YIELD, QUALITY, AND FRUIT DISTRIBUTION IN BOLLGARD/ROUNDUP READY AND BOLLGARD II/ROUNDUP READY FLEX COTTON

by

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(Under the Direction of Craig W. Bednarz)

ABSTRACT

New transgenic technology (Bollgard II/Roundup Ready Flex) will continue to revolutionize cotton production. A two year study (2004-2005) was conducted at two locations in southwest Georgia to test the responses of Bollgard II/Roundup Ready Flex (BGII/RRF) and Bollgard/Roundup Ready (BG/RR) to water stress, flower removal (FR), and late glyphosate applications. Late glyphosate applications delayed maturity in BG/RR cotton, which compensated for fruit loss by producing heavier remaining bolls, while BGII/RRF cotton produced a higher number of bolls per 10 plants. The BGII/RRF cotton had increased boll number and weight at the first sympodial position at lower main stem nodes, while BG/RR produced more and heavier bolls on the upper main stem nodes. Flower removal did not negatively affect BGII/RRF or BG/RR, further supporting the hypothesis that compensation for early fruit loss may occur. Few differences in fiber quality were observed.

INDEX WORDS: Bollgard, Bollgard II, fiber quality, flower removal, glyphosate, Roundup Ready, Roundup Ready Flex, water stress

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CHAPTER 1

INTRODUCTION

Cotton is just one of the many crops that have been genetically altered to address challenges with weed and insect control. Most of the cotton grown in the southeastern United States contains transgenes for glyphosate resistance (Roundup Ready) and Bacillus thuringiensis (Bt) toxin (Bollgard) production (Figure 1). Increased use of transgenic cotton has resulted in more efficient insect and weed management practices. Two of the concerns with these technologies are the sensitivity of cotton fruiting structures to glyphosate and the fact that Bt technology relies on a single mode of action, making insect resistance more likely.

In 2006, cotton with two new transgenic technologies will be commercially available. In contrast to Roundup Ready (RR) cotton, the new Roundup Ready Flex (Flex) cultivars have pollen and fruiting structures that are tolerant to glyphosate throughout the growing season. In addition, the new Bollgard II technology has a second Bt toxin with an additional mode of action for increased lepidopteran activity and for resistance management.

Bacillius thuringiensis **(Bt)**

A naturally occurring bacteria, *Bacillius thuringiensis* var. *kurstaki,* that encodes for the Cry1Ac δ-endotoxin has been an alternative to pesticides for management of specific lepidopteran pests which include tobacco budworms (*Heliothis virescens*); bollworms (*Helicoverpa zea*); and pink bollworms (*Pectinophora gossypiella*). *Bacillus thuringiensis* (Bt) is a spore-forming insecticidal bacterium that produces crystal proteins (Cry proteins). The crystals are aggregates of large proteins referred to as protoxins (Federici, 2003). The spore is the outer capsule that protects the reproductive organs which are located just inside the outer walls. The spore is ingested and must become activated for any effect to occur. Plants are engineered to produce the toxin within the plant tissue allowing some protection from worm pests. The crystal protein is highly insoluble at pH below 8.0 making it safer for humans, animals, and most insects. The crystal protein is highly soluble at pH of 8.0 and above selecting for specific lepidopteran species (Federici, 2003). The endotoxin binds to a receptor site located on the stomach lining causing cell lyses.

Bacillus thuringiensis (Bt) provides control of larval pests with a high level of safety combined with selectivity. Each strain of Bt affects a specific group of insects; in this case, caterpillars. In contrast to many chemical insecticides, the Bt toxin does not directly affect many natural enemies of insects. This allows the full integration of natural, beneficial insects in a total pest management program and reduces the use of non-selective insecticides. Bt can be restricted by the development of insect resistance. There are concerns about the development of resistance to Bt. Resistance management efforts with Bt cotton have included refuge programs and the development of dual gene Bt cultivars. Some insects also attack locations within the plant where Bt is expressed at lower concentrations allowing damage. Thus, the focus of the development of dual gene Bt cultivars for increased control is such.

Glyphosate Resistance

Glyphosate resistant crops have been adopted by growers throughout the United States. Currently, 95% of Georgia grown cotton is glyphosate resistant (USDA/AMS, 2005). Glyphosate is a non-selective herbicide widely used to control weeds in agriculture and landscape systems. RR is the commercial term used for glyphosate resistance in specific crops, which include cotton, corn, and soybeans.

Glyphosate is a phloem-mobile herbicide that is translocated throughout plants and accumulates in meristematic tissue. Glyphosate inhibits plant aromatic amino acid biosynthesis by targeting the enzyme 5-enolpyruvylshikimate 3-phosphate synthase (EPSPS) located in the shikimic acid pathway (Franz et al., 1997). EPSPS is responsible for catalyzing the production of shikimate-3-phosphate (SP3) and phosphoenolpyruvate (PEP) into 5-enolpyruvylshikimate 3-phosphate (EPSP). EPSP is a precursor for the formation of amino acids phenylalanine, tryptophan, and tyrosine produced by plants, which are necessary for protein synthesis. The glyphosate molecule mimics PEP, inhibiting the binding of SP3 and PEP, stopping EPSP production. By inhibiting the production of EPSP, which is one step into the shikimic pathway, essential amino acids and protein production further into the process are limited, causing plant shutdown (Franz et al., 1997).

The source of glyphosate resistance in glyphosate-resistant cotton occurs from the use of a naturally occurring form of an EPSP synthase from Agrobacterium strain CP4 (CP4-EPSPS). The CP4-EPSPS is inserted into a plant and is expressed in the rest of the plant. As glyphosate binds in place of PEP to prohibit the necessary production of EPSP, CP4-EPSPS provides a dissimilar binding site not allowing the glyphosate molecule to bind, thus providing a glyphosate resistant organism.

The transfer of genes from one or more species into the genome of an organism is termed transgenics. Genetic modification enhances plant traits for optimal yield and growth by providing resistance or toxins for insect control. One or multiple genes have been transferred to provide enhanced resistance management. In this case, genes have been stacked combining Bt and glyphosate resistance together to provide agronomic crops additional ability to compete with the evolving surrounding environment. In addition, two Bt genes with two different modes of action have been jointly inserted. Genetic alteration has provided a different perspective for scientists and current growers in crop production. Introduction of transgenics has brought a variety of advantages and new challenges.

Glyphosate resistant crops have revolutionized weed management. They have allowed growers to reduce traditional herbicide use and provided more convenience for conventional tillage, no-till, and reduced tillage management systems. Glyphosate is a unique herbicide. It controls many annual and perennial weeds and is readily translocated within sensitive plants. In addition, glyphosate is rapidly absorbed and tightly bound to soil particles, resulting in very little effects on soil pH and the environment. Glyphosate is also known for its wide use and very low levels of weed resistance (Franz et al., 1997).

