2001 between SSD and overhead sprinkler irrigation (Sorensen *et al.*, 2003).

### **Objectives and Hypotheses**

The objectives of this study were to investigate crop maturity, lint yield, yield distribution, and fiber quality under overhead, sprinkler, irrigation, subsurface drip irrigation, and dryland systems.

The hypotheses of this study are based on two comparisons: the overhead treatment compared to the SSD matched and compared to the SSD fed treatment. The comparison between the overhead and SSD matched treatments provided a way to compare the irrigation systems directly. The hypothesis for this comparison is that the SSD matched treatment will produce comparable yields with the overhead treatment and better maintain soil moisture. The qualities of the SSD irrigation system allowed for more frequent, smaller increment irrigations to the cotton crop over the growing season. The SSD fed treatment provided a comparison to the overhead treatment in both irrigation system and irrigation application timing. The hypothesis for this comparison is that the SSD fed treatment will save irrigation water compared to the overhead treatment, maintain soil moisture as effectively as the overhead treatment, affect maturity of the cotton crop, produce comparable yields with the overhead treatment, shift yield distribution, and ultimately, change fiber quality.

### **Literature Cited**

- Bauer, P.J., P.G. Hunt, and C.R. Camp. 1997. In-season evaluation of subsurface drip and nitrogen-application method for supplying nitrogen and water to cotton. *Journal of Cotton Science* 1:29-37.
- Bednarz, C., J. Hook, R. Yager, S. Cromer, D. Cook, and I. Griner. 2002. Cotton crop water use and irrigation scheduling p. 61-64, In A. S. Culpepper, et al., eds. *Cotton Research-Extension Report*
- Ben-Hur, M., and S. Assouline. 2002. Tillage effects on water and salt distribution in a vertisol during effluent irrigation and rainfall. *Agronomy Journal* 94:1295-1304.
- Bordovsky, J.P., and D. Porter. 2003. Cotton response to pre-plant irrigation level and irrigation capacity using spray, LEPA, and subsurface drip irrigation. 2003 ASAE Annual International Meeting, Las Vegas, NV:Paper No: 032008
- Burke, J.J. 2003. Sprinkler-induced flower losses and yield reductions in cotton (*Gossypium hirsutum* L.). *Agronomy Journal* 95:709-714.

- Calhoun, J.W. 1983. Soil Survey of Tift County Georgia. Soil Conservation Service. United States Department of Agriculture.
- Camp, C.R. 1998. Subsurface drip irrigation: a review. *ASAE* 41:1353-1367.
- Camp, C.R., P.J. Bauer, and P.G. Hunt. 1997. Subsurface drip irrigation lateral spacing and management for cotton in the southeastern coastal plain. *Transactions of the ASAE* 40:993-999.
- Campbell, R.B., D.C. Reicosky, and C.W. Doty. 1974. Physical properties and tillage of the Paleudits in the southeastern Coastal Plains. *Journal of Soil and Water Conservation* 29:200-224.
- Cetin, O., and L. Bilgel. 2001. Effects of different irrigation methods on shedding and yield of cotton. *Agricultural Water Management* 54:1-15.
- Detar, W.R., C.J. Phene, and D.A. Clark. 1994. Subsurface drip irrigation vs. furrow irrigation: 4 years of continuous cotton on sandy soil. Beltwide Cotton Conference, Memphis, TN. National Cotton Council:542-545.
- Georgia's Environment. 2003. Georgia Department of Natural Resources. [http://www.gaepd.org/Files\\_PDF/gaenviron/annualreport/gaenv02\\_03.pdf](http://www.gaepd.org/Files_PDF/gaenviron/annualreport/gaenv02_03.pdf)
- Grabow, G.L., R.L. Huffman, R.O. Evans, K.L. Edmisten, and D.L. Jordan. 2002. Subsurface drip irrigation research on commodity crops in North Carolina. 2002 ASAE Annual International Meeting, Chicago, Illinois:Paper No: 022290
- Guinn, G., and J.R. Mauney. 1984a. Fruiting of cotton. I. Effects of moisture status on flowering. *Agronomy Journal* 76:90-94.
- Guinn, G., and J.R. Mauney. 1984b. Fruiting of cotton. II. Effects of plant moisture status and active boll load on boll retention. *Agronomy Journal* 76:94-98.
- Harrison, K.A. 1993. Water application efficiency measurements for three sprinkler packages in Georgia. Annual Irrigation Meetings.
- Harrison, K.A. 2005. Irrigation Survey. The University of Georgia Cooperative Extension Service.
- Harrison, K.A., and J. Hook. 2005. Status of Georgia's irrigation system infrastructure. 2005 Georgia Water Resources Conference, University of Georgia Athens, GA
- Krieg, D.R., and J.F.M. Sung. 1986. Source-sink relations as affected by water stress during boll development, p. 73-79, In J. R. Mauney and J. M. Stewart, eds. *Cotton Physiology*, Vol. 1. The Cotton Foundation, Memphis, TN.
- Lloyd, F.E. 1920. Environmental changes and their effect upon boll-shedding in cotton (*Gossypium herbaceum*). *Ann. NY Acad. of Sci.* 29:1-131.

- McLean, R.K., R.S. Ranjan, and G. Klassen. 2000. Spray evaporative losses from sprinkler irrigation systems. *Canadian Agricultural Engineering* 42:1-15.
- Ocampo, L.R., D.L. Thomas, J.E. Hook, and K.A. Harrison. 2003. Comparative loss study of four different sprinkler packages on center pivot systems under south Georgia conditions. 2003 ASAE Annual International Meeting, Las Vegas, Nevada:Paper: 032013
- Pennington, D.A., and I. H. C. Pringle. 1987. Effect of sprinkler irrigation on open flowers. Beltwide Cotton Conference, Dallas, TX. National Cotton Council:69-71
- Pettigrew. 2004. Physiological consequences of moisture deficit stress in cotton. *Crop Science* 44:1265-1272.
- Sorensen, R.B., M.J. Bader, and E.H. Wilson. 2003. Cotton yield and grade response to nitrogen applied daily through a subsurface drip irrigation system. *ASAE* 20:13-16.
- Southeast Regional Climate Center. 2002. Georgia statewide monthly precipitation average 1895-2001 [Online]. [http://climate.engr.uga.edu/state/ga\\_precip.html](http://climate.engr.uga.edu/state/ga_precip.html).
- Spurgeon, W.E., T.L. Thompson, and J.R. Gilley. 1983. Irrigation management using hourly spray evaporative loss estimates. 1983 International Annual Meeting, St. Joseph, MI:Paper No: 83-2591
- Steiner, J.L., E.T. Kanemasu, and R.N. Clark. 1983. Spray losses and partitioning of water under a center pivot irrigation system. *Transactions of the ASAE* 26:1128-1134.
- Stoner, H.T. 1986. Soil Survey of Baker and Mitchell Counties. Soil Conservation Service. United States Department of Agriculture.

## CHAPTER 2

### MATERIALS AND METHODS

#### **Cultural Practices**

This study was conducted in 2004 and 2005 at the C.M. Stripling Irrigation Research Park in Mitchell County, GA (SIRP '04 and '05). The study was repeated in 2005 at the Coastal Plain Experiment Station (CPES) Lang Farm in Tift County, GA (Lang '05). The soil at the Mitchell County location is a Lucy loamy sand (loamy, kaolinitic, thermic, Arenic, Kandiuults) and the soil at the Tift County location is a Tifton loamy sand (Fine-loamy, kaolinitic, thermic, Plinthic Kandiuults).

Cotton, 'DeltaPine 488 BR,' was planted in all environments for a final plant density of 10.7 plants m<sup>-2</sup> on May 5, 2004, April 20, 2005, and May 15, 2005 for Lang '05, SIRP '04, and SIRP '05 respectively. At planting, 5.6 kg ha<sup>-1</sup> Aldicarb [2-methyl-2-(methylthio) propionaldehyde O-(methyl-carbamoyl)oxime] was applied in the seed furrow. Fertility, weed control, and insect monitoring and control were done in accordance with the University of Georgia Cooperative Extension Service Guidelines (Jost *et al.*, 2005). To ensure an equal stand among treatments, all plots were irrigated until emergence with an overhead irrigation system. This added 2.8, 0, and 3.45 cm of irrigation water to SIRP '04, SIRP '05 and Lang '05 respectively.

#### **Treatments**

Treatments were established before planting using a randomized complete block design with 4 treatments and 4 replications. Plots were 18 m long and 9 m wide with 9 m borders. Prior to planting, 2 of the treatments were designated as subsurface drip

treatments (SSD). In these 2 treatments, 5 lines of drip tape were installed 183 cm apart, 30 cm deep. At SIRP, SSD was installed prior to land preparation in 2004 and a system was built with permanently buried laterals for delivery and flushing. The treatment plots were retained in 2005. The tape that was used was 0.38 mm thick tape with 20 cm spaced emitters. Water volume was 3.56 L in a 30 m tape span, and the system was pressurized to 0.70 kg cm<sup>-2</sup>. The drip system in the Lang '05 location was set up after land preparation but before planting. Drip tape 0.51 mm thick with emitters spaced 30.48 cm apart was knifed into the soil at inter-row position. Water traveled through the system at 1.7 L in a 30 m span of tape. The pressure of the water in the system was 0.42 kg cm<sup>-2</sup>.

Both drip systems were calibrated to obtain similar application rates to equal approximately .38 cm hr<sup>-1</sup> over the entire area. Cotton was subsequently planted on rows .9 m apart, 45 cm away from the tape.

Four irrigation treatments were designated for the two irrigation systems and were as follows.

- Overhead Sprinkler Irrigation (Overhead)

2.54 cm of irrigation water was applied to this treatment when soil water suction was below -40 kPa at the 20 cm depth, and below -50 kPa at 40 cm depth with a linear overhead irrigation system equipped with spray rotations on drop tubes 2 m above the soil as now recommended for center pivots.

- Non-irrigated (Dryland)

This treatment did not receive irrigation at any time except for emergence.

- Subsurface drip irrigation matching overhead sprinkler irrigation application amount, depth, and day (SSD Matched)

- Subsurface drip irrigation based on crop use (SSD Fed)

Potentially multiple irrigations per day with SSD, irrigation cancelled when soil water potential was below irrigation trigger point.

The SSD fed treatment received water based on soil water content. In 2004, 0.76 - 1.5 cm of water was applied by the subsurface drip system to maintain soil moisture above the trigger point. Watermark ® soil water potential sensors Model, 30KTCD-NL (Irrometer Company Inc., Riverside, CA) were manually read once daily at this location. In 2005, an automated monitoring system was installed to optimize this treatment. A Field Manager ® computer system (Automata Inc., Nevada City, CA) was installed which triggered irrigations according to soil water status. The system queried AQUA-TEL-TDR ® (TDR) sensors (Automata Inc., Nevada City, CA), a time domain reflectometer sensor which measured dielectric constant, related to water content of the soil. The 45 cm, tube-shaped sensors were buried parallel to the row between the row of drip tape and the row of cotton, (23 cm from the cotton row) 25.4 cm deep in the field and read 3 times daily. The field manager monitored the TDR sensors and irrigated if needed in increments of 0.3 cm up to 3 times a day to keep soil water suction below the irrigation trigger of -40 kPa. Since the TDR sensors gave a measure dielectric constant in percent, the Field Manager was calibrated to irrigate at approximately -40 kPa using values of soil water potential observed by watermark sensors.

### **Defoliation**

In 2004, harvest aids were applied [2.3 L ha<sup>-1</sup> of ethephon, 2-chloroethylphosphonic acid, plus cyclanalide, 1-(2,4-dichloroanilincarbonyl)]

cyclopropanecarboxylic acid, and 0.7 kg ai ha<sup>-1</sup> of thidiazuron, 1-phenyl-3-(1,2,3-thiadiazol-5-yl)urea] when all treatments were at 90% open boll 127 DAP and the cotton was harvested at 141 DAP. Due to possible differences in maturity between irrigation treatments, harvest aids were applied in 2005 when each treatment reached 4 nodes above cracked boll (NACB). At SIRP '05 this occurred at the same time, and all irrigation treatments were defoliated at 140 DAP and harvested at 161 DAP. At Lang '05 treatments were defoliated at 122, 127, 127, and 129 DAP for the dryland, SSD Fed, SSD Matched, and overhead irrigation treatments respectively. All treatments were then harvested at 148 DAP. The later maturity of SIRP '05 as compared to Lang '05 may have been due to the fact that SIRP '05 was planted 26 days earlier and weather was unfavorable for seedling development during the time after SIRP '05's planting date.

### **Soil Moisture Monitoring**

In all of the locations soil moisture was monitored in 2 of the 4 replications of each treatment. Watermark Soil Moisture Sensors, Model 30KTCD-NL (Irrometer Company Inc., Riverside, CA) were used in this experiment. This sensor measured soil water suction. In all locations sensors were buried in the crop row at 20, 40, and 60 cm deep. These sensors were connected through interface units with Adcon telemetry equipment (Adcon Telemetry, Boca Raton, FL) that relayed observations to base-station computers. This equipment allowed for continuous monitoring throughout the season (frequency of 15 minutes). In the SIRP '04 and SIRP '05 locations, Watermark sensors were also installed between the crop rows that contained drip tape. These sensors were

installed 15, 60, and 91 cm deep and read daily throughout the season to evaluate soil water potential directly above and below the drip tape.

### **Maturity**

Cotton maturity was monitored throughout the season. For this measurement the number of main-stem nodes above the 1<sup>st</sup> square (NAFS) was recorded on 10 plants per plot weekly. Upon anthesis, main-stem nodes above the 1<sup>st</sup> flower (NAWF) was recorded on 10 plants per plot weekly. Plant height and the total number of main-stem nodes were also recorded in each plot until anthesis.

### **Yield Data**

At harvest, 3 m of row from one of the middle rows per plot were cut down at ground level and reserved for hand harvest. Hand harvesting by main-stem node and sympodial branch fruiting position was completed to determine proportion of total yield from each fruiting position. Also, two rows of each plot were reserved for machine picking using a standard spindle cotton harvester. The cotton machined picked was ginned and weighed at the University of Georgia Micro-gin for lint yield, lint percentage, and fiber quality measurements. Fiber quality samples were sent to Cotton Incorporated for HVI and AFIS data.