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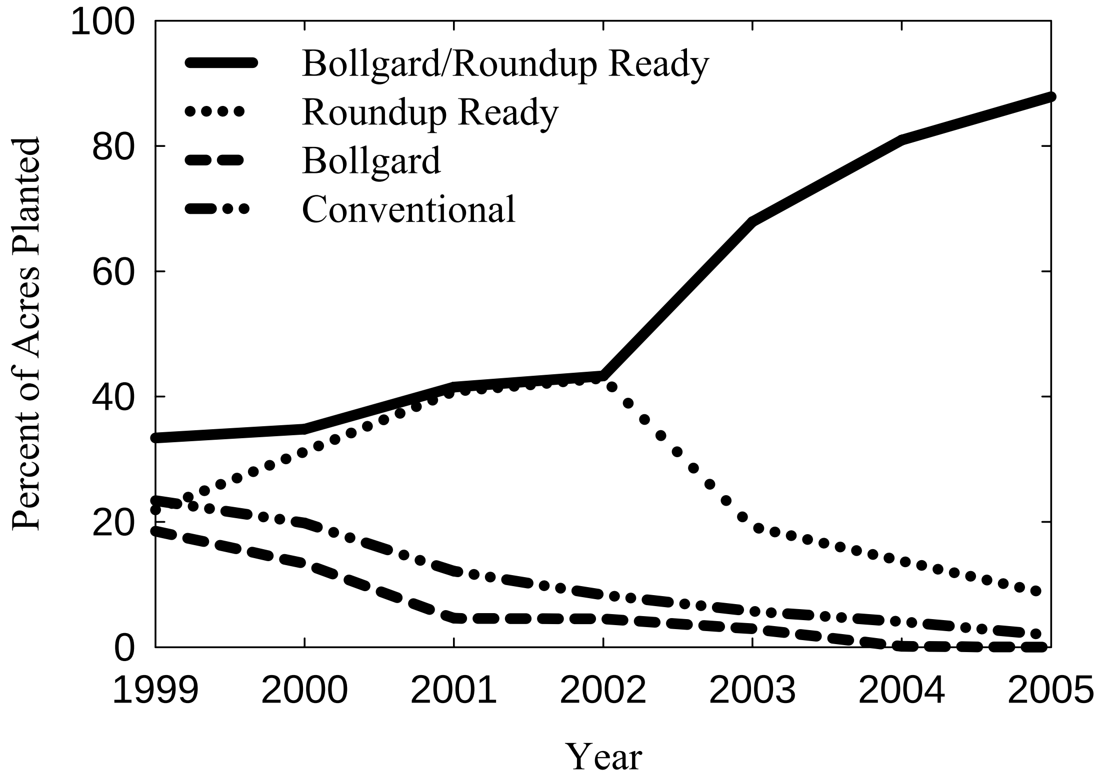

Figure 1. United States Department of Agriculture Agricultural Marketing Service (USDA/AMS) survey report of the percent of acres planted to transgenic cotton from years 1999-2005.

CHAPTER 2

LITERATURE REVIEW

Bollgard Containing *Bacillus thuringiensis* (Bt)

Transgenic crops that are engineered to produce the Bt toxin are widely used and control key pests in cotton. Bollgard, which contains the Cry1Ac δ-endotoxin and Bollgard II, which contains both the Cry1Ac δ-endotoxin and the Cry2Ab δ-endotoxin, have been introduced to provide an alternative integrated management program for larval pests. The addition of these genes has reduced the use of insecticides in the field and has reduced chemical and equipment costs.

Bollgard, containing one insecticidal protein, the Cry1Ac δ-endotoxin (Bt gene), has provided great control on tobacco budworm, *Heliothis virescens*, but has not been as effective on bollworm *Helicoverpa zea* and other foliage feeders. Mahaffey et al. (1995) concluded that high bollworm larvae populations are less susceptible to the Cry 1Ac endotoxin compared with tobacco budworm. These pests have the potential to decrease yields and create a negative economic impact. Differences in the expression of δ-endotoxin have been seen with respect to terminal leaves and flowers in addition to varieties (Greenplate et al., 2000). Expression of the toxin varies throughout the growing season and can result in varying larval mortality. Bollworm larvae have been reported feeding in white flowers of Bollgard cotton. Bollworms were found to move a greater distance from where they were hatched on Bollgard plants when compared to non-Bollgard plants. Larvae were found lower in the canopy of Bollgard plants feeding on white flowers and bolls while larvae on non-Bollgard plants were found feeding on squares and terminals in the upper part of the plant (Gore et al., 2001b).

Bollworm larvae preference to feed on white flowers in Bt cotton could be due to several factors. The flowering structures could provide adequate nutritional needs for the bollworm and toxins could be expressed in lower levels within reproductive units. Bollworm larvae preferring white flowers resulted in similar trends in both non-Bollgard and Bollgard cotton. Therefore, Gore et al. (2001a) suggests that it could be the combination of expression levels and secondary plant chemicals that entice bollworm larvae to white flowers.

Bollgard II cultivars, containing the two Bt endotoxins, were introduced to provide better control of bollworms and to enhance resistance management. Recent studies have shown the pyramiding effect of these endotoxins has significantly increased protection against beet armyworms, soybean loopers, and bollworms (Adamczyk et al., 2001; Gore et al., 2001a). Bollgard II cotton provides a wider spectrum of control than Bollgard and provides superior control of larvae that feed on reproductive structures.

With additional control, Adamczyk et al. (2001) observed higher levels of Cry2Ab endotoxin expressed in the terminal leaves compared to Cry1Ac. Bollgard II genotypes performed significantly better against bollworm larvae damage on squares and bolls than Bollgard cotton. The addition of multiple genes in Bollgard II genotypes sustained lower levels of damage on bolls and squares (Jackson et al., 2003).

Roundup Ready Cotton

An increased amount of glyphosate has been widely used in the past several years for weed control. Glyphosate resistant crops have allowed a greater utilization of this non-selective herbicide. This technology has provided additional convenience to cotton producers by allowing a non-selective herbicide weed control option. This technology allows growers increased convenience, substituting a broad spectrum over-the-top herbicide for several standard residual and post-emergence herbicides. Glyphosate has also significantly displaced tillage, both pre-plant and in crop.

The inserted glyphosate resistant 5-enolpyruvylshikimate-3-phosphate synthase (CP4-EPSPS) gene provides resistance to glyphosate. The current technology shows resistance to topical application up to the fourth true leaf stage. The CP4-EPSPS is expressed in different levels throughout the various tissues in the plant. Pline et al. (2002) reported the stigma, floral bud, anther, apical meristem, petal, and fruiting branch had significantly less concentration of CP4-EPSPS than the leaf and ovary. The amount of CP4-EPSPS expressed in plant parts could affect cotton yield and quality.

The current glyphosate resistance has been exposed to some limitations. The reproductive structures on the plant are sensitive to glyphosate applications after the fourth true leaf stage resulting in fruit abortion. This may be explained by the structure, deposition, and morphology of pollen grains or the amount of CP4-EPSPS content in certain locations on the plant or both (Pline et al., 2003; Pline et al., 2002).

Viable pollen is vital for proper fertilization in a flower. When treated with glyphosate, glyphosate resistant cotton supplied 42% less loose pollen resulting in a decrease in pollen deposition than non-treated glyphosate plants (Pline et al., 2003; Pline et al., 2002). The pollen deposition could also be affected by the longer distance between the anthers and the stigma of glyphosate treated cotton (Pline et al., 2002). Pline et al. (2002) showed the actual pollen grains having a distorted or collapsed structure in glyphosate treated cotton plants. The fertilization process is of primary importance in the production of cotton. The affect on pollen viability caused by late glyphosate application could have a detrimental effect on fruit set and yield.

The male reproductive organs in the flower structure seem to be more sensitive to glyphosate than female organs (Pline et al., 2003). Pline et al., (2003) discovered the most severe damage with glyphosate applications occurs during the first two weeks of flowering, applications thereafter did not have much of an effect. The pollen in the glyphosate treated plants was found to be negatively affected in the three stages of pollen development (Pline et al., 2002). The effects triggered by reduction of fertilized ovules in a boll could cause boll abscission or lower fiber quality. Flowers that open within the first two weeks of bloom are heavier metabolic sinks in comparison to later maturing fruit, and therefore, could receive a larger dose of glyphosate.

Viator et al. (2003) confirmed the amount of glyphosate translocated to bolls increased as the topical application of glyphosate increased. They further showed as the glyphosate increased in bolls, abscission of bolls per plant increased. Glyphosate is absorbed into plants through the leaves and stems. Pline et al. (2001) reported stem tissue absorbs more glyphosate than leaf tissue on an equal area basis. Their study showed a substantial increase in ^{14}C-glyphosate absorption after the fourth leaf stage Glyphosate was applied foliar postemergence (POST) and POST-directed spray (PDS) at the 4^{th} leaf, 8^{th} leaf, 12^{th} leaf, and midbloom stages resulting in averages of 19, 29, 45, and 41% absorption respectively (Pline et al., 2001). They found the 12^{th} leaf stage had higher levels of absorption when compared with the other growth stages. Conversly, Harris and Vencill (1999) found more ^{14}C-glyphosate was absorbed at the match head square stage of growth than at first white-flower stage when applied to either the leaves or stems. Glyphosate could have a greater absorbance potential when applied at reproductive stages compared to vegetative stages (Pline et al., 2001). Glyphosate absorption however, is affected by application styles, growth stage, and the environment. Radio labeled studies indicate ^{14}C-glyphosate remains in the plant throughout the growing season and that it accumulates in the reproductive tissues as shown by others (Pline et al., 2001; Viator et al., 2003). Thus, applications of glyphosate during reproduction could pose a problem with sensitive cotton fruiting structures.

Vaitor et al. (2003) observed that boll abscission occured when 35 ug/g of glyphosate was present within cotton bolls. Viator et al. (2003) also reported bolls that were not aborted contained less glyphosate than those abscised by various applied glyphosate rates at the 12th leaf stage. Furthermore, as glyphosate application rates increased, the numbers of first and second position bolls were reduced overall by 45 %. In addition, glyphosate reduced the number of bolls, flowers, and squares on the lower, middle, and upper parts of the plant (Viator et al., 2003). Previous research has also shown damage at lower parts of the plant (Jones and Snipes, 1999). Yield loss from later glyphosate applications either over the top or directly applied toward the base of cotton plants has been documented (Kalaher et al., 1997; Viator et al., 2004). Others have reported that over the top applications of glyphosate sometimes did not significantly affect lint yield (Jones and Snipes, 1999; Viator et al., 2004). Cotton plants treated after the fourth leaf stage (seventh leaf stage) had lower number of bolls than the untreated in addition to the lower number of first position bolls (Pline-Srnic et al., 2004). Research has shown that late glyphosate applications have an effect on the number of bolls and specifically first position bolls. In conjunction with these findings, abnormal boll abscission and boll numbers varies with changeable environmental factors (Jones and Snipes, 1999; Pline-Srnic et al., 2004; Viator et al., 2003); (Viator et al., 2004).

Compensation For Fruit Loss

Cotton is an indeterminate plant with a perennial growth habit. As bolls, flowers, or squares are aborted the cotton plant attempts to compensate for the lost fruit by initiating fruit in other areas of the plant. Bednarz and Roberts (2001) observed early-season removal of floral buds moved cotton seed production to the upper and outer fruiting positions. Kennedy et al. (1986) reported an increase in plant size when exposed to early floral bud removal. Plant height, leaf area index, and number of sympodial branches were increased with early bud removal. Fruit set was more rapid in a shorter time interval but the total number of bolls was not different (Kennedy et al., 1986). Therefore, cotton plants have the ability, if given suitable environmental conditions, to compensate for lost fruit.

Ungar et al. (1987) reported square-removal or small boll removal did not result in significant yield reduction but delayed maturity by up to 3 weeks. Late large-boll removal however, had significant negative effects on yield (Ungar et al., 1987). They also reported that compensation from large boll removal was improved when the actual boll set was delayed because of the square removal earlier in the season. Thus, compensation is also affected by the time of fruit removal (Ungar et al., 1987). In addition, the concept of overcompensation has been discussed. Over compensation is defined as a cotton plant compensating for fruit loss to the point that the final yield is actually increased compared to the yield that would be observed under no fruit loss. Stewart et al (2001) observed overcompensation where all squares were removed from the plant one week after squaring began resulting in a yield increase. They furthered explained this overcompensation occurred by increasing the number and weight of bolls produced following early-season square removal.

Crop Maturity

Environmental stress and boll load are suggested to be responsible for mid summer cut-out in cotton (Patterson et al., 1978). Saleem and Buxton (Saleem and Buxton, 1976) observed a cyclic pattern with low levels of total available carbohydrates during mid season. Their study showed developing bolls effectively reduced the total available carbohydrates levels throughout the plant, slowing vegetative growth. Rank vegetative growth in turn, reduced the total available carbohydrate levels and thereby reduced reproductive growth. Thus, excess vegetative or reproductive growth competes for total available carbohydrates (Saleem and Buxton, 1976).

Some have suspected that high temperatures and high relative humidity have attributed to low boll retention in mid season. Research has shown that high temperatures and humidity had no direct relationship to low boll retention (Ehlig and LeMert, 1973). They reported that the level of early fruit load is the primary cause of low boll retention and abscised flowers in midseason. Furthermore, Patterson et al. (1978) concluded that boll load was the main factor in the timing of cut-out in the cultivars tested. Ehlig and LeMert (1973) also observed plants that set fruit immediately after flowering expressed low boll retention from July until the flowering process decreased. Flower removal treatments during the growing season or as flowering declined resulted in an increase in percent boll retention during normal low boll set or cut-out in mid season (Ehlig and LeMert, 1973; Patterson et al., 1978). Furthermore, when the boll load was low in early season, boll retention at midseason was increased regardless of temperature or humidity (Ehlig and LeMert, 1973).

Bollgard II provides improved caterpillar control that could lead to an accelerated increase in maturity. As the number of damaged fruit decreases, the available carbohydrates produced by the plant are used up more readily. Thus, setting fruit earlier could cause low boll retention and affect the timing of cut-out as was discussed previously (Ehlig and LeMert, 1973; Patterson et al., 1978).

This phenomenon, of excessive fruit retention, is further discussed by Hay and Walker (1989). As a plant undergoes photosynthesis it produces substrate. This substrate in turn is used by the plant for maintenance of growth and new growth. Growth is categorized as vegetative or reproductive. If the plant uses the majority of its substrate for reproductive growth early in the season, vegetative growth could become neglected and early cut-out could occur. This phenomenon in cotton could be explained as too high fruit retention.

The new technology (tradename Roundup Ready Flex) has been introduced that may provide growers additional weed control options with a wider application window. May et al. (2004) confirmed the new technology does have extended resistance to later and higher dosages of glyphosate than the current Roundup Ready technology. With extended glyphosate protection, more fruit were produced on the first five, first position, fruiting sites (May et al., 2004) as opposed to Roundup Ready. As discussed earlier, when early boll load was high, low boll retention in midseason or midseason cut-out occurred (Ehlig and LeMert, 1973).

Hypothesis

1) Fruit retention can be too high such that the crop cuts out prematurely, especially when exposed to stress.
2) The new generation technology may result in increased fruit retention.