### **Statistical Analysis**

Lint weight, gin turnout, and fiber quality data was analyzed using Proc GLM (SAS, 2002) based on computing least squares differences among irrigation treatments.

The following variables: number of bolls, seed cotton weight, and average boll weight on a plot basis were analyzed using Proc ANOVA (SAS, 2002) to obtain un-weighted means over main-stem nodes and sympodial positions. Data was sorted by plot and totals were obtained for the above variables. Percent number of bolls and seed cotton weight were computed for each fruiting position in each plot. As described before, Proc ANOVA was used to analyze percent boll number and percent seed cotton weight of total plant seed cotton weight. Mixed models were used to analyze the data involving main-nodes. Proc MIXED (run with Satterthwaite [ddfm=Satterth]) was used to obtain least squares means (LSM) for percent number of bolls and seed cotton weight by main-stem node and sympodial position. This was done to find LSM for irrigation treatments, main-stem nodes, and irrigation and main-stem node interactions. LSM are weighted means due to the fact that each treatment may not have the same number of fruiting positions on a plant. Total seed cotton weight over nodes was analyzed by position using Proc MIXED to obtain LSM for the irrigation treatments. The analysis described above was repeated for percent of total boll number and seed cotton weight of each sympodial position, and only first sympodial position data was presented. Average boll weight was also analyzed with Proc MIXED to find LSM for irrigation treatments, main-stem nodes, and irrigation and main-stem node interactions.

The model of accumulated weight by day after flowering (DAF) was obtained by calculating percent of accumulated weight from grand total seed cotton weight. Proc MEANS (SAS, 2002) was used to obtain mean DAF and the center of the regression was moved to the mean DAF of each location (Draper and Smith, 1981). Proc MIXED was used to obtain linear, slope, quadratic, and cubic coefficients to describe the functional

relationship between each irrigation treatment and percent yield accumulated weight of seed cotton.

## CHAPTER 3

### RESULTS AND DISCUSSION

#### Applied Water Use

Prior research has shown applied irrigation water savings with subsurface drip (Bordovsky and Porter, 2003; Cetin and Bilgel, 2001). In this research, water savings associated with SSD were also observed across all locations (Table 1). The SSD fed treatment saved an average of 4.35 cm applied water compared to the overhead treatment per location. These savings reduced irrigation water use an average of 37%. Based on applied irrigation amounts, we conclude that the SSD fed treatment saved water in comparison to overhead sprinkler irrigation.

Bordovsky and Porter (2003) found that water use efficiency was higher with SSD irrigation than sprinkler irrigation. We calculated the increase in lint yield ( $\text{kg ha}^{-1}$ ) per cm of applied irrigation water. At the Lang '05 location, increases in lint yield from irrigation were 6.35 and 27.45  $\text{kg ha}^{-1} \text{cm}^{-1}$  for the overhead and SSD fed treatments, respectively. At the SIRP '04 location, increases in lint yield from irrigation were 36.63 and 61.52  $\text{kg ha}^{-1} \text{cm}^{-1}$  for the overhead and SSD fed treatments respectively. At the SIRP '05 location, the overhead and SSD matched irrigation treatments actually decreased yields while the SSD fed irrigation treatment increased yields when compared to dryland. The increase was 37.95  $\text{kg ha}^{-1} \text{cm}^{-1}$  for the SSD fed treatment and the decrease was 3.83  $\text{kg ha}^{-1} \text{cm}^{-1}$  for the overhead treatment. This increase in irrigation water use efficiency by the SSD fed treatment averaged 29.25  $\text{kg ha}^{-1} \text{cm}^{-1}$  higher than the overhead irrigation treatment. We conclude that the SSD fed treatment was most efficient in irrigating cotton during our experiment.

## Soil Moisture

Watermarks were buried in the row of cotton at 20, 40, and 60 cm. Soil tension measurements made every 15 minutes are reported from 2:00 AM each day from each irrigation treatment and depth. Dryland soil tension measurements were not taken in the SIRP '04 location. Figures 1, 2, and 4 illustrate soil water potentials reported as soil tension throughout the growing seasons at each location. Soil tension measurements are represented in (-kPa), and a higher number in the corresponding graphs represent a drier soil. The bottom graph reports cumulative rainfall and irrigation events throughout the season. Symbols with the same color as the cumulative water lines show irrigation or precipitation events. Figures 3 and 5 illustrate TDR sensor readings in the SSD fed irrigation treatments at the SIRP '05 and the Lang '05 locations, respectively. These sensors triggered irrigation events and the dotted lines show irrigation triggers. The data is presented with a reverse y-axis in order that higher measurements of the graph represent drier soils, to follow Figures 1, 2, and 4.

For the SIRP '04 location at the 20 cm depth, the overhead treatment had measurements above the desired soil tension level (-40 kPa) 60 to 65 DAP (Figure 1). At the 20 cm depth, the overhead treatment had measurements above the desired soil tension level (-40 kPa) 60 to 65 DAP. At the 40 cm depth, irrigation treatment and soil tension were more pronounced. The overhead irrigation treatment had two periods of time in which soil tension was higher than the desired level of -50 kPa (49 – 65 DAP and 73 - 77 DAP). Three irrigation events occurred during the 49 – 65 DAP period and two irrigation events occurred during the 73 – 77 DAP period totaling 13.3 cm. Both the SSD fed and SSD matched treatments had soil tension measurements that remained at or below the

desired soil tension level throughout the season. The SSD fed treatment triggered 10 irrigation events applying a total of 11 cm of irrigation water. The SSD matched treatment triggered 6 irrigation events applying 15 cm of irrigation water. At the 60 cm depth, the overhead irrigation treatment had soil tension measurements that were above the desired level (-50 kPa) for irrigations 62 – 77 DAP, while the other irrigation treatments kept soil tension measurements below the desired soil tension level. In the SIRP '04 location, the overhead irrigation treatment was the least effective irrigation treatment in delivering water to or maintaining soil water potential in the 40 and 60 cm soil depths.

Figure 2 shows soil tension measurements and irrigation and precipitation data for the SIRP '05 location. At the 20 cm depth, the SSD fed treatment had a desired soil tension level higher than the trigger point 62 -73 DAP. The dryland treatment had soil water potentials above the desired soil tension level 64 – 77 DAP. The overhead and SSD matched treatments had soil water potentials that stayed below or at the desired level throughout the year. At the 40 cm depth, all irrigation treatments remained below the desired level except for the dryland treatment, which was above the desired soil tension level 70 – 75 DAP. At the 60 cm depth, the SSD fed and SSD matched irrigation treatments had soil water potentials below or at the desired level throughout the season. The dryland treatment had soil tension measurements above the desired level 61 – 73 DAP. The soil tension measurements of the overhead treatment were above the desired soil tension level 64 – 73 DAP. The explanation for the SSD fed treatment's soil tension measurements occurring above the desired soil tension level may be due to the irrigations being triggered by the TDR sensors, which were located 15 cm closer to the drip tape

than the watermark sensors. Figure 3 contains relative soil water content measurements for the TDR sensors and the irrigation events triggered by the sensors. During the period that soil tension was higher -40 kPa, 5 irrigation events occurred in the SSD fed treatment.

Figure 4 contains the same information that is found in Figures 1 and 2 for the Lang '05 location. At the 20 cm depth, the overhead and SSD matched treatments held soil water potential below the desired soil tension level throughout the season. The SSD fed treatment had a brief period in which readings were above the desired soil tension level (69 – 75 DAP), while the dryland treatment had measurements that were above the desired level during the same brief period and from 94 DAP to the end of the season. The 40 cm depth graph showed similar data as the 20 cm depth graph. The overhead and SSD matched treatments kept soil tension measurements below the desired soil tension level throughout the season. The SSD fed treatment in the 40 cm depth also had a brief period of measurements above the desired level at 72 – 77 DAP and also from 96 – 108 DAP. At the 60 cm depth, the overhead and the SSD matched treatments had soil tension readings at or below the desired soil tension level throughout the season. After 70 and 67 DAP until the end of the season the SSD fed and dryland treatments had measurements above the desired level, respectively. Figure 5 shows the relative soil water content in the SSD fed treatment at the Lang '05 location. The TDR sensors showed that 7 irrigation events were triggered as the relative soil water content was measured above the irrigation trigger point (16%).

From the soil tension data in this experiment, several observations were made. At the SIRP '04 location, the SSD fed treatment was successful in maintaining soil tension

below the irrigation trigger, while the overhead treatment had periods of time in which soil tension was above the trigger point. The periods of time in which the overhead treatment did not maintain soil water potential below the desired level occurred during times of peak water use (flowering) later in the season. Also from the SIRP '04 data, we observed that water from the overhead treatment did not recharge soil water at deeper depths as well as the SSD fed treatment did. The SIRP '05 soil tension data showed a similar trend at the 60 cm depth in which water from the overhead treatment did not recharge soil water at this depth while the SSD fed and SSD matched treatments did. The SSD fed treatment maintained soil water potential consistently below the irrigation desired soil tension levels compared to the overhead treatment at the SIRP '04 and SIRP '05 locations.

At the Lang '05 location soil water potential data showed different trends than the other two locations. The overhead and SSD matched treatments maintained soil tension below the trigger point much more consistently than the SSD fed treatment. The SSD fed treatment did not recharge soil water at the depth of 60 cm similar to the overhead and SSD matched treatments, and reached soil tension measurements above the desired soil tension level for much of the season at that depth. The SSD fed treatments at the Lang '05 and the SIRP '05 locations were designed to irrigate based on measurements made at 25 cm with the Automata system. At the SIRP '04 location water was applied in much larger increments (0.76 – 1.5 cm per day) than at the other two locations (0.3 cm up to 3 times daily) when soil water potential reached the irrigation trigger point at any of the three depths. From the 20 cm depth graphs at the Lang '05 and the SIRP '05 locations, soil water potential was generally maintained below the irrigation trigger point. While

soil water potential at depths of 40 and 60 cm were generally higher than the irrigation trigger point at the Lang '05 location. The explanation for SIRP '05 data not following the Lang '05 data considering the same irrigating system was used may involve the large amount of precipitation received at the SIRP '05 location (66 cm). If more irrigation events were needed at the SIRP '05 location, the same trends may have occurred.

The SSD fed treatment was successful in maintaining soil water potential below the desired soil tension level at all depths when irrigation water was applied in increments of 0.76 cm or larger (SIRP '04). At SIRP '05 and Lang '05 applications in increments of 0.3 cm was not enough to maintain soil water potential above the irrigation trigger point at depths of 40 and 60 cm at the Lang '05 location and at depths of 20 cm at the SIRP '05 location. Several irrigation events were triggered at the SIRP '05 and Lang '05 locations during the dry periods, yet proved unsuccessful in maintaining soil moisture. Therefore, the SSD fed treatment may warrant larger increments of water (0.76 – 1.5 cm) to obtain its full benefit. The overhead treatment did not maintain soil water potential below the desired soil tension level throughout the growing season at SIRP '04 and SIRP '05 at the 40 and 60 cm depths, which was not the case with the SSD fed treatment. The SSD matched treatment maintained soil moisture most effectively during this experiment, with the fewest days that soil tension was measured to be above the irrigation trigger.

## **Maturity**

Burke (2003) showed the possibility for fruit loss associated with overhead sprinkler irrigation. If this loss were to occur, cotton is known to compensate for the fruit loss by partitioning resources to vegetative growth (Sadras, 1995). Increased vegetative

growth may result in increased fruiting sites and in turn a delay in maturity. Figure 6 illustrates maturity across all locations as main-stem nodes above white flower (NAWF). Main-stem nodes above white flower measurements give a reliable measure of cotton maturity. When NAWF equals 5, physiological maturity has occurred (Bourland *et al.*, 2001). In the SIRP '04 and SIRP '05 locations irrigation treatment affected NAWF. The dryland irrigation treatment had fewer NAWF at ~80 DAP than the other irrigation treatments. The overhead irrigation treatment was significantly later in maturity in comparison with all other treatments. This supports Pettigrew (2004) who said that overhead irrigation delayed maturity. SSD Fed and SSD Matched treatments had a lower NAWF than the overhead treatment. By observing maturity by NAWF, overhead irrigation resulted in later maturity than SSD and SSD matured later than dryland.

In the Lang '05 location, no significant differences in maturity were documented, although the overhead treatment tended to be later in maturity. High within treatment variability in plant growth was observed in this location. As a result, nematode and nutrient petiole samples were taken at 91 DAP. Table 2 shows petiole sample nutrient levels found from the petiole analysis. Nitrate levels were extremely variable, and the standard deviation was found to be very high. All treatments except for the dryland treatment contained low petiole nitrate (ppm) levels (2500 – 5000 ppm are acceptable levels for nitrate ppm at full bloom). Soil samples also revealed the presence of nematodes at damaging levels (*Meloidogyne incognita* 2710 per 150 cc of soil, treatment is recommended when species numbers are above 100 per 150 cc).

## **Lint Yield and Gin Turnout**

Previous studies shows increases in yield from SSD irrigation (Bordovsky and Porter, 2003; Cetin and Bilgel, 2001; Sorensen *et al.*, 2003). Lint yields from this experiment are shown in Table 3. In SIRP '04 and SIRP '05 the SSD Fed treatments yielded as well as the overhead and higher than the dryland treatment. At the Lang '05 location, SSD Fed had a higher yield than overhead irrigation. Over all locations the SSD fed treatment yielded as well or better than the overhead treatment and better than the dryland. We conclude that the SSD fed treatment is an irrigation system that can produce comparable lint yields to overhead, sprinkler, irrigation.