Objectives

The purpose of this study was to compare yield, quality, and yield distribution from the current technology, Bollgard/Roundup Ready cotton (BG/RR), and with the new technology, Bollgard II/Roundup Ready Flex cotton (BGII/RRF). The current technology responds with fruit abscission after late glyphosate application while the new technology does not. How does this affect the plant when exposed to environmental stresses? Does fruit distribution differ? How does each plant respond to early fruit set when one sheds fruit and the other does not? If early fruit set is successful, will the new technology prematurely cutout with high fruit retention early in the season when exposed to stress? Does the current technology have the ability to compensate for early fruit loss? If the boll distribution is different, are there any fiber quality differences? How does Bollgard II perform compared to Bollgard? These are some answers that would aid the questions of researchers and growers.

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CHAPTER 3

MATERIALS AND METHODS

Cultural Practices

Studies were conducted in one location in 2004 and two locations in 2005. The 2004 study was conducted at the University of Georgia Coastal Experiment Station Gibbs Farm (Gibbs 2004) on a Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults). The study in 2005 was repeated at the Gibbs Farm (Gibbs 2005) and was conducted at the University of Georgia CM Stripling Irrigation Park Camilla, GA (Stripling 2005) on a Lucy loamy sand (loamy, kaolonitic, thermic, Arenic, Kandiudults). 'Suregrow 215' cultivar with Bollgard/Roundup Ready and recurrent parent of 'Suregrow 215' with Bollgard II/Roundup Ready Flex transgenics were planted on 2 June 2004 (Gibbs 2004), 11 May 2005(Gibbs 2005), and 20 April 2005 (Stripling 2005) with a Monosem air planter (Lenexa, KS) on 91-cm-row widths. While planting, 6.7 kg ai ha^{-1} aldicarb [2-methyl-2-(methylthio) propionaldehyde *O*-(methylcarbamoyl)oxime] was applied in furrow for insect control. Fertility, weed control, and insect scouting and control measures were in accordance with the University of Georgia Cooperative Extension Service guidelines (Jost et al., 2005). Lepidopteron insecticide sprays were withheld and the cotton plants were observed for possible caterpillar damage. Moth traps were installed at each end of the field plots to quantify bollworm, *Helicoverpa zea,* and tobacco budworm, *Heliothis virescens*, populations in the surrounding area. Harvest aids were applied [2.3 L ha^{-1} of ethephon, 2-chloroethylphosphonic acid, plus cyclanilide, 1-(2,4-dicholoroanilinocarbonyl) cyclopropanecarboxylic acid, and 0.7 kg ai ha^{-1} of thidiazuron, 1-

phenyl-3-(1,2,3-thiadiazol-5-yl)urea] when the crop reached 90% open boll (7 Oct. 2004, 28 Sept. 2005, and 14 Sept. 2005).

The 2004 design was a split plot with 5 dryland and 5 irrigated replicates. Specific guidelines were observed for new technology cotton trials in 2004. Plots were 21 m long and 3.66 m wide (4 rows) with a 9 m buffer regions between irrigation treatments in addition to a 12.19 m border region around the entire perimeter. The design, at both locations in 2005, was a split plot with 4 dryland and 4 irrigated replicates. Plots were 21 m long and 1.83 meter wide (2 rows) with 9 m buffer regions between irrigation treatments. Variety and flower removal treatments were randomized within each irrigation treatment. The plots were irrigated using a linear overhead sprinkler system. Three sets of watermark sensors were buried at depths of 20, 40, and 60 cm and irrigation triggers were set at -40, -50, and -50 kPa to minimize drought stress for each study.

Glyphosate Applications

Glyphosate was applied (Roundup Weathermax) over-the-top at the 3rd leaf (6.5 L ha^{-1}) and 7th leaf (9.76 L ha^{-1}) stages plus directed at the bottom 53.3 cm of the plants (9.76 L ha^{-1}) at the 12th node.

Plant Mapping And Flower Removal

Ten plants in each plot were mapped weekly for main stem nodes, plant height, nodes above first square or white flower, and number of present and missing first-position fruit. The days required to crop maturity was determined by 4 nodes above white flower and 3 nodes above cracked boll. In bloom removal plots, bloom shedding was simulated by removing blooms by hand. After flowering began, blooms were removed daily for one week and counted.

Yield Data

A section of 3.1 m from the middle two rows in each plot was reserved for hand harvest. Prior to harvest, plants were removed from this area and harvested by fruiting position to determine the percent of total yield from each fruiting position. The remainder of plots was machine picked and ginned at University of Georgia Micro-Gin for gin percentage, lint yield, and fiber quality determinations. Fiber quality samples were sent to Cotton Incorporated for high volume instrument (HVI) analysis and advanced fiber information system (AFIS) analysis.

Statistical Analyses

Statistical analyses were conducted on lint yield (kg ha^{-1}), total boll weight (g m^{-2}), number of bolls per 10 plants, total boll number (m^{-2}), and the average boll weight (g $boll^{-1}$). Total boll weight and total boll number were totaled over all nodes and positions per plot. Number of bolls per 10 plants and average boll weight were averaged over all nodes and positions per plot. The first model analysis was presented as least squares means (LSM) taken from proc MIXED (SAS Inst. 2002) output. In the second analysis, first, second, and third sympodial positions were included but only first sympodial position least squares means (LSM) were presented.

The experimental design at each location and year was a split plot with 4 replications (Gibbs 2005 and Stripling 2005) or 5 replications (Gibbs 2004) where irrigations were the main plot and the remaining two factors were variety and flower removal arranged as a factorial. The analyzed variables were: lint yield (kg ha^{-1}), total boll weight (g m^{-2}), number of bolls (per 10 plants), total boll number (m^{-2}), and the average boll weight (g). These variables were analyzed using proc MIXED (SAS Inst. 2002) where irrigation, variety, and fruit removal were fixed effects and rep, main plot error, and subplot error were random effects. Variables were also analyzed considering nodes as a fixed effect, using a split split plot design. Since node could not be randomized it is considered as an effect in space for total boll weight (g m^{-2}), number of bolls (per 10 plants), total boll number (m^{-2}), and the average boll weight (g).

There were two models used to analyze the data because not every one of the 8 treatments had the same number of nodes. The first model involved the 8 treatments and the main effect of nodes as the fixed effects; with the following effects in the random statement: rep, main plot error, subplot error, rep by node, irrigation by variety, by flower removal, by node, and residual error. The second model has irrigation by variety, by flower removal, by node as a single fixed effect with rep, main plot error, subplot error, rep by node, and residual error in the random statement. Inspections of irrigation by variety, by flower removal, and by node in the first model in the random statement provides us an idea of how much interaction there is when the same effect is run in the second analysis as a fixed effect.

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CHAPTER 4

RESULTS AND DISCUSSION

Lepidopteran Quantification

Moth data. Bollgard and Bollgard II cotton were assessed through on site field observations and moth counts of tobacco budworm (*Heliothis virescens*) and bollworm (*Helicoverpa zea*). Damage was observed and assessed in the vegetative tissues and boll parts of the plant. In 2004, moth numbers were not quantified. Moth data in 2005 was quantified by placing moth traps at each end of the fields at Gibbs 2005 and Stripling 2005 to estimate potential bollworm and tobacco budworm pressure (Figure 2). Figure 2 illustrates the general trend in populations of the two species throughout the growing season. Populations varied between locations, providing an estimation of bollworm and tobacco budworm pressure in each area. No plant damage was observed.

Maturation

Irrigation. Bourland et al. (2001) explained that physiological cutout in cotton occurs when nodes above white flower ~ 5.0. As cotton matures, the addition of nodes to the plant slows and eventually ceases. This is due to the increased assimilate that is partitioned to more fruiting sites (Bourland et al., 2001). Irrigation triggers were based on watermark sensor readings and the amount of rain received (Figure 3). Crop maturity was affected by irrigation in this study at 0.05 and 0.01 p-values (Tables 1-3). Gibbs 2004 (Table 1) had fewer nodes above first square/white flower (NAFS/WF) in the non-irrigated at 63 and 72 days after planting (DAP) when compared to the irrigated. Stripling 2005 (Table 3) showed similar trends from 76 DAP through 104 DAP. Significant results were found mid to late season. Pettigrew (2004a) observed that NAWF differences due to irrigation were not seen until later in the growing season. Humid, temperate environments can cause slower developing and less severe drought stress which delays physiological response to moisture deficit stress (Pettigrew, 2004b). This may be attributed to the amount of available water in the beginning of the season providing adequate water for sustainable growth which is subsequently depleted later in the growing season.

Variety. Bollgard/Roundup Ready (BG/RR) and Bollgard II/Roundup Ready Flex (BGII/RRF) cotton showed similar trends in maturity progressively to the point of maximum NAFS/WF. At Gibbs 2004, Gibbs 2005, and Stripling 2005 maximum NAFS/WF occurred at 55 DAP (Table 1), 63 DAP (Table 2), and 63 DAP (Table 3) respectively. In all locations differences in NAFS/WF were observed. In all locations the BGII/RRF cotton matured quicker. This could be explained by the early fruit loss caused by the late glyphosate application. Also, while both varieties had similar background, genetics of the different transgenic events may have resulted in differences in maturity.

Irrigation By Variety (I x V). Irrigation by variety interaction was observed in all environments. However, these interactions were not consistent and reasonable conclusions cannot be drawn.

Removal. Early-season bloom removal was also significant at all locations affecting maturity. Generally, early-season bloom removal resulted in delayed maturity.

Lint Yield

Irrigation. Lint yield was significantly affected by irrigation at Gibbs 2004 (Table 4) and Gibbs 2005 (Table 5) at a p-value of 0.10. Irrigation resulted in higher lint yield in these two environments. The lack of response to irrigation at Stripling 2005 was likely due to several precipitation events throughout the growing season that measured 20 mm or more of rainfall (Figure 3).

Variety. Significant yield differences were observed at Gibbs 2005 (Table 5) with BGII/RRF yielding 1355 kg ha^{-1} and BG/RR yielding 1425 kg ha^{-1} and at Stripling (Table 6) with BGII/RRF yielding 1140 kg ha^{-1} and BG/RR yielding 1221 kg ha^{-1}. The loss of sensitive fruiting structures in BG/RR from late glyphosate application was observed by May et al. (2004) but did not have a negative yield impact. May et al. (2004) observed BGII/RRF cotton extends resistance to glyphosate providing the capability to produce yield at lower main stem nodes and first position fruiting sites. In the current study, BG/RR compensated for early season fruit loss due to late glyphosate applications (discussed later). In addition, Jones and Snipes (1999) observed similar yields when comparing RR varieties with and without late glyphosate applications, but decreased boll retention at lower main stem nodes and first position fruiting sites with late glyphosate applications. Even though second and third sympodial positions, in general, are not major contributors to lint yield, under early fruit loss conditions yields are shifted to these more distal fruiting positions (Bednarz and Roberts, 2001).

Irrigation By Variety (I x V). Irrigation by variety interaction was significant at Gibbs 2004 (Table 4) only. At this location under irrigated conditions, lint yield was higher in the BG/RR cotton. However, this trend was not repeated in non-irrigated conditions. These results suggest that RR cotton could not compensate for fruit shed from late glyphosate applications or early-season flower removal under non-irrigated conditions.

Removal. Flower removal (FR) treatment, which was conducted during the first week of blooming, was significant at Stripling 2005 (Table 6). At this location FR resulted in increased yields relative to the NoFR treatment (1243 versus 1118 kg ha^{-1} respectively). Stewart et al.

(2001) reported a yield increase when all squares were removed from the plant one week after squaring began. It has been suggested early-season fruit loss may extend vegetative growth and improve the crop's ability to acquire resources such as water, sunlight, and nitrogen, resulting in increased yields (Sadras, 1995). Late season boll removal, however, has been shown to reduce total lint yield (Jones et al., 1996). Thus, the amount of reproductive compensation after fruit loss is generally dependent upon the stage of crop development when the loss occurred, growing season length, and environmental conditions (Jones and Snipes, 1999; Jones et al., 1996).

Lint Percent. Lint percent was highly significant with a p-value of 0.01 at all three locations (Tables 4-6). The BG/RR variety had significantly higher lint fraction when compared with BGII/RRF. Generally, smaller seed size has a higher lint percentage when compared to a larger seed.

Total Boll Weight (g m^{-2})

Irrigation. Irrigation effects on total boll weight were observed at Gibbs 2004 (Table 7). At this location total boll weight was greater at first sympodial position only.

Variety. Jenkins et al. (1990) concluded that main stem nodes 9 through 14 were generally the largest contributors to yield. They also observed first sympodial position fruiting sites accounted for 71% of the yield averaged over two years while second sympodial position averaged 20%, and third sympodial position averaged 3%. BGII/RRF and BG/RR cotton showed significant differences at the second and third sympodial positions at Gibbs 2004 (Table 7) and Stripling 2005 (Table 9) locations. At both locations BG/RR had greater total boll weight at second and third sympodial positions. Total boll weight (g m^{-2}) across nodes show a variety yield distribution trend (Tables 10 and 12). Total boll weight in BGII/RRF at first sympodial position at main stem nodes 5-10 respectively was greater when compared to BG/RR under non-irrigated conditions. Under irrigated conditions, BGII/RRF produced a greater total boll weight at main stem nodes 5-8 respectively. BG/RR generally resulted in greater total boll weight above main stem nodes 8 and 10 in both irrigation treatments. These results may be explained by the fruit loss caused by late glyphosate applications. May et al. (2004) observed nearly 50% fruit loss when RR cotton received 4 topical glyphosate treatments with 3 applications being applied after the 4^{th} leaf stage. This supports the hypothesis that compensation for fruit loss results in redistribution of fruit to outer sympodial positions and upper main stem nodes.

Removal. Flower removal differences were observed at all three locations (Tables 7-9). Generally, FR resulted in greater total boll weight at outer sympodial positions. Bednarz and Roberts (2001) found early season removal of floral buds resulted in additional cotton production on more apical and distal fruiting positions. This could explain the compensatory response to FR in this study. Sadras (1995) developed four types of responses for plant compensation for fruit loss. One response is an active and instantaneous response in which resources that would have been partitioned into damaged structures are partitioned into undamaged structures resulting in heavier fruits. Another response is an active and time-dependent response in which resources that would have been partitioned into damaged structures are partitioned into additional fruiting structures (Sadras, 1995). The increase in total boll weight (g m^{-2}) at second and third sympodial positions with FR in the current study supports both of these hypothesies. Information provided above (Tables 1 and 3) indicates FR resulted in delayed crop maturity (NAFS/WF) at two out of the three locations. These data support the active and time-dependent response which indicates resources that would have been partitioned into damaged structures are partitioned into additional fruiting structures.