Table 3 also shows gin turnout represented as a percentage of lint from seed cotton pre-gin weights. In both the SIRP '04 and SIRP '05 locations gin turnout in the SSD fed treatment was higher than the overhead irrigated cotton. At the Lang '05 location SSD fed trended in the same direction, yet was not significant. This may be linked to the physical structure of the cotton due to irrigation. The SSD fed treatment was generally smaller in stature and more compact than the overhead irrigated cotton. With this change in stature, the amount of trash and non-lint matter may have been lower in the SSD fed treatment, resulting for the higher gin turnouts. However, seed size may also impact lint turnout. Stewart (1986) reported that seed index (weight 100 seed<sup>-1</sup>) is related to moisture stress. For example, dryland conditions generally produce a smaller seed size and a higher lint percentage than irrigated cotton. Thus irrigation treatment may have affected seed size. Additionally, differences in yield distribution (discussed below) may have contributed to differences to lint percentage. The SSD fed treatment

was shown to be more mature than overhead at approximate cutout. This may lead to the assumption that the SSD fed treatment may have been defoliated more effectively, ultimately causing a higher gin turnout.

### **Seed Cotton Weight**

Irrigation and main-stem node interactions were found in seed cotton yields analyzed across main-stem nodes and sympodial fruiting positions. At the SIRP '04 and SIRP '05 locations Irrigation x Node interactions were found to be significant at the 0.01 level in the 1<sup>st</sup> and 2<sup>nd</sup> sympodial positions (Tables 4, 5, and 6). At Nodes 5 through 10 in the 1<sup>st</sup> sympodial position more cotton was produced in the SSD fed treatment than in the overhead treatment in SIRP '04. At Nodes 11 through 20, the overhead tended to have more weight than the SSD treatment. In SIRP '05 SSD fed produced more cotton on Nodes 5 through 12 than overhead and from Nodes 14 through 20 overhead produced more cotton than the SSD fed treatment. The Irrigation x Node interactions with seed cotton weight may be explained by Sadras, (1995) who reported that as fruit load increases the rate of vegetative growth slows and eventually results in cutout. Fruit load may have been affected by irrigation, with the overhead irrigation resulting in decreased fruit load at lower main-stem nodes which was compensated by increased production at higher main-stem nodes. This effect would be in agreement with Burke (2003) who reported increased flower abortion with overhead irrigation due to pollen sterility.

### **Percentage of Total Weight**

After examining the actual seed cotton weight distribution of cotton over the plant between irrigation treatments, percentages of yield at each main-stem node and sympodial position were then analyzed. This analysis restricts differences of total yield between treatments from interfering with distribution analysis. At both the SIRP '04 and SIRP '05 locations Irrigation x Node interactions were again found at the 1<sup>st</sup> and 2<sup>nd</sup> sympodial positions (Tables 7, 8, and 9). Across locations the overhead irrigation treatment had 67.7% of its yield on the 1<sup>st</sup> sympodial position and SSD fed cotton had 75.2% of its yield on the 1<sup>st</sup> sympodial position. A study by Jenkins *et al.* (1990b) found that 66 to 75% of the total yield is produced from the 1<sup>st</sup> sympodial position. This study indicates that the SSD fed treatment may have resulted in a higher percentage of the total yield produced in the 1<sup>st</sup> sympodial fruiting position. Heitholt (1997) indicated that cotton fibers produced from the 1<sup>st</sup> sympodial fruiting position are longer and more mature than fiber produced from other sympodial positions.

Jenkins *et al.* (1990a) indicated in his study that main-stem nodes 9 through 14 were the largest contributor to yield on a cotton plant. In SIRP '04 the highest percentage of yield in the 1<sup>st</sup> sympodial position was at main-stem node 10 and 11 for the SSD fed and overhead irrigation treatments respectively. In SIRP '05, SSD fed's highest contributor to yield was main-stem node 10 and overhead's was main-stem node 14. At Lang '05, main-stem node 9 was the highest contributor to yield for the SSD fed treatment and main-stem node 12 was the highest contributor to yield in the overhead treatment. In all locations the SSD fed treatment had a lower main-stem node of peak yield and a higher percentage of the total yield in the 1<sup>st</sup> sympodial position than the overhead irrigation treatment.

### **Percentage of Total 1<sup>st</sup> Sympodial Position Seed Cotton Weight**

Because the majority of the cotton was located on the 1<sup>st</sup> sympodial position, proportion of yield in only the 1<sup>st</sup> sympodial position was graphically analyzed. This distribution was acquired by dividing 1<sup>st</sup> sympodial position seed cotton weight at each main-stem node by the total seed cotton weight from the 1<sup>st</sup> sympodial position. At the SIRP '04 and SIRP '05 locations Irrigation x Node interactions were observed. Figure 7 shows percent of 1<sup>st</sup> sympodial position seed cotton yield at all locations. In two of the three locations (SIRP '04 and SIRP '05) a greater percentage of the dryland yield was located on lower main-stem nodes than the other irrigation treatments. These data also indicate that the SSD fed treatment resulted in a higher percentage of total seed cotton weight at lower main-stem nodes. At higher main-stem nodes there also tended to be a higher percentage of yield in the overhead treatment than the SSD fed treatment. This data shows that a shift in yield distribution may occur because of irrigation treatment.

### **Percentage of Total Boll Number**

Boll number is another component of yield and can be affected by irrigation (Cetin and Bilgel, 2001; Ertek and Kanber, 2003). Cetin and Bilgel (2001) reported a higher boll number for drip irrigation compared to overhead irrigation. Differences were not observed in total boll number in this experiment therefore the proportion of boll number was analyzed. Tables 10, 11, and 12 show percentages of total boll number as a function of main-stem node, sympodial position, and irrigation treatment. In SIRP '04

and SIRP '05 Irrigation x Node interactions were found to be significant in sympodial position 1 and 2 at the 0.001 level.

At SIRP '04 location a higher percentage of total boll numbers was observed at main-stem nodes 5 through 12 in the 1<sup>st</sup> sympodial position in the SSD fed treatment than the overhead treatment. The overhead irrigation treatment had a higher percentage of total boll number at main-stem nodes 13 through 21 in the 1<sup>st</sup> sympodial position than the SSD fed treatment. In SIRP '05 SSD fed produced higher percentage of total number of bolls at main-stem nodes 5 through 10 in the 1<sup>st</sup> sympodial position than the overhead treatment. From main-stem nodes 11 through 18 in the 1<sup>st</sup> sympodial position the overhead treatment produced a higher percentage of boll number than the SSD fed treatment. Also, in locations SIRP '04 and SIRP '05 the SSD fed treatment produced a higher percentage of total boll number in the 1<sup>st</sup> sympodial position relative to the overhead irrigation treatment. Pettigrew (2004) found that irrigation affected percentage of 1<sup>st</sup> sympodial position bolls and that this in turn affected fiber quality.

### **Percentage of Total 1<sup>st</sup> Sympodial Position Boll Number**

To examine percentage boll number more closely, 1<sup>st</sup> sympodial position bolls were investigated (Figure 8). Irrigation x Node interactions were observed for percentage of total 1<sup>st</sup> sympodial position boll number in SIRP '04 and SIRP '05. In two of the three locations (SIRP '04 and SIRP '05) the dryland 1<sup>st</sup> sympodial position boll number was greatest on lower main-stem nodes than the other irrigation treatments. These data also indicate that the SSD fed treatment resulted in a higher percentage of 1<sup>st</sup> sympodial position boll number at lower main-stem nodes. There tended to be a higher percentage

of 1<sup>st</sup> sympodial position bolls in the overhead treatment than the SSD fed treatment at higher main-stem nodes in the SIRP '04 and SIRP '05 locations. These data indicate changes in boll distribution may occur from irrigation treatment.

### **Average Boll Weight**

Researchers have found increased boll weight with fruit shedding (Bednarz and Nichols, 2005; Jenkins *et al.*, 1990a). Jenkins *et al.* (1990b) examined boll weight by fruiting position and showed that boll weight tended to be greatest from main-stem node 6 through 12. Our data shows that boll weight was greatest at main-stem node 13-15 (Tables 13, 14, and 15). An Irrigation x Node interaction was observed at the SIRP '04 location in the 1<sup>st</sup> sympodial position (Table 13). This interaction was likely due to larger boll weight in the overhead treatment than in the dryland treatment in the mid canopy region. This interaction was not observed in the other two locations. Boll weights across main-stem nodes were similar in the 1<sup>st</sup> and 2<sup>nd</sup> sympodial positions in the overhead and SSD fed treatments (Tables 13, 14, and 15).

### **Model of Accumulated Weight**

Bednarz and Nichols (2005) reported vertical and horizontal flowering intervals to be 2.5 and 3.8 days in the Southeastern US. Using a 2.5 and 3.8 day vertical and horizontal flowering interval, a flower date was assigned to each fruiting position. This information was then used to develop a model for percent of accumulated yield as a function of days after flowering (Figure 9).

Other studies have shown changes in yield distribution due to cultivar (Bednarz and Nichols, 2005; Jenkins *et al.*, 1990a). These studies examined differences in yield between main-stem nodes. Figure 9 shows yield accumulation over time, examining differences between irrigation treatments. In SIRP '04, percent of total yield accumulated at a greater rate in the dryland treatment relative to the overhead treatment. This difference may be associated with the decreased seed cotton weight in the dryland treatment at higher main-stem nodes than other irrigation treatments (Table 4). Both SSD treatments accumulated yield in a similar manner at a rate that was between the dryland and overhead treatments. Differences in cubic relationship were found between the dryland treatment and all other irrigation treatments. The overhead treatment was different from all other irrigation treatments in a quadratic relationship (Table 16).

In SIRP '05, the dryland and SSD fed treatments accumulated yield at a greater rate than the overhead and SSD matched treatments. For the cubic relationship, differences were not found between the dryland and SSD fed treatment while both were different than the overhead and SSD matched treatments (Table 16).

At the Lang '05 location, the dryland irrigation treatment accumulated yield differently than the other irrigation treatments. The quadratic relationships between the dryland treatment and the other irrigation treatments were found to be different (Table 16). Table 6 shows that dryland yield from main-stem node 13 through 17 in the 1<sup>st</sup> sympodial position and main-stem node 11 through 18 on the 2<sup>nd</sup> sympodial position was lower than the other treatments.

In SIRP '04 the number of days after flowering in which 95% of total yield occurred was approximately 4 days earlier in the SSD fed treatment compared to the

overhead treatment (26 and 30 DAF). In SIRP '05, the SSD fed accumulated 95% of its yield approximately 6 days earlier than the overhead treatment (33 and 39 DAP). In the Lang '05 location 95% yield accumulation occurred approximately the same time for the SSD fed and overhead treatments. From Figure 9 we concluded that irrigation treatment may have affected the effective flowering period.

## **Fiber Quality**

### **HVI**

In Tables 17, 18, and 19 High Volume Instrument (HVI) fiber quality data is shown. In locations SIRP '05 and Lang '05 micronaire was higher in the SSD fed treatment than the overhead treatment. Heitholt (1997) and Pettigrew (2004) found that changes in proportion of 1<sup>st</sup> and 2<sup>nd</sup> sympodial position fruit can affect overall micronaire. In our study higher proportions of 1<sup>st</sup> sympodial position fruit and increased maturity and micronaire were observed with the SSD fed treatment relative to the overhead treatment. All other HVI fiber properties differed but these differences varied among treatments and locations. HVI fiber properties in general were above the minimum fiber quality requirements established by the United States Department of Agriculture Commodity Credit Corporation.

### **AFIS**

Advanced fiber information system (AFIS) fiber quality measurements are presented in Tables 20, 21, and 22. Maturity is a ratio and represents the degree of development or thickening of the fiber relative to the perimeter of the fiber. Fibers with a low maturity ratio present problems in the textile industry (Thibodeaux and Rajasekaran,

1999). At the SIRP '04 and Lang '05 locations, the maturity ratio was significantly higher in the SSD fed treatment than the overhead treatment. Fineness measurements were also given in Tables 20, 21, and 22. The SSD fed treatment fineness measurement was higher than the overhead treatment in the SIRP '05 location. Fineness is a measurement similar to micronaire and follows the micronaire data given from the HVI data closely. All other AFIS fiber properties differed but these differences varied among treatments and locations.

### **Literature Cited**

- Bednarz, C., and R.L. Nichols. 2005. Phenological and morphological components of cotton crop maturity. *Crop Science* 45:1497-1503.
- Bordovsky, J.P., and D. Porter. 2003. Cotton response to pre-plant irrigation level and irrigation capacity using spray, LEPA, and subsurface drip irrigation. 2003 ASAE Annual International Meeting, Las Vegas, NV:Paper No: 032008
- Bourland, F.M., N.R. Benson, E.D. Vories, N.P. Tugwell, and D.M. Danforth. 2001. Measuring maturity of cotton using nodes above white flower. *Agronomy Journal* 5:1-8.
- Burke, J.J. 2003. Sprinkler-induced flower losses and yield reductions in cotton (*Gossypium hirsutum* L.). *Agronomy Journal* 95:709-714.
- Cetin, O., and L. Bilgel. 2001. Effects of different irrigation methods on shedding and yield of cotton. *Agricultural Water Management* 54:1-15.
- Draper, N.R. and Smith, H. 1981. *Applied Regression Analysis*. (2nd Ed) New York: Wiley 709.
- Ertek, A., and R. Kanber. 2003. Effects of different drip irrigation programs on the boll number and shedding percentage and yield of cotton. *Agricultural Water Management* 60:1-11.
- Heitholt, J.J. 1997. Floral bud removal from specific fruiting positions in cotton: yield and fiber quality. *Crop Science* 37:826-832.
- Jenkins, J.N., J.C. McCarty, and W.L. Parrott. 1990a. Effectiveness of fruiting sites in cotton: yield. *Crop Science* 30:365-369.

- Jenkins, J.N., J.C. McCarty, and W.L. Parrott. 1990b. Fruiting efficiency in cotton: boll size and boll set percentage. *Crop Science* 30:857-860.
- Jost, P., S. M. Brown, S. Culpepper, G. Harris, B. Kermerait, P. Roberts, D. Shurley, and J. Williams. 2005. 2005 Georgia Cotton Production Guide.
- Pettigrew, W.T. 2004. Moisture deficit effects on cotton lint yield, yield components, and boll distribution. *Agronomy Journal* 96:377-383.
- Sadras, V.O. 1995. Compensatory growth in cotton after loss of reproductive organs. *Field Crops Research* 40:1-18.
- SAS Institute Inc. 2002. SAS/C OnlineDoc™, Ver. 9.1 Cary, NC: SAS Institute, Inc.
- Sorensen, R.B., M.J. Bader, and E.H. Wilson. 2003. Cotton yield and grade response to nitrogen applied daily through a subsurface drip irrigation system. *ASAE* 20:13-16.
- Stewart, J.M. 1986. Integrated events in the flower and fruit, p. 261-300, In J. R. Mauney and J. M. Stewart, eds. *Cotton Physiology*. The Cotton Foundation, Memphis, TN.
- Thibodeaux, D.P., and K. Rajasekaran. 1999. Development of new reference standards for cotton fiber maturity. *Journal of Cotton Science* 3:188-193.

**Table 1. Total irrigation water applied (cm) over all locations and water savings (cm) from the SSD fed irrigation treatment compared to the overhead treatment.**

Treatment	SIRP '04	SIRP '05	Lang '05
Overhead	15.75	10.16	10.74
SSD Fed	11.43	2.00	10.16
SSD Matched	15.75	10.16	10.74
Dryland	2.8	0	3.45
Water Savings	4.32	8.16	0.58

**Table 2. Nutrient levels in the petiole of uppermost mature leaf from cotton plants at the Lang Farm, Tifton, GA 91 DAP.**

<u>Petiole Nutrient Levels</u>				
Treatment	Nitrate (ppm)	Phosphorus (ppm)	Potassium (%)	Sulfur (ppm)
Dryland	2775	2023	4.48	1669
Overhead	1925	2683	5.75	1855
SSD Fed	2225	2143	5.56	1697
SSD Matched	1425	2094	5.43	2080
Standard Deviation	1537	533	1.48	475

**Table 3. Lint yield (kg ha<sup>-1</sup>) and Gin Turnout (%) at all locations.**

Treatment	<u>Location</u>						
	<u>Lang '05</u>		<u>SIRP '04</u>		<u>SIRP '05</u>		
	Lint Yield	Gin Turout	Lint Yield	Gin Turout	Lint Yield	Gin Turout	
	kg ha <sup>-1</sup>	%	kg ha <sup>-1</sup>	%	kg ha <sup>-1</sup>	%	
Dryland	1425.11b	36.14ab	1240.73b	35.41ab	1152.30ab	35.41ab	
Overhead	1493.46b	34.45b	1817.66a	34.89b	1113.75ab	34.89b	
SSD Fed	1704.09a	36.06ab	1943.93a	35.78a	1227.93a	35.78a	
SSD Matched	1728.73a	36.46a	1889.50a	34.94b	1080.03b	34.94b	
			<u>ANOVA</u>				
df	12	12	12	12	12	12	
LSD (0.05)	155.87	0.017	460.42	0.65	149.78	0.65	

\* means followed by the same letter within a column are not significantly different.

**Table 4. Seed cotton weight (g m<sup>-1</sup>) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2004.**

Node	<u>Sympodial Position</u>											
	1		2				3					
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
20		0.39										
19		4.11		2.21								
18	0.44	4.22	3.14	1.29								
17	1.35	8.30	1.72	2.88		0.88						
16	2.96	9.76	6.74	6.08		2.57		2.01				
15	3.11	14.31	10.88	8.58	0.39	3.77	2.63					
14	7.01	24.55	16.32	23.09	1.12	7.76	3.46	2.55		1.98	0.63	
13	13.92	30.47	30.00	32.72	0.82	9.63	9.06	5.61	0.27	1.19	2.69	
12	19.71	36.74	31.52	37.83	2.64	11.00	9.79	14.56	1.05	4.56		0.53
11	26.21	38.27	32.57	45.38	7.82	12.09	15.04	18.20	0.54	0.48	0.92	2.31
10	32.47	30.60	37.31	36.81	7.68	22.80	23.99	27.08	1.52	3.81	2.42	2.36
9	34.23	22.05	32.04	30.95	10.55	22.99	19.81	26.87	1.65	3.78	1.05	4.50
8	30.81	17.87	21.88	25.38	5.27	13.91	18.78	21.03	0.41	1.39	3.55	6.27
7	19.70	10.54	14.66	20.06	4.96	8.28	6.43	10.75	2.49	2.24	1.09	2.25
6	6.44	3.29	8.81	8.46	4.48	4.16	5.48	4.22	1.30	0.71	1.92	0.93
5	5.11	1.37	2.98	2.96	2.90		1.04	2.29			1.31	4.70
4	0.53			1.23	1.76			1.04				
Total	204.00	256.84	250.57	285.91	50.39	119.84	115.51	136.21	9.23	20.14	15.58	23.85

38

Effect	<u>Pr &gt; F</u>		
	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	0.023	0.0037	NS
Node (N)	<.0001	<.0001	0.064
I X N	<.0001	<.0001	0.075
I X N LSD*	7.64	6.78	4.87

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 5. Seed cotton weight (g m<sup>-1</sup>) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005.**

Node	Sympodial Position											
	1			2						3		
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
20	3.90	7.14	0.74	5.50	1.78	1.33		1.92				
19	5.67	8.71	4.80	8.90	2.30	3.21		2.05				
18	8.42	12.55	4.49	7.21	1.80	3.67	2.20	2.02				
17	9.27	9.72	6.77	7.16	3.94	4.67	1.86	3.14				1.02
16	11.19	14.00	7.31	13.46	1.84	7.56	2.42	4.33		1.93		3.10
15	10.86	18.68	16.91	16.35	5.39	7.20	3.85	4.97	3.52	2.93	1.04	3.22
14	17.35	23.33	17.14	28.89	4.83	5.34	4.11	2.94	2.00	1.39	0.89	3.12
13	22.22	23.05	24.42	23.22	3.54	7.11	7.07	7.53	6.65	6.20	1.20	3.92
12	25.64	21.20	30.09	24.42	9.20	6.61	7.42	10.74	3.04	3.61	0.77	2.00
11	25.29	18.01	21.62	18.82	10.70	12.65	10.54	8.16	3.31	2.86	3.60	4.70
10	30.84	16.27	35.16	14.05	10.55	6.48	5.59	8.29	4.06	3.55	2.08	2.80
9	24.80	9.93	28.63	14.52	5.24	5.15	6.73	2.63	2.38	2.14	1.80	2.52
8	21.61	6.19	24.78	9.43	7.90	1.75	7.03	5.19	2.98	2.08	2.32	2.20
7	15.53	1.74	16.34	9.42	9.70	2.97	8.78	3.19	2.06	1.71	2.28	1.86
6	9.57	2.35	9.18	2.86	2.36	1.46	5.02	1.23	1.90			1.06
5	7.24	2.62	6.15	3.64	2.32	1.81	1.76	1.58	1.61			
4	5.40	4.13	2.64	2.57	3.19				2.45			
Total	257.09	203.60	260.92	213.60	98.34	80.87	74.38	71.35	37.47	28.40	15.98	31.52

39

Effect	Pr > F		
	Sympodial Position		
	1	2	3
Irrigation (I)	NS	NS	NS
Node (N)	<.0001	<.0001	0.058
I X N	.0017	0.012	NS
I X N LSD*	9.73	4.71	NS

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 6. Seed cotton weight (g m<sup>-1</sup>) at time of harvest at the Lang Farm, Tifton, GA in 2005.**

Node	<u>Sympodial Position</u>											
	1			2						3		
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
21		1.35	1.11									
20		2.01	2.00	1.49								
19	2.72	2.12	3.60	3.82	0.15	0.81						
18	3.10	5.04	5.61	4.18		1.77	1.27	0.95				
17	3.79	9.37	9.70	10.23	1.28	2.34	1.80	0.20				0.86
16	3.38	11.42	21.74	12.30	1.16	3.57	3.71	2.18			0.69	0.32
15	11.75	22.24	23.08	25.29	2.45	6.49	3.32	4.74	2.10	1.94	0.65	1.34
14	18.98	24.08	30.30	32.06	3.42	8.13	6.12	4.97	1.49	2.11		3.99
13	28.39	29.65	33.73	34.21	4.95	8.08	11.37	7.65	1.63	2.26	7.06	2.34
12	34.69	37.45	31.95	38.50	6.62	10.69	12.69	7.26	7.17	2.00	3.36	2.41
11	38.56	27.93	36.63	37.30	6.02	9.68	7.95	11.04	9.68	2.55	1.06	2.15
10	36.26	35.70	32.11	40.15	10.77	8.58	6.44	9.24	5.48	2.43	1.61	5.07
9	41.36	32.14	35.99	38.20	12.81	8.26	7.81	10.70	4.62	1.69	2.00	3.43
8	33.97	34.30	35.37	42.14	10.17	8.10	10.97	12.73	2.79	1.06	0.96	3.09
7	26.41	31.10	33.73	33.66	7.71	5.37	10.32	13.25	2.79	5.23	2.90	2.87
6	17.26	28.98	21.54	22.45	4.15	5.47	5.36	6.65	1.44	2.37	4.08	1.54
5	7.13	12.21	10.27	10.15	1.65	2.92	3.86	3.11	2.67	0.89		
4	2.29	3.98	3.75	3.18	11.76	1.90		1.44	1.51			
Total	310.04	351.07	372.21	389.31	85.07	92.16	92.99	96.11	43.37	24.53	24.37	29.41

40

Effect	<u>Pr &gt; F</u>		
	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	NS	NS	NS
Node (N)	<.0001	<.0001	0.068
I X N	NS	NS	0.071
I X N LSD*	NS	NS	4.12

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 7. Percentage of total seed cotton weight at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2004.**

Node	Sympodial Position											
	1				2				3			
	-----LS Mean %-----											
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
18	0.32	0.95	0.88	0.32								
17	0.57	2.20	0.45	0.67								
16	1.19	2.54	1.77	1.41								
15	1.23	3.74	2.89	1.97								
14	2.71	6.46	4.47	5.34	0.32	1.07	0.83	0.52				
13	5.37	8.00	8.24	7.60	0.28	2.50	2.43	1.29				
12	7.78	9.78	8.71	8.78	0.96	2.84	2.63	3.33				
11	10.96	10.07	9.15	10.57	2.82	3.17	4.14	4.19	0.32	0.34	0.32	0.21
10	13.04	8.05	10.36	8.59	3.03	5.97	6.57	6.31	0.56	0.99	0.61	0.54
9	14.20	5.82	8.79	7.20	4.12	5.98	5.52	6.22	0.66	0.98	0.32	0.98
8	13.07	4.67	5.94	5.90	2.08	3.60	5.11	4.84	1.24	0.36	0.86	1.37
7	8.16	2.73	4.03	4.66	1.88	2.14	1.80	2.45	0.23	0.52	0.27	0.52
6	2.51	0.82	2.48	1.96	1.31	1.05	0.85	0.76	0.64	0.26	0.55	0.40
5	1.50	0.43	0.87	0.58								
Total	82.60	66.26	69.03	61.17	16.79	28.32	29.87	29.90	3.64	3.45	2.92	4.00

Effect	Pr > F		
	Sympodial Position		
	1	2	3
Irrigation (I)	0.038	0.008	NS
Node (N)	<.0001	<.0001	0.050
I X N	<.0001	0.009	0.069
I X N LSD*	2.39	1.69	1.13

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 8. Percentage of total seed cotton weight at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005.**

Node	Sympodial Position											
	1				2				3			
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
21	1.28	1.40	0.08	1.28								
20	1.23	2.42	0.34	1.87								
19	1.78	2.99	1.42	2.97								
18	2.53	4.34	1.32	2.51	1.06	0.61	0.70	0.56				
17	2.74	3.35	2.04	2.72	1.62	1.25	0.55	1.05				
16	3.32	4.95	2.18	5.00	2.56	0.45	0.72	1.47	0.51	0.48	0.14	0.72
15	3.16	6.59	5.12	5.75	2.46	1.48	1.02	1.58	1.08	1.11	0.38	1.01
14	5.00	8.21	5.13	10.07	1.88	1.39	1.26	1.02	0.58	0.29	0.26	1.05
13	6.40	8.12	7.29	8.22	2.57	1.02	2.13	2.58	2.02	1.95	0.35	1.22
12	7.30	7.34	9.07	8.32	2.29	2.72	2.17	3.78	0.91	1.22	0.30	0.72
11	7.24	6.43	6.51	6.58	4.29	3.09	3.26	2.84	0.96	1.13	1.03	1.73
10	8.63	5.74	10.44	4.78	2.18	3.04	1.65	2.73	1.22	1.14	0.65	0.86
9	6.93	3.50	8.56	5.25	1.81	1.57	2.01	0.93	0.72	0.68	0.36	0.80
8	5.99	2.07	7.41	3.26	0.64	2.23	2.17	1.90				
7	4.32	0.65	4.87	3.58	1.08	2.75	2.56	1.03				
6	2.61	0.74	2.77	1.02	0.57	0.68	1.50	0.47				
5	1.82	1.03	1.87	1.38	0.69	0.81	0.55	0.44				
4	1.40	1.44	0.74	0.84								
Total	73.67	60.15	76.73	72.24	25.71	23.09	21.57	21.82	7.99	8.00	3.47	8.10

42

Effect	Pr > F		
	Sympodial Position		
	1	2	3
Irrigation (I)	NS	NS	0.075
Node (N)	<.0001	<.0001	0.001
I X N	<.0001	0.008	NS
I X N LSD*	2.86	1.56	NS

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 9. Percentage of total seed cotton weight at time of harvest at the Lang Farm, Tifton, GA in 2005.**