Variety By Removal (V x R). Variety by removal interaction was highly significant at Gibbs 2004 (Table 7) at the second sympodial position. At this location FR in BGII/RRF resulted in an increase in total boll weight at the second sympodial position while FR in the BG/RR did not. This observation also supports the hypothesis that early-season fruit retention could be too high and FR may extend vegetative growth which would improve the crop's ability to acquire resources such as water, sunlight, and nitrogen, resulting in increased total boll weights (Sadras, 1995).

Number Of Bolls Per 10 Plants

Irrigation. Significant irrigation effect was observed at Gibbs 2004 (Table 13) in the number of bolls per 10 plants. At this location irrigation increased the number of bolls per 10 plants at the first and second sympodial positions. Guinn and Mauney (1984) also observed that water deficit decreased flowering and boll retention. As has been previously discussed, irrigation increased lint yield and total boll weight at this location. These data suggest that increased yield occurred, at least in part, from an increase in the number of bolls per 10 plants.

Variety. At Gibbs 2004 (Table 13) BGII/RRF resulted in greater number of bolls per 10 plants in the first sympodial position compared to the BG/RR. First sympodial position data at Gibbs 2005 and Stripling 2005 locations (Tables 14 and 15) were not significant but followed a similar trend with BGII/RRF having a higher number of bolls per 10 plants than did BG/RR. Conversely, at Stripling 2005 (Table 15) BG/RR resulted in a greater number of bolls per 10 plants in the second and third sympodial positions relative to the BGII/RRF. Significant effects were not detected at Gibbs 2004 and Gibbs 2005 (Tables 13 and 14) but followed a similar trend of the BG/RR having a greater number of bolls per 10 plants than the BGII/RRF in the second and third sympodial positions. The differences of the number of bolls per 10 plants observed at the second and third sympodial positions are in agreement with the same differences observed in total boll weight (g m^{-2}) discussed above (Tables 7 and 9).

In the non-irrigated treatments at Gibbs 2004 (Table 16) and Stripling 2005 (Table 18), BGII/RRF generally resulted in a greater number of first sympodial position bolls per 10 plants at main stem nodes 5-9 when compared to BG/RR. BGII/RRF also resulted in a greater number of bolls per 10 plants at main stem nodes 8-10 in the irrigated treatments at all locations. Generally, BG/RR resulted in a greater number of first sympodial position bolls per 10 plants compared with BGII/RRF at main stem nodes 13-20 at Stripling 2005 (Table 18). Generally, the BGII/RRF resulted in a higher number of bolls per 10 plants compared with BG/RR in the lower plant canopy while BG/RR was resulted in a higher number of bolls per 10 plants compared with BGII/RRF in the upper plant canopy. These findings help support the concept of BG/RR compensation from fruit loss caused either by late glyphosate applications or early-season fruit removal.

Removal. Bednarz and Roberts (2001) observed under intense early-season floral bud removal the probability of harvesting a mature boll was reduced in the lower plant canopy and in the first sympodial position. However, floral bud removal increased the probability of harvesting a mature boll in the upper canopy and in the third sympodial position (Bednarz and Roberts, 2001). In the current study, FR was significant at the first and third sympodial positions at Gibbs 2005 (Table 14). At this location, the number of first sympodial position bolls per 10 plants was greater for the NoFR treatment In contrast, the number of third sympodial position bolls per 10 plants were greater for FR treatments. In addition, at Gibbs 2004 (Table 13) the number of second and third sympodial position bolls per 10 plants was greater in the FR treatment. Bednarz and Roberts (2001) attributed these changes in yield distribution to the hypothesis that greater retention of reproductive structures, in the upper canopy and third sympodial position occurred in plants which had early season FR (Sadras, 1995). Changes in yield distribution could also support the other hypothesis supporting the production of additional fruiting sites (Sadras, 1995).

Variety By Removal (V x R). Variety by removal interaction was highly significant at Gibbs 2004 (Table 7) at the second sympodial position. At this location FR in BGII/RRF resulted in an increase in the number of bolls per 10 plants at the second sympodial position while FR in the BG/RR did not. This observation also supports the hypothesis that early-season fruit retention could be too high and FR may extend vegetative growth which would improve the crop's ability to acquire resources such as water, sunlight, and nitrogen, resulting in increased number of bolls per 10 plants (Sadras, 1995).

Total Boll Number (m^{-2})

Irrigation. Pettigrew (2004a) observed irrigated plots consistently produced significantly more blooms per unit ground area than did non-irrigated plots. He also observed that non-irrigated plants had significantly higher blooming rates earlier in the growing season in comparison to irrigated plants. The irrigation compensated for this difference with increased late-season bloom development (Pettigrew, 2004a). Boll numbers (m^{-2}) at Gibbs 2004 (Table 19) were greater at first and second sympodial positions in the irrigated treatment versus the non-irrigated treatment. These data are in agreement with increased number of bolls per 10 plants and total boll weight ($g\ m^{-2}$) in irrigated plots discussed earlier.

Variety. First sympodial position boll numbers (m^{-2}) at Gibbs 2004 (Table 19) and Stripling 2005 (Table 21) were greater in the BGII/RRF than in the BG/RR While not significant, similar trends were observed at Gibbs 2005 (Table 20). Second sympodial position boll numbers at Stripling 2005 were greater in BG/RR when compared to the BGII/RRF. Similar trends at second sympodial position boll numbers were observed at Gibbs 2004. These findings are consistent with those reported earlier that indicate BGII/RRF resulted in a higher number bolls per 10 plants and boll weight at the first sympodial position as compared with BG/RR while BG/RR resulted in a higher number of bolls per 10 plants and boll weight at the second sympodial position as compared with BGII/RRF.

BGII/RRF cotton was greater in boll numbers (m^{-2}) at first sympodial position, main stem nodes 5-7 and 9-12 at Gibbs 2004 (Table 22) and main stem nodes 5-11 at Stripling 2005 (Table 24) in the non-irrigated treatments. Irrigated BGII/RRF also resulted in greater boll numbers at first sympodial position, main stem nodes 5-8 and 10-12 at Gibbs 2004 (Table 24) and main stem nodes 6 and 8-10 at Stripling (Table 24) as compared with BG/RR. These data indicate BGII/RRF resulted in greater boll number (m^{-2}), number bolls per 10 plants, and total boll weight ($g\ m^{-2}$) at lower main stem nodes, first sympodial positions as compared to BG/RR which has been supported by May et al. (2004).

Removal. Flower removal was significant in all three studies at the second sympodial position (Tables, 19, 20, and 21). These results indicate FR resulted in a higher number of bolls (m^{-2}) over NoFR. Gibbs 2005 (Table 20) was significant for boll number at the first sympodial position. In contrast to second position findings, NoFR possessed higher boll numbers (m^{-2}) than did FR at the first sympodial position at this location. A similar trend was observed at Gibbs 2004 (Table 19) with respect to first sympodial position data. These data support the results of boll weight and number of bolls per 10 plants discussed above (i.e. first sympodial position is greater in the NoFR and second or third sympodial positions are greater in the FR). These data also support the findings of Stewart et al. (2001) observing increased boll weight (g m^{-2}) and boll number (m^{-2}) compensation succeeding early season square removal.

Irrigation By Removal (I x R). Irrigation by flower removal interaction was significant for second sympodial positions at Gibbs 2004 (Table 19). The irrigation with FR resulted in a higher number of bolls (m^{-2}) than did the non-irrigated with NoFR. This further extends the similarities discussed above suggesting greater boll weight (g m^{-2}), greater boll number (m^{-2}), and increased number of bolls per 10 plants at the second sympodial positions within irrigation and FR treatments.