Node	<u>Sympodial Position</u>											
	1				2				3			
	-----LS Mean %-----											
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
19	0.57	0.46	0.61	0.51								
18	0.53	1.26	1.30	0.87								
17	0.78	2.19	2.05	2.11	0.17	0.46	0.35	0.12				
16	0.80	2.46	4.65	2.52	0.26	0.85	0.80	0.46				
15	3.04	5.10	4.95	5.16	0.60	1.51	0.70	0.99	0.25	0.30	0.09	0.06
14	4.86	5.36	6.62	6.56	0.85	1.94	1.28	1.04	0.10	0.39	0.52	0.62
13	7.34	6.70	7.30	6.98	1.22	1.83	2.42	1.59	0.12	0.49	1.37	0.49
12	9.00	8.06	7.05	7.86	1.68	2.41	2.75	1.50	1.38	0.46	0.66	0.46
11	10.07	6.05	7.96	7.61	1.47	2.13	1.71	2.26	1.92	0.56	0.18	0.39
10	9.43	7.74	7.06	8.19	2.77	1.82	1.42	1.89	1.02	0.58	0.35	0.88
9	10.70	7.13	7.86	7.74	3.32	1.77	1.62	2.20	1.13	0.38	0.37	0.64
8	8.73	7.40	7.58	8.59	2.65	1.72	2.29	2.59	0.69	0.18	0.25	0.61
7	6.59	6.74	7.19	6.94	1.95	1.20	2.22	2.69	0.39	1.22	0.64	0.55
6	4.44	6.43	4.59	4.62	1.07	1.20	1.13	1.37	0.43	0.31	0.84	0.29
5	1.83	2.66	2.20	2.10	0.99	0.59	0.80	0.55				
4	0.60	0.98	0.79	0.63								
Total	79.31	76.73	79.76	78.98	19.00	19.43	19.49	19.24	7.42	4.87	5.27	4.98

43

Effect	<u>Pr &gt; F</u>		
	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	NS	NS	NS
Node (N)	<.0001	<.0001	0.067
I X N	NS	NS	0.066
I X N LSD*	NS	NS	0.90

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 10. Percentage of total boll number (m<sup>-2</sup>) at each main-stem node and sympodial position at time of harvest at the C.M. Stripling Irrigation Research Park, Camilla, GA in 2004.**

Node	Sympodial Position											
	1		2				3					
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
	----- LS Mean % -----											
21	1.80	2.30	0.22	1.89								
20	1.52	3.03	0.43	2.81								
19	2.19	3.48	1.63	3.06								
18	2.26	4.42	1.63	2.97	0.71	1.35	0.85	0.86				
17	2.84	2.30	2.46	2.89	1.42	2.05	0.63	1.28				
16	3.21	4.30	2.65	4.40	0.62	2.99	0.75	1.71	0.77	0.67	0.35	0.93
15	3.07	5.56	4.77	4.89	1.33	2.59	1.13	1.45	1.37	1.23	0.32	1.22
14	4.82	7.18	4.70	8.60	1.50	1.79	1.29	1.34	0.85	0.44	0.35	1.11
13	6.44	7.96	6.84	8.03	1.00	2.26	2.04	2.31	1.90	1.93	0.51	1.00
12	7.01	6.75	8.32	7.73	2.33	3.06	2.24	3.71	0.92	1.16	0.32	0.73
11	7.00	5.92	6.76	6.32	3.04	4.01	3.38	2.56	1.01	0.99	1.00	1.65
10	7.42	5.82	10.01	4.69	3.16	2.11	1.76	3.17	0.97	1.08	0.66	0.88
9	7.02	3.61	7.99	4.95	1.91	1.93	1.90	1.08	0.72	0.91	0.39	0.76
8	6.16	2.42	7.64	3.63	2.26	0.79	2.21	2.15	0.84	0.44	0.67	0.76
7	4.52	0.89	5.03	3.53	2.25	1.17	2.10	1.13	0.57	0.60	0.53	0.51
6	3.02	0.94	2.85	1.20	0.63	0.57	1.50	0.63				
5	2.29	0.66	2.05	1.65	0.77	0.55	0.51	0.50				
4	1.64	1.66	0.97	1.10								
Total	74.23	69.18	76.94	74.34	22.93	27.21	22.30	23.87	9.93	9.45	5.09	9.53
	<u>Sympodial Position</u>											
	<u>Pr &gt; F</u>											
Effect	1	2	3									
Irrigation (I)	0.016	<.0001	NS									
Node (N)	<.0001	<.0001	0.015									
I X N	<.0001	0.001	NS									
I X N LSD*	2.22	1.68	NS									

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 11. Percentage of total boll number (m<sup>-2</sup>) at each main-stem node and sympodial position at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005.**

Node	<u>Sympodial Position</u>											
	1		2				3					
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
	-----LS Mean %-----											
18	0.83	1.01	0.97	0.41								
17	1.54	2.36	0.64	0.81								
16	1.30	2.69	1.87	1.62								
15	1.63	4.19	2.99	2.04								
14	3.06	5.50	4.16	4.80	0.67	1.40	0.93	0.76				
13	5.05	7.02	7.49	6.43	0.58	2.79	2.31	1.41				
12	7.31	7.79	7.58	7.59	1.14	3.13	2.72	3.18				
11	10.21	8.64	8.59	9.41	2.64	3.34	3.93	4.15	0.47	0.44	0.60	0.36
10	12.28	7.57	9.71	8.90	3.08	5.74	6.48	6.08	0.88	1.16	0.81	0.88
9	14.42	6.10	8.82	7.06	4.08	5.96	5.77	6.33	0.95	1.50	0.48	1.23
8	13.13	5.19	6.54	6.62	2.05	4.29	5.61	5.06	1.33	0.64	1.17	1.57
7	8.13	3.17	4.52	5.37	1.68	2.25	2.08	2.45	0.48	0.52	0.40	0.61
6	2.51	0.97	2.50	2.30	1.21	1.03	0.98	0.89	0.72	0.42	0.52	0.51
5	1.65	0.46	0.86	0.61								
Total	83.06	62.65	67.22	63.96	17.14	29.94	30.81	30.30	4.84	4.68	3.97	5.17

45

Effect	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	NS	<.0001	NS
Node (N)	<.0001	<.0001	0.097
I X N	<.001	0.004	NS
I X N LSD*	2.73	1.51	NS

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 12. Percentage of total boll number (m<sup>-2</sup>) at each main-stem node and sympodial position at time of harvest at the Lang Farm, Tifton, GA in 2005.**

Node	<u>Sympodial Position</u>											
	1		2				3					
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
	-----LS Mean % -----											
19	0.69	0.62	0.94	0.81								
18	0.55	1.94	1.74	1.29								
17	1.07	2.67	2.92	2.56	0.41	0.62	0.50	0.38				
16	1.18	2.77	5.10	2.90	0.34	1.38	1.27	0.73				
15	3.79	5.22	5.79	5.35	0.89	1.97	0.89	1.47	0.47	0.65	0.32	0.23
14	5.58	5.56	6.55	6.46	1.38	2.36	1.52	1.38	0.09	0.67	0.73	0.84
13	7.21	6.09	6.79	6.27	1.60	2.19	2.66	1.92	0.02	0.87	1.67	0.86
12	8.71	7.41	6.46	7.29	2.02	2.74	2.99	1.83	1.51	0.58	0.89	0.70
11	8.86	5.42	7.08	7.03	1.82	2.15	1.78	2.47	1.75	0.65	0.27	0.65
10	8.72	7.04	6.18	7.42	2.74	1.81	1.71	2.00	1.58	0.67	0.47	0.92
9	9.87	6.10	7.12	7.01	3.68	1.92	1.73	2.38	1.27	0.47	0.34	0.59
8	7.67	6.49	6.33	7.06	2.65	1.88	2.19	2.47	0.81	0.27	0.43	0.69
7	5.67	5.89	6.38	6.51	2.16	1.30	2.33	2.82	0.44	1.16	0.66	0.51
6	4.29	5.78	4.60	4.63	1.20	1.22	1.31	1.38	0.42	0.36	0.73	0.46
5	1.96	2.69	2.49	2.59	1.16	0.63	0.91	0.71				
4	0.68	1.06	0.76	0.72								
Total	76.47	70.18	66.52	73.81	21.29	22.18	20.04	21.93	8.37	6.34	6.50	6.43

46

Effect	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	NS	NS	NS
Node (N)	<.0001	<.0001	NS
I X N	NS	NS	NS
I X N LSD*	NS	NS	NS

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 13. Average boll weight (g) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2004.**

Node	<u>Sympodial Position</u>											
	1		2				3					
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
20		1.08										
19		4.57		3.16								
18	1.24	4.48	4.37	2.74								
17	1.52	3.92	3.06	3.61		2.46						
16	4.14	4.34	4.22	3.64		3.59		3.26				
15	3.26	4.06	4.27	4.12	1.10	4.06		2.63				
14	3.72	5.43	4.81	4.78	2.68	3.66	3.66	3.90		5.52	1.75	
13	4.32	5.23	4.84	5.07	2.30	4.30	3.87	4.41	0.76	3.33	3.75	
12	4.47	5.70	5.11	4.95	4.32	4.09	4.70	4.29	2.94	4.23		1.47
11	4.51	5.38	4.63	4.79	4.74	4.39	4.22	4.44	1.50	1.35	1.70	2.49
10	4.46	4.91	4.68	4.05	3.98	4.76	4.63	4.21	3.41	4.30	3.90	2.22
9	4.14	4.34	4.41	4.34	4.16	4.60	4.45	4.08	2.30	3.45	2.94	2.76
8	4.18	4.15	3.99	3.78	4.23	3.92	4.16	4.32		2.91	3.28	3.50
7	4.27	3.85	4.03	3.65	5.14	4.50	4.01	3.86	1.13	3.99	3.05	3.82
6	4.75	3.89	4.35	3.75	4.65	4.74	4.69	3.20	3.48	1.98	5.36	2.60
5	4.37	3.81	3.68	4.31	3.89		4.22	2.89	3.62		3.64	4.36
4	1.49			3.44	4.90		2.90					
Average	3.66	4.32	4.32	4.20	3.84	4.09	4.14	3.79	2.39	3.45	3.26	2.90

47

Effect	<u>Pr &gt; F</u>		
	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	0.080	NS	NS
Node (N)	<0.0001	0.0048	NS
I X N	0.024	NS	NS
I X N LSD*	1.24	NS	NS

**Note: NS = Not Significant.**

**\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.**

**Table 14. Average boll weight (g) at time of harvest at the C. M. Stripling Irrigation Park, Camilla, GA in 2005.**

Node	<u>Sympodial Position</u>											
	1			2				3				
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
21	2.91	2.93	1.77	3.13				2.91				
20	4.06	4.04	4.10	3.22	4.96	1.85		2.68				
19	4.17	4.03	4.18	4.71	3.21	4.49		3.54			2.13	4.40
18	5.58	4.63	3.64	4.00	5.03	3.81	3.70	3.37		3.34		4.40
17	4.50	4.45	4.03	4.47	4.59	3.58	4.23	3.87	3.97	4.88		1.88
16	4.89	5.33	4.04	5.23	4.04	3.93	4.58	4.07	3.48	3.91	1.99	4.32
15	5.07	5.55	5.17	5.56	4.45	4.44	4.21	4.69	4.62	4.02	4.78	3.93
14	5.09	5.33	5.18	5.55	4.55	4.92	4.72	4.06	3.51	3.87	3.52	4.11
13	4.84	4.78	5.04	4.77	4.85	5.17	4.92	5.20	4.92	4.92	3.38	5.55
12	5.15	5.04	5.15	5.06	5.88	3.57	4.59	4.70	4.85	5.19	4.31	4.76
11	5.15	5.02	4.55	4.61	4.95	4.98	4.57	5.29	4.62	5.50	4.82	4.86
10	5.68	4.63	4.95	5.18	4.77	5.05	4.49	3.95	5.62	5.31	4.49	4.41
9	4.77	4.51	5.09	4.82	4.09	3.99	4.90	4.23	5.19	3.66	5.01	4.61
8	4.65	3.79	4.59	4.16	4.83	3.17	4.78	4.12	5.74	5.80	5.37	3.69
7	4.89	2.99	4.82	4.07	4.84	4.78	5.64	4.38	5.73	4.78	3.18	5.17
6	4.13	4.37	4.74	4.44	5.21	4.06	4.82	3.42	5.30			
5	3.44	2.99	4.63	3.62	4.76	5.05	4.53	4.40	4.48			
4	4.38	3.84	3.71	3.58	5.53				4.59			2.96
Average	4.63	4.35	4.41	4.45	4.74	4.18	4.62	4.05	4.76	4.60	3.91	4.22

Effect	<u>Pr &gt; F</u>		
	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	NS	0.003	NS
Node (N)	NS	0.098	0.078
I X N	NS	NS	NS
I X N LSD*	NS	NS	NS

**Note:** NS = Not Significant.

\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.

**Table 15. Average boll weight (g) at time of harvest at the Lang Farm, Tifton, GA in 2005.**

Node	<u>Sympodial Position</u>											
	1			2						3		
	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched	Dryland	Overhead	SSD Fed	SSD Matched
21		3.76	3.09									
20		2.80	2.79	2.85								
19	3.79	3.63	3.13	3.55	0.43	1.13						
18	4.32	2.56	3.46	3.39		3.69	3.54	2.64				
17	2.97	3.99	3.17	4.20	3.57	4.46	3.25	0.57			1.92	2.41
16	2.82	4.22	4.30	4.52	3.23	3.02	2.98	2.92		2.71	1.80	0.90
15	3.73	4.50	4.12	4.78	3.49	3.68	3.65	3.49	2.93	2.94		3.73
14	4.13	4.59	4.87	5.12	2.97	3.61	3.90	3.64	4.15	2.88	3.93	3.71
13	4.82	5.22	5.20	5.55	4.33	3.85	4.32	3.91	4.54	3.83	3.42	2.53
12	4.88	5.18	5.31	5.43	3.71	4.12	4.38	4.05	3.99	3.80	2.97	3.75
11	5.40	5.26	5.44	5.36	3.75	4.70	4.68	4.54	4.50	4.10	3.52	3.43
10	5.07	5.14	5.55	5.49	4.68	5.50	4.05	4.71	3.06	3.76	5.58	4.71
9	5.17	5.55	5.51	5.42	4.56	4.18	4.44	4.77	4.23	2.96	2.68	4.85
8	5.43	5.33	5.83	6.06	4.86	4.85	4.89	5.40	4.08	5.03	4.58	4.12
7	5.49	5.37	5.40	5.28	4.88	4.28	4.70	4.84	3.89	6.61	5.69	5.14
6	5.15	5.23	4.53	4.83	4.13	4.90	3.98	4.82	4.01	2.47		3.28
5	4.33	4.72	4.43	3.95	3.55	4.08	4.48	4.14	5.00			
4	4.36	4.33	5.31	4.19	4.10	5.30		4.02	4.21			
Average	4.49	4.52	4.52	4.70	3.75	4.08	4.09	3.90	4.05	3.74	3.61	3.55

Effect	<u>Pr &gt; F</u>		
	<u>Sympodial Position</u>		
	1	2	3
Irrigation (I)	NS	NS	NS
Node (N)	NS	<0.0001	0.041
I X N	NS	NS	NS
I X N LSD*	NS	NS	NS

**Note:** NS = Not Significant.

\* LSD (0.05) is computed from the weighted average standard errors. This LSD is for comparison of irrigation treatments at each node only.