Variety By Removal (V x R). Second sympodial position at Gibbs 2004 (Table 19) was highly significant within the variety by removal interaction. BGII/RRF with FR resulted in a higher total boll number (m^{-2}) than BGII/RRF with NoFR while BG/RR remained relatively the same. These results support the hypothesis that BGII/RRF may have over compensated for fruit loss.

Average Boll Weight (g $boll^{-1}$)

Irrigation. Irrigation had a significant effect upon average boll weight at the second sympodial position at Gibbs 2004 (Table 25). At this location and sympodial position average boll weight was greater in the non-irrigated than irrigated. As discussed previously, the number of bolls per 10 plants was greater for the irrigated treatment at this location (Table 13). Thus, while the non-irrigated treatment resulted in fewer numbers of bolls per 10 plants, the crop was attempting to compensate by producing greater average boll weights.

Variety. At all locations average boll weight was higher for the BG/RR than the BGII/RRF (Tables 25-27). In the non-irrigated treatments at Gibbs 2005 and Stripling 2005, greater boll weights were generally observed in the BG/RR at main stem nodes 8 and above

(Tables 29 and 30) as compared to BGII/RRF. At Stripling 2005 (Table 30), average boll weight was also greater at main stem nods 8 and above in the irrigated BG/RR treatments as compared to BGII/RRF.

Irrigation By Variety (I x V). The irrigation by variety interaction was similar to the irrigation treatment effects discussed above. BG/RR, regardless of irrigated treatment, resulted in a higher average boll weight (g $boll^{-1}$) than did BGII/RRF.

Removal. Flower removal treatments were significant at Gibbs 2005 and Stripling 2005 (Tables 26 and 27). At both locations, average boll weight was greater at the first and third sympodial positions in the FR treatment. Heitholt (1997) observed a greater percentage of bolls and larger bolls were found at first sympodial positions when squares were removed from second and third sympodial positions. Lint yield in this study decreased when compared to the control. Hietholt (1997) therefore concluded that second position fruit is necessary for maximum yield. Thus, the greatest compensation potential for fruit loss may occur through a combination of apical and distal fruiting positions. In this study, FR resulted in increased yield differences in one of the three locations (Table 6). Our data indicate that these yield differences occurred at the apical and distal fruiting positions.

Variety By Removal (V x R). The variety by removal interaction was significant at third sympodial position at Stripling 2005 (Table 27). The results were similar as above showing BGII/RRF with FR had a higher average boll weight (g) than BGII/RRF with NoFR. These results support the hypothesis that BGII/RRF may have over compensated for fruit loss.

High Volume Instrument (HVI) Fiber Quality

Irrigation. Irrigation effects for HVI fiber properties were variable. At Gibbs 2004, fiber length, strength and micronaire were greater in the non-irrigated treatment (Table 4). At

Gibbs 2005, HVI short fiber content was greater in the irrigated treatment (Table 5). At Camilla 2005, HVI fiber strength was greater and short fiber content was lower in the irrigated treatment (Table 6).

Variety. Variety effects for HVI fiber properties, however, were much more consistent. In all environments HVI micronaire was lower in the BGII/RRF. At Gibbs 2004 however, HVI micronaire in BGII/RRF was considered “low” by the United States Department of Agriculture Agricultural Marketing Service guidelines (USDA/AMS). In all environments HVI fiber length was longer in the BGII/RRF cotton (Tables 4-6). According to the USDA/AMS guidelines HVI staple length for the BGII/RRF was “37” in all environments. HVI fiber length (staple) for the BG/RR ranged from “34” to “36” across environments. HVI fiber length uniformity varied across the environments but was always above 80%. HVI fiber strength was greater in the BGII/RRF in all environments. According to the USDA/AMS guidelines, fiber strength in the BGII/RRF was “average” or “strong” and BGRR was “average.”

Advanced Fiber Information System (AFIS) Fiber Quality

Irrigation. Advanced fiber information system (AFIS) is a fiber testing instrument which provides the means to measure single fibers of cotton. AFIS fiber length and fineness at Gibbs 2004 were greater in the non-irrigated treatment which is consistent with the HVI fiber data for this location. The AFIS length by weight coefficient of variation [L(w) CV] was also lower in this environment (Table 31). However, AFIS fiber length in Gibbs 2005 was lower in the non-irrigated (Table 32). Irrigated treatments at Gibbs 2004 and Stripling 2005 resulted in lower fineness and maturity ratio ratings when compared to non-irrigated treatments (Tables 31 and 33).

Variety. AFIS fiber length by weight [L(w)] and the upper quartile length by weight [UQL(w)] was greater in the BGII/RRF in all environments. However, length by weight coefficient of variation [L(w) CV] was also higher for the BGII/RRF in all environments and short fiber content by weight [SFC(w)] was higher in two of the three environments. Finally, AFIS fineness (Fine) was lower in the BGII/RRF in all locations and maturity ratio was lower in two of the three locations.

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Table 1. Nodes above first square or white flower (NAFS/WF) from 37 days after planting to 72 days after planting at the Gibbs Farm located in Tifton, GA in 2004.

			NAFS/WF					
Treatment Effects			Days After Planting					
Irrigation	Variety	Removal	37	43	50	55	63	72
Dry			4.85	5.84	6.56	7.13	4.35	2.20
Irr			4.63	5.85	6.75	7.23	5.68	3.21
	Flex		4.77	5.85	6.49	7.29	4.70	3.12
	RR		4.72	5.85	6.82	7.07	5.33	2.29
		FR	4.65	5.85	6.55	7.28	4.98	2.84
		NoFR	4.84	5.84	6.76	7.09	5.05	2.57
Dry	Flex		4.85	5.74	6.35	7.28	4.15	2.68
Dry	RR		4.85	5.94	6.78	6.98	4.55	1.72
Irr	Flex		4.68	5.95	6.63	7.31	5.25	3.55
Irr	RR		4.59	5.75	6.86	7.16	6.10	2.86
Dry		FR	4.87	5.83	6.41	7.28	4.42	2.32
Dry		NoFR	4.83	5.85	6.72	6.98	4.28	2.08
Irr		FR	4.43	5.87	6.70	7.28	5.54	3.35
Irr		NoFR	4.84	5.83	6.79	7.19	5.81	3.06
	Flex	FR	4.79	5.87	6.45	7.46	4.68	3.31
	Flex	NoFR	4.74	5.82	6.53	7.13	4.72	2.92
	RR	FR	4.51	5.83	6.66	7.10	5.28	2.36
	RR	NoFR	4.93	5.86	6.98	7.04	5.37	2.22
Dry	Flex	FR	5.04	5.71	6.19	7.48	4.16	2.82
Dry	Flex	NoFR	4.66	5.78	6.50	7.08	4.14	2.54
Dry	RR	FR	4.70	5.96	6.62	7.08	4.68	1.82
Dry	RR	NoFR	5.00	5.92	6.94	6.88	4.42	1.62
Irr	Flex	FR	4.54	6.04	6.70	7.44	5.21	3.81
Irr	Flex	NoFR	4.82	5.86	6.56	7.18	5.30	3.30
Irr	RR	FR	4.32	5.70	6.70	7.12	5.88	2.90
Irr	RR	NoFR	4.86	5.80	7.02	7.20	6.32	2.82
	Source of variation							
	Irrigation (I)		NS	NS	NS	NS	***	**
	Variety (V)		NS	NS	***	***	***	***
	I x V		NS	*	NS	NS	***	NS
	Removal (R)		*	NS	**	***	NS	**
	I x R		**	NS	NS	NS	***	NS
	V x R		**	NS	NS	*	NS	NS
	I x V x R		NS	NS	NS	NS	**	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 2. Nodes above first square or white flower (NAFS/WF) from 50 days after planting to 83 days after planting at the Gibbs Farm located in Tifton, GA in 2005**.**