**Table 16. Statistical analysis of intercept and linear, quadratic, and cubic functions from Figure 9 from 20, 24, and 22 DAF for the SIRP '04, SIRP '05, Lang '05 locations, respectively.**

Comparisons	SIRP '04				SIRP '05				Lang '05			
	Intercept	Slope	Quadratic	Cubic	Intercept	Slope	Quadratic	Cubic	Intercept	Slope	Quadratic	Cubic
O vs. F	NS	NS	**	NS	NS	**	**	**	NS	NS	NS	NS
O vs. M	**	**	**	NS	NS	NS	**	NS	NS	**	NS	NS
O vs. D	NS	**	**	**	**	NS	**	*	NS	*	**	NS
F vs. M	**	**	NS	NS	NS	**	**	**	NS	**	NS	NS
F vs. D	**	**	NS	**	*	**	NS	NS	NS	**	**	NS
M vs. D	**	**	NS	**	**	NS	**	*	NS	**	**	NS

**Note: O=Overhead, F=SSD Fed, M=SSD Matched, D=Dryland**

**NS = Not Significant**

**\* Significant at P = 0.05**

**\*\* Significant at p = 0.01**

**Table 17. Fiber quality measurements by high volume instrument (HVI) fiber micronaire, strength, color, length, length uniformity, area percent, and short fiber content at the C. M. Stripling Irrigation Park in 2004.**

Treatment	Micronaire	Staple length	Uniformity	Strength	Elongation	Color Rd	Color +b	Area	SFC	
		mm	%	kN kg <sup>-1</sup>				%		
Dryland	4.71a	30.5a	82.0a	328.3a	4.41b	76.1b	8.80a	0.73a	8.73a	
Overhead	4.24b	29.0b	82.0a	304.3b	5.38a	77.0ab	8.83a	0.90a	9.26a	
SSD Fed	4.23b	30.5a	81.3b	327.6a	4.45b	77.5a	8.25b	0.80a	8.99a	
SSD Matched	4.24b	29.7ab	82.0a	321.7a	4.73b	77.2a	8.25b	0.82a	9.10a	
				<u>ANOVA</u>						
df	44	44	44	44	44	44	44	44	44	
LSD (0.05)	0.15	0.9	0.6	16.6	0.62	1.0	0.36	NS	NS	

\* means followed by the same letter within a column are not significantly different.

\*\* NS = Not Significant

**Table 18. Fiber quality measurements by high volume instrument (HVI) fiber micronaire, strength, color, length, length uniformity, area percent, and short fiber content at the at the C. M. Stripling Irrigation Park in 2005.**

Treatment	Micronaire	Staple Length mm	Uniformity %	Strength kN kg <sup>-1</sup>	Elongation	Color Rd	Color +b	Area %	SFC
Dryland	4.52a	29.5ab	81.3a	288.4a	4.79b	72.2a	8.74a	0.50a	8.31a
Overhead	4.28b	29.7a	81.5a	291.6a	5.04a	73.2a	8.80a	0.59a	7.15b
SSD Fed	4.53a	29.2b	81.4a	286.4a	5.01a	72.0a	9.14a	0.47a	7.98ab
SSD Matched	4.33b	29.6a	81.4a	286.7a	5.00a	72.0a	9.13a	0.47a	7.83ab
<u>ANOVA</u>									
df	44	44	44	44	44	44	44	44	44
LSD (0.05)	0.12	0.3	NS	NS	0.12	NS	NS	NS	0.92

\*means followed by the same letter within a column are not significantly different.

\*\* NS = Not Significant

**Table 19. Fiber quality measurements by high volume instrument (HVI) fiber micronaire, strength, color, length, length uniformity, area percent, and short fiber content at the Lang Farm, Tifton, GA in 2005.**

Treatment	Micronaire	Staple Length mm	Uniformity %	Strength kN kg <sup>-1</sup>	Elongation	Color Rd	Color +b	Area %	SFC
Dryland	4.43a	30.5a	82.7a	300.3b	5.57a	74.3b	8.15c	0.48b	4.73a
Overhead	4.22b	30.5a	82.7a	300.8b	5.47a	75.1a	8.88a	0.63a	4.46a
SSD Fed	4.44a	30.0ab	82.4a	306.6a	5.46a	74.4b	8.42b	0.57ab	4.98a
SSD Matched	4.52a	29.7b	82.7a	304.2ab	5.46a	74.4b	8.31bc	0.63a	5.17a
<u>ANOVA</u>									
df	44	44	44	44	44	44	44	44	44
LSD (0.05)	0.17	0.1	NS	4.7	NS	0.6	0.25	0.13	NS

\* means followed by the same letter within a column are not significantly different.

\*\* NS = Not Significant

**Table 20. Advanced fiber information system (AFIS) fiber length by weight [L(w)], length by weight coefficient of variation [L(w)CV], upper quartile length by weight [UQL(w)], short fiber content [SFC(w)], fineness (Fine), and maturity ratio at the C. M. Stripling Irrigation Park in 2004.**

Treatment	L(w)	L(w) CV	UQL(w)	SFC(w)	Fine	Maturity Ratio
	mm	%	mm	%	mg km <sup>-1</sup>	
Dryland	27.9a	31.1b	33.6a	5.9b	117.4b	0.87a
Overhead	26.5c	33.0a	31.8b	7.3a	170.9a	0.82c
SSD Fed	27.7ab	33.0a	33.5a	7.2a	169.8a	0.83b
SSD Matched	27.1bc	33.0a	32.7ab	7.4a	168.8a	0.82c
			<u>ANOVA</u>			
df	44	44	44	44	44	44
LSD (0.05)	0.7	1.1	1.0	0.8	2.6	0.01

\* means followed by the same letter within a column are not significantly different.

\*\* NS = Not Significant

**Table 21. Advanced fiber information system (AFIS) fiber length by weight [L(w)], length by weight coefficient of variation [L(w)CV], upper quartile length by weight [UQL(w)], short fiber content [SFC(w)], fineness (Fine), and maturity ratio at the C. M. Stripling Irrigation Park in 2005.**

Treatment	L(w)	L(w) CV	UQL(w)	SFC(w)	Fine	Maturity Ratio
	mm	%	mm	%	mg km <sup>-1</sup>	
Dryland	27.1 a	33.4a	32.8a	7.7a	170.2a	0.84a
Overhead	27.1 a	33.5a	32.7a	7.6a	166.4b	0.84a
SSD Fed	27.1 a	33.6a	32.6a	7.6a	169.8a	0.84a
SSD Matched	27.0a	33.8a	32.7a	7.9a	168.8a	0.83a
			<u>ANOVA</u>			
df	44	44	44	44	44	44
LSD (0.05)	NS	NS	NS	NS	2.3	NS

\* means followed by the same letter within a column are not significantly different.

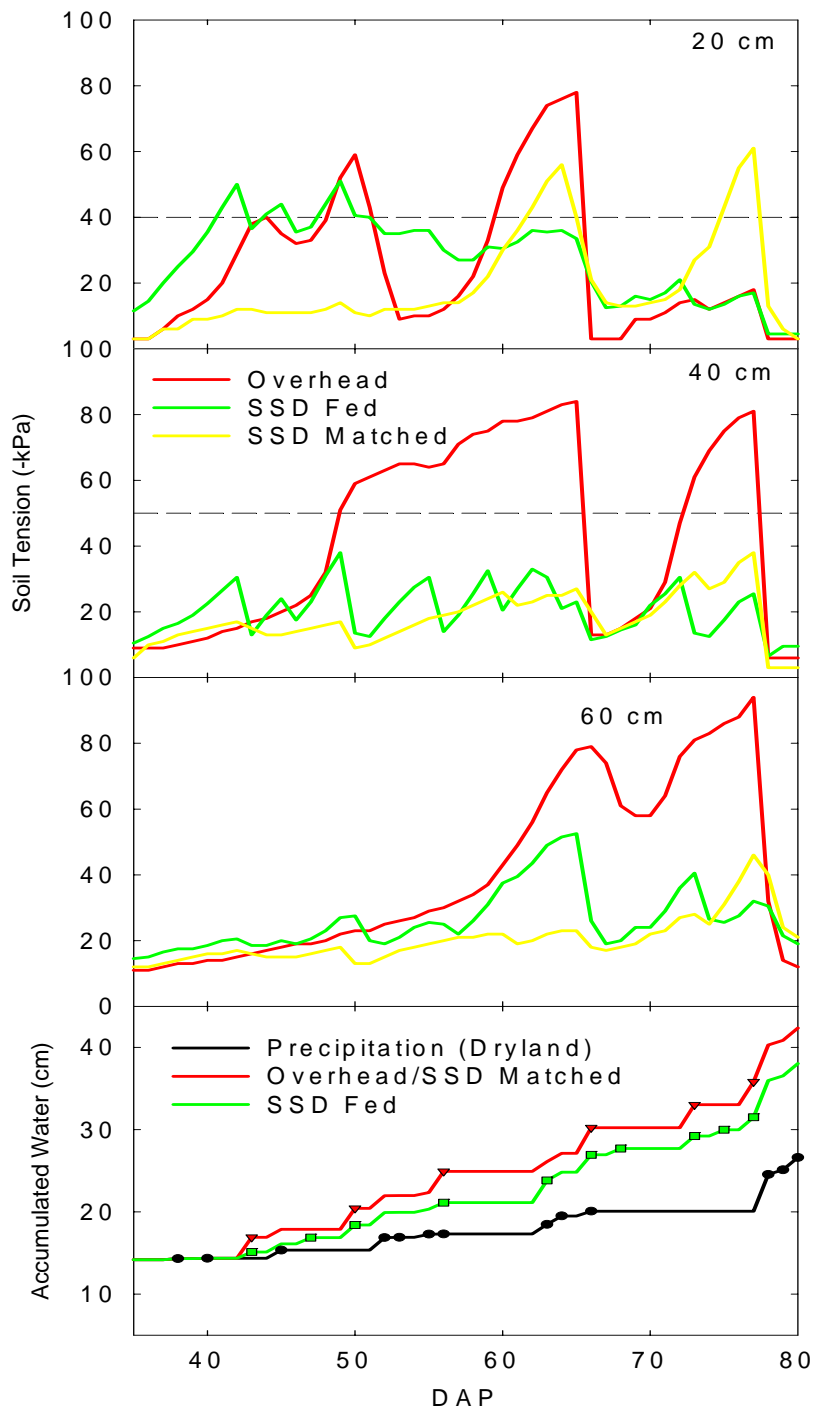
\*\* NS = Not Significant

**Table 22. Advanced fiber information system (AFIS) fiber length by weight [L(w)], length by weight coefficient of variation [L(w)CV], upper quartile length by weight [UQL(w)], short fiber content [SFC(w)], fineness (Fine), and maturity ratio at the Lang Farm, Tifton, GA in 2005.**

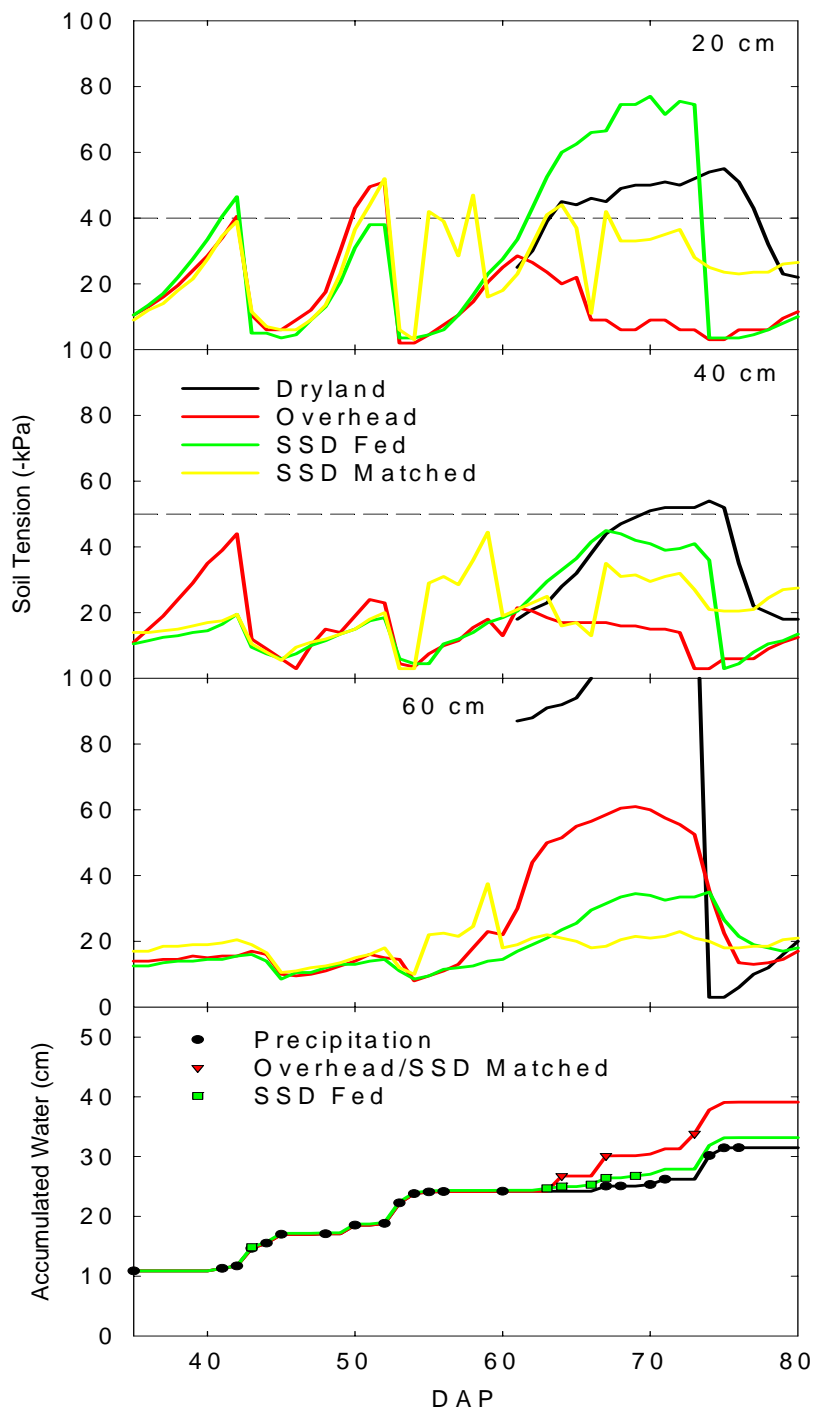
Treatment	L(w)	L(w) CV	UQL(w)	SFC(w)	Fine	Maturity Ratio
	mm	%	mm	%	mg km <sup>-1</sup>	
Dryland	28.0b	30.9ab	33.2b	5.7a	168.8a	0.85a
Overhead	28.5a	31.4a	33.9a	5.8a	164.5b	0.84b
SSD Fed	28.4a	30.8b	33.9a	5.7a	167.8ab	0.85a
SSD Matched	28.6a	30.6b	33.9a	5.5a	170.4a	0.86a
			<u>ANOVA</u>			
df	44	44	44	44	44	44
LSD (0.05)	0.3	0.6	0.4	NS	3.2	0.012

\* means followed by the same letter within a column are not significantly different.

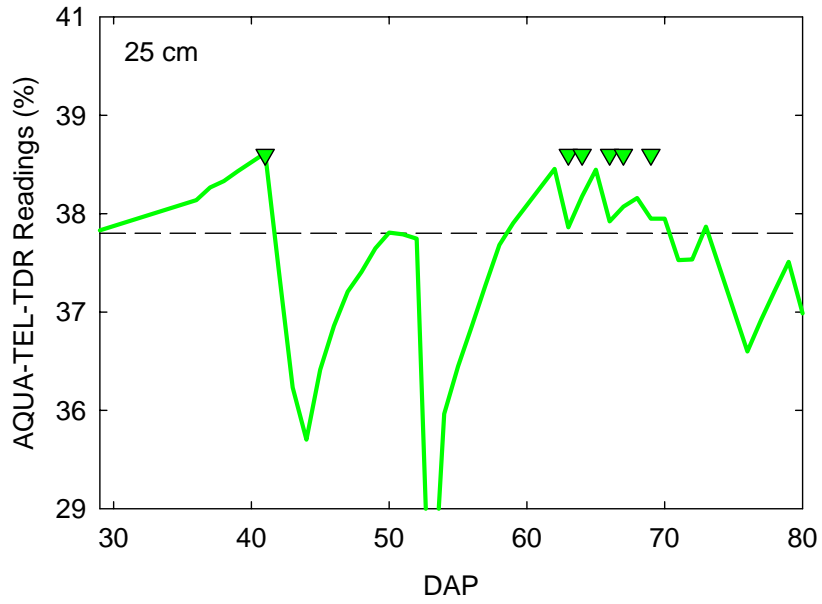
\*\* NS = Not Significant



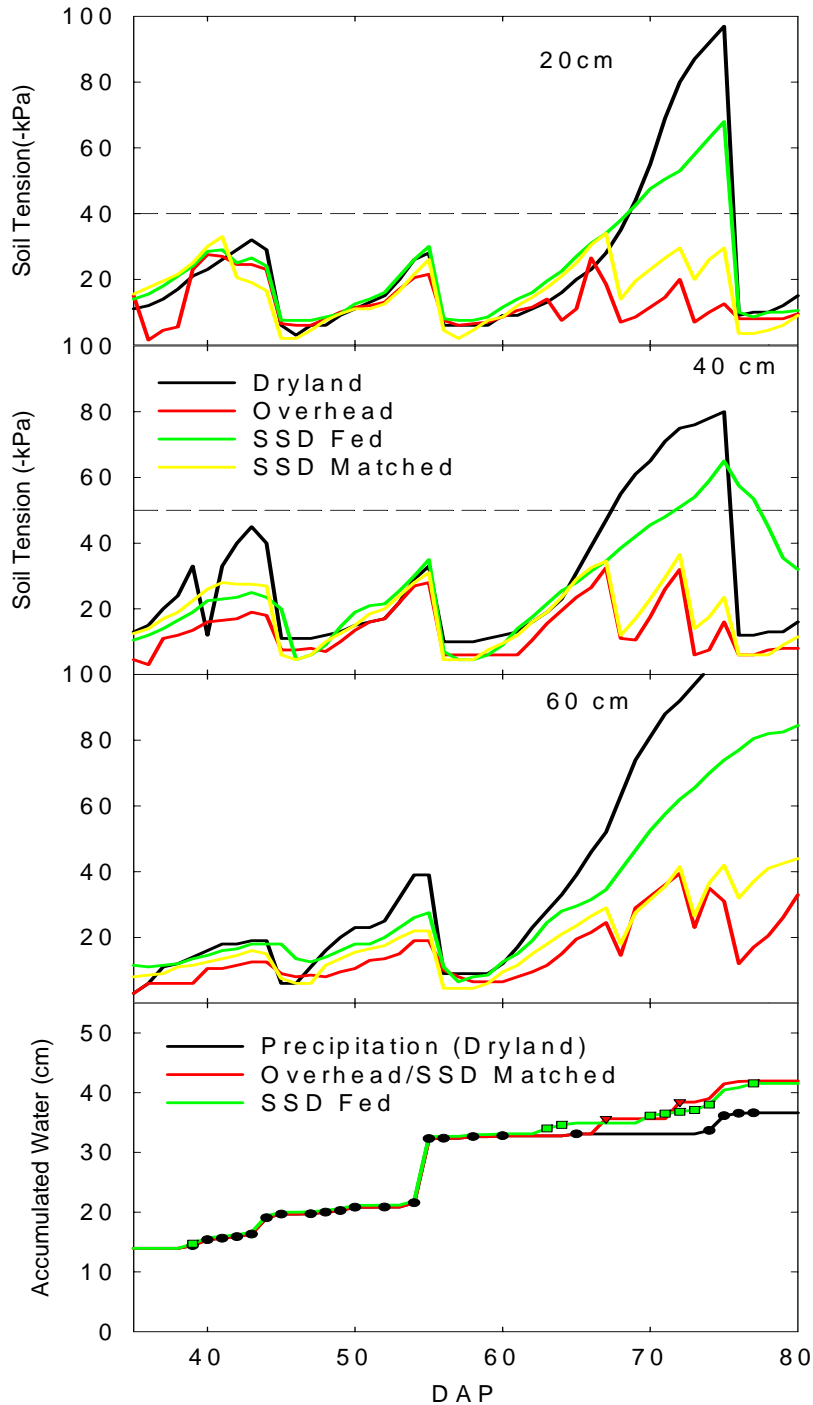
**Figure1. Soil tension (-kPa) measurements from the SIRP '04. Bottom graph represents total accumulated water (cm) from precipitation and irrigation. Accumulated water graph lines begin above zero because of irrigation water applied for emergence and precipitation. Symbols represent rainfall or irrigation events. Soil tension measurements for the dryland treatment are not reported. Dotted lines represent irrigation trigger levels.**



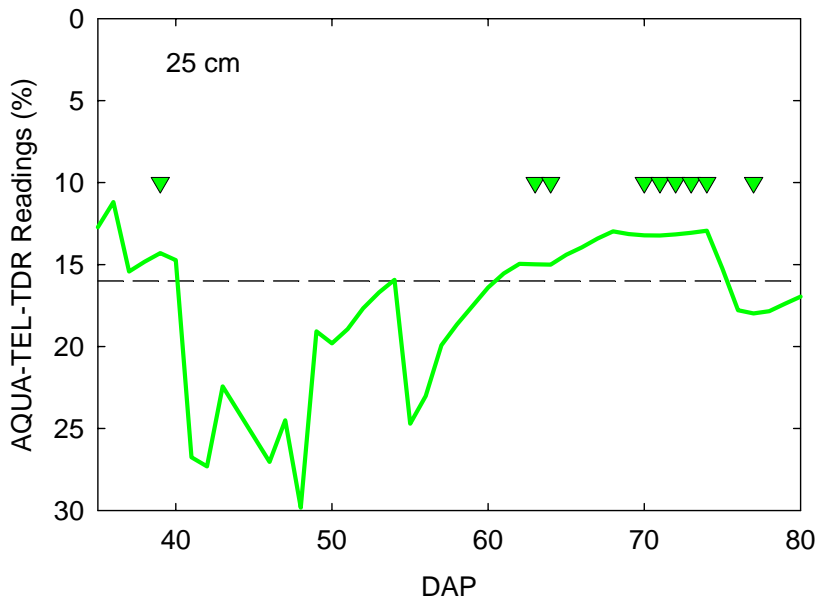
**Figure 2. Soil tension measurements (-kPa) at the SIRP '05 location. Bottom graph represents total accumulated water (cm) from precipitation and irrigation. Accumulated water graph lines begin above zero because of irrigation water applied for emergence and precipitation. Symbols represent rainfall or irrigation events. Soil tension measurements were not recorded in the dryland treatment until 60 DAP. Dotted lines represent irrigation trigger levels.**



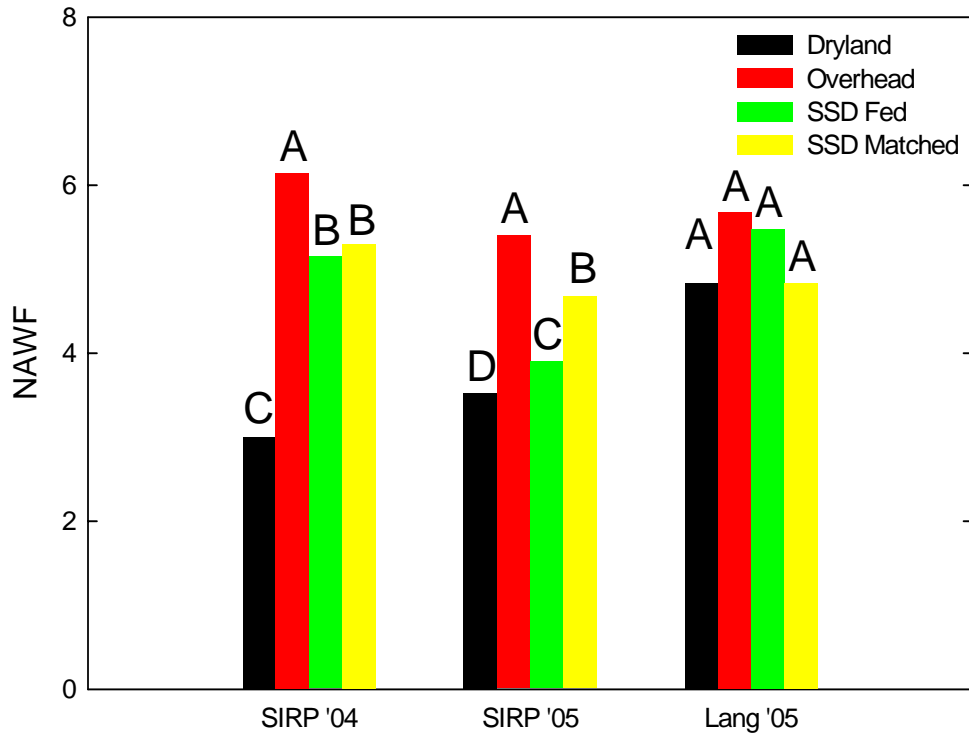
**Figure 3. AQUA-TEL-TDR sensor readings representing relative soil water content (%) measurements from the SSD fed treatment at the SIRP '05 location. The dotted line represents the irrigation trigger point and symbols represent irrigation events.**



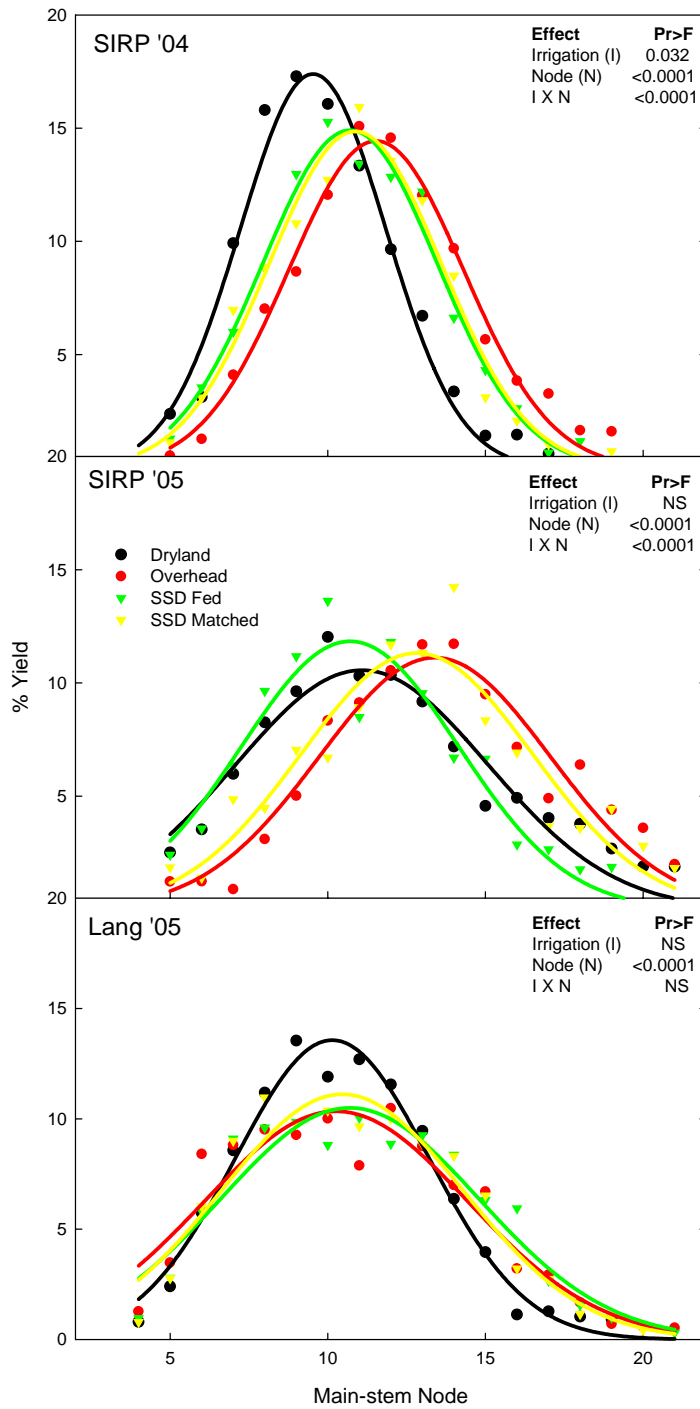
**Figure 4. Soil tension measurements (-kPa) at the Lang '05 location. Bottom graph represents total accumulated water (cm) from precipitation and irrigation. Accumulated water graph lines begin above zero because of irrigation water applied for emergence and precipitation. Symbols represent rainfall or irrigation events. Dotted lines represent irrigation trigger levels.**



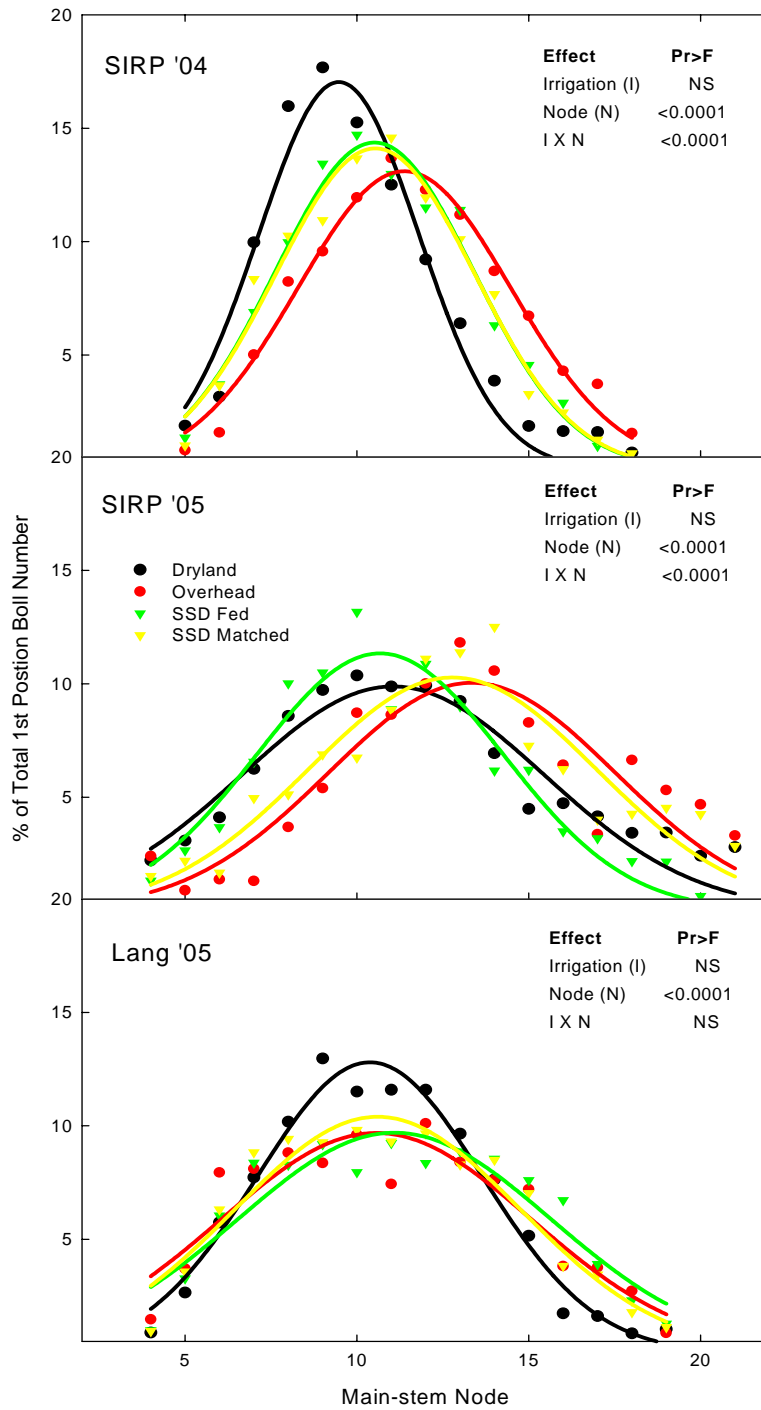
**Figure 5. AQUA-TEL-TDR sensor readings representing relative soil water content (%) measurements from the SSD fed treatment at the Lang '05 location. The dotted line represents the irrigation trigger point and symbols represent irrigation events.**



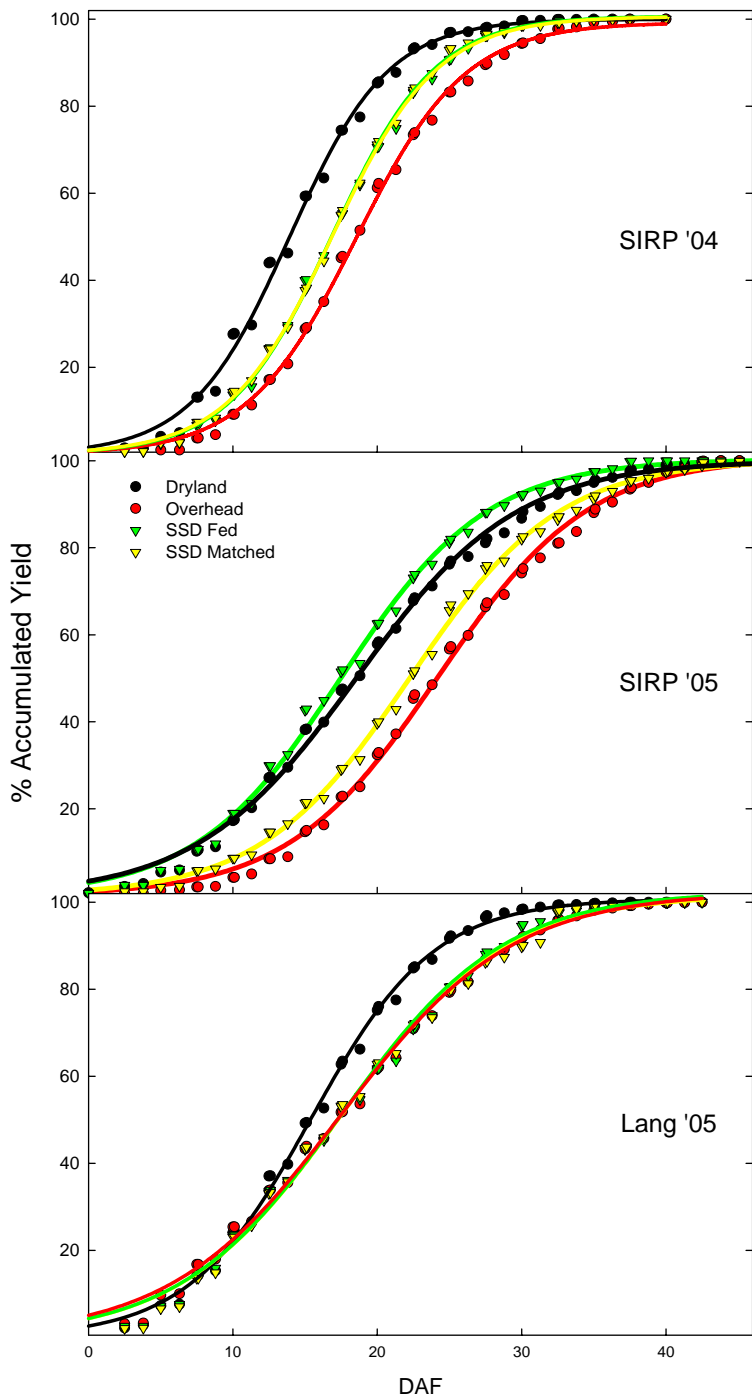
**Figure 6. Maturity measured as main-stem nodes above white flower (NAWF) at approximate cutout taken at 69, 79, and 72 DAP at the SIRP '04, SIRP '05, and Lang '05 locations respectively. LSD(0.05) was calculated to be 0.659, 0.33, and Not Significant for the SIRP '04, SIRP '05, and Lang '05 locations respectively.**



**Figure 7.** Percentage of total 1<sup>st</sup> sympodial position seed cotton (g) at each main-stem node at time of harvest.



**Figure 8. Percentage of total 1<sup>st</sup> sympodial position boll number at each main-stem nodes at time of harvest.**



**Figure 9. Model of percentage of accumulated yield total by days after flowering (DAF) assuming 2.5 days for vertical main-stem nodes and 3.8 days for horizontal sympodial fruiting positions.**

## **CHAPTER 4**

### **CONCLUSIONS**

The objectives of this study were to investigate the agronomic effects of SSD and overhead irrigation. Several properties of cotton growth were observed to obtain a more in depth look at SSD in comparison to overhead irrigation. Our hypotheses were based on the comparisons of the overhead and the SSD matched treatments and between the overhead and the SSD fed treatments. We believed that the SSD matched treatment would produce comparable lint yields with the overhead treatment and the SSD matched treatment would better maintain soil moisture than the overhead treatment. We also believed that the SSD fed treatment would produce several agronomic differences when compared to the overhead treatment. The SSD fed treatment would save applied irrigation water, maintain soil moisture effectively, affect maturity, produce comparable lint yields, shift yield distribution, and ultimately change fiber quality when compared to the overhead treatment. Of the agronomic effects investigated, several differences between the two irrigation systems were found.

A large issue surrounding this study was the possibility for water savings associated with SSD. In this study we recorded irrigation water applications among the different irrigation application methods. It was found that irrigation water can be saved with SSD when compared to overhead irrigation, and thus allows the hypothesis to be accepted. With water use issues becoming increasingly important, SSD may provide producers with an efficient alternative to overhead irrigation in cotton.

Soil moisture was affected by irrigation treatment also. SSD irrigation (when irrigations events of 0.3 cm or larger were applied) maintained soil moisture below the

irrigation trigger point more easily than overhead irrigation at deeper soil depths (40 and 60 cm). SSD also provided a quicker response to moisture deficit than an overhead irrigation. When SSD applied irrigations of less than 0.3 cm, water did not move deep into the soil profile, thus decreasing effectiveness of the SSD irrigating capabilities. SSD also provides a producer with the opportunity to apply multiple irrigation events to the crop in subsequent days when larger overhead irrigation systems typically cannot. The hypothesis in this study was supported in the fact that the SSD fed treatment can be effectively managed to maintain soil moisture.

Maturity was also affected by irrigation treatment. The SSD fed and the SSD matched treatments matured faster than the overhead treatment as determined by NAWF. This increase in maturity provides the possibility of increased earliness when compared to overhead irrigation. Cotton was set typically earlier over the entire plant with SSD compared to overhead irrigation, also supporting the suggestion that SSD irrigation changed yield distribution and increased earliness, a desirable quality to some producers.

Lint yield and its components were notably affected in this study. Results from other studies showed positive yield increases with the use of SSD irrigation. Our study showed that both SSD irrigation treatments (SSD matched and SSD fed) provided a comparable yield response compared to overhead irrigation. The SSD fed irrigation treatment showed positive yield responses over cotton grown in dryland situations when overhead irrigation did not. From a yield standpoint SSD irrigation is a viable option to overhead irrigation and our hypothesis from a lint yield standpoint is accepted.

The yield responses from SSD may have been attributed to yield distribution. Therefore, yield components were analyzed to expand on this observation to investigate

shifts in yield distribution between the SSD fed and overhead treatments. Seed cotton weight was greater at lower main-stem nodes on the plant in the SSD fed treatment compared to the overhead irrigation treatment. Overhead irrigation may have caused fruit abortion from water distributed by the system. Also, a higher percentage of the total yield was found to occur on lower main-stem nodes in the 1<sup>st</sup> sympodial position in the SSD fed treatment compared to the overhead treatment. Percent boll number was also affected by the SSD fed treatment, in which a higher percentage of bolls occurred lower on the plant in the SSD fed treatment and higher percentage of bolls occurred in the overhead treatment higher in the plant. This data provides evidence that a shift in yield distribution occurred between the overhead and SSD fed treatments, which follows our hypothesis.

This study also showed that some advantages associated with overhead irrigation were not lost with SSD irrigation. Overhead irrigation of cotton has been reported to affect fiber quality. HVI and AFIS data collected in this study reported that SSD irrigation showed similar effects on fiber quality as overhead irrigation, except for micronaire and maturity ratio, which was higher in the SSD fed treatment compared to the overhead treatment. Our hypothesis in this experiment suggested that the SSD fed treatment would change fiber quality when compared to the overhead treatment, yet overall, our data does not support this and leads us to reject this portion of the hypothesis.