			NAFS/WF					
Treatment Effects			Days After Planting					
Irrigation	Variety	Removal	50	58	63	69	77	83
Dry			6.63	7.71	7.77	6.99	5.82	4.79
Irr			6.38	7.58	7.65	6.87	5.53	4.30
	Flex		6.42	7.78	7.34	6.64	5.38	4.29
	RR		6.59	7.51	8.08	7.22	5.97	4.80
		FR	6.38	7.62	7.66	6.93	5.68	4.57
		NoFR	6.63	7.68	7.76	6.93	5.67	4.52
Dry	Flex		6.56	7.76	7.43	6.65	5.54	4.46
Dry	RR		6.70	7.66	8.11	7.34	6.10	5.12
Irr	Flex		6.28	7.80	7.26	6.64	5.23	4.11
Irr	RR		6.48	7.36	8.04	7.10	5.84	4.49
Dry		FR	6.59	7.84	7.66	6.99	5.76	4.88
Dry		NoFR	6.68	7.59	7.88	7.00	5.88	4.70
Irr		FR	6.16	7.40	7.65	6.88	5.60	4.26
Irr		NoFR	6.59	7.76	7.65	6.86	5.46	4.34
	Flex	FR	6.11	7.76	7.34	6.63	5.41	4.39
	Flex	NoFR	6.73	7.80	7.35	6.66	5.35	4.19
	RR	FR	6.64	7.48	7.98	7.24	5.95	4.76
	RR	NoFR	6.54	7.55	8.18	7.20	5.99	4.85
Dry	Flex	FR	6.25	7.95	7.40	6.63	5.50	4.55
Dry	Flex	NoFR	6.88	7.58	7.45	6.68	5.58	4.38
Dry	RR	FR	6.93	7.73	7.93	7.35	6.03	5.21
Dry	RR	NoFR	6.48	7.60	8.30	7.33	6.18	5.03
Irr	Flex	FR	5.98	7.58	7.28	6.63	5.33	4.23
Irr	Flex	NoFR	6.58	8.03	7.25	6.65	5.13	4.00
Irr	RR	FR	6.35	7.23	8.03	7.13	5.88	4.30
Irr	RR	NoFR	6.60	7.50	8.05	7.08	5.80	4.68
	Source of variation							
	Irrigation (I)		NS	NS	NS	NS	NS	NS
	Variety (V)		NS	**	***	***	***	***
	I x V		NS	NS	NS	*	NS	**
	Removal (R)		**	NS	NS	NS	NS	NS
	I x R		NS	**	NS	NS	*	*
	V x R		***	NS	NS	NS	NS	**
	I x V x R		NS	NS	NS	NS	NS	**

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 3. Nodes above first square or white flower (NAFS/WF) from 49 days after planting to 104 days after planting at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

			NAFS/WF							
Treatment Effects			Days After Planting							
Irrigation	Variety	Removal	49	56	63	76	84	91	97	104
Dry			4.54	6.12	6.61	4.82	4.13	3.54	2.78	1.73
Irr			4.44	6.02	6.57	6.06	5.49	4.44	4.00	3.02
	Flex		4.69	6.14	6.71	4.83	4.65	3.65	3.15	2.11
	RR		4.29	6.00	6.46	6.06	4.96	4.34	3.63	2.64
		FR	4.50	6.01	6.62	5.38	4.76	4.08	3.57	2.53
		NoFR	4.47	6.14	6.56	5.50	4.85	3.91	3.21	2.21
Dry	Flex		4.92	6.13	6.71	4.36	3.69	3.15	2.51	1.43
Dry	RR		4.15	6.11	6.52	5.29	4.56	3.93	3.05	2.03
Irr	Flex		4.45	6.15	6.72	5.29	5.61	4.14	3.79	2.78
Irr	RR		4.43	5.89	6.41	6.83	5.36	4.74	4.21	3.25
Dry		FR	4.48	6.02	6.62	4.74	3.98	3.65	2.85	1.84
Dry		NoFR	4.59	6.22	6.61	4.91	4.27	3.43	2.72	1.62
Irr		FR	4.53	5.99	6.62	6.03	5.54	4.50	4.30	3.22
Irr		NoFR	4.35	6.05	6.52	6.08	5.44	4.38	3.70	2.81
	Flex	FR	4.66	5.92	6.60	4.77	4.60	3.78	3.37	2.24
	Flex	NoFR	4.72	6.36	6.83	4.88	4.70	3.51	2.93	1.98
	RR	FR	4.35	6.09	6.64	6.00	4.92	4.37	3.78	2.83
	RR	NoFR	4.23	5.91	6.29	6.11	5.01	4.30	3.49	2.45
Dry	Flex	FR	4.84	5.87	6.54	4.25	3.53	3.38	2.61	1.43
Dry	Flex	NoFR	5.01	6.40	6.89	4.47	3.85	2.93	2.41	1.43
Dry	RR	FR	4.13	6.18	6.70	5.22	4.44	3.93	3.08	2.25
Dry	RR	NoFR	4.18	6.05	6.33	5.35	4.69	3.93	3.03	1.80
Irr	Flex	FR	4.48	5.97	6.66	5.29	5.67	4.19	4.13	3.04
Irr	Flex	NoFR	4.43	6.32	6.78	5.29	5.55	4.09	3.45	2.52
Irr	RR	FR	4.58	6.00	6.58	6.78	5.40	4.80	4.48	3.40
Irr	RR	NoFR	4.28	5.78	6.25	6.88	5.33	4.68	3.95	3.10
	Source of variation									
	Irrigation (I)		NS	NS	NS	***	***	**	**	**
	Variety (V)		***	NS	***	***	***	***	***	***
	I x V		***	NS	NS	***	***	NS	NS	NS
	Removal (R)		NS	NS	NS	NS	NS	***	***	***
	I x R		*	NS	NS	NS	**	NS	***	NS
	V x R		NS	***	***	NS	NS	*	NS	NS
	I x V x R		NS	NS	NS	NS	NS	*	NS	**

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 4. Lint yield, lint percentage, and high volume instrument (HVI) fiber micronaire, staple length, length uniformity, strength, elongation, color, area% not cotton, and short fiber content at the Gibbs Farm located in Tifton, GA in 2004.

Treatment Effects													
Irrigation	Variety	Removal	Lint Yield	Lint Pct.	Micronaire	Staple	Uniformity	Strength	ELO	Color Rd	Color +b	Area	SFC
			kg ha^{-1}	%		mm		kN kg^{-1}				%	%
Dry			734	31.79	3.66	28.05	81.21	276	6.65	73.90	9.60	1.21	10.22
Irr			988	33.01	3.18	27.88	81.12	263	7.06	74.57	9.59	1.28	10.61
	Flex		844	31.38	3.10	29.07	80.68	280	5.94	74.79	9.13	1.39	10.16
	RR		878	33.42	3.73	26.86	81.65	259	7.77	73.67	10.06	1.10	10.67
		FR	859	32.29	3.38	28.07	81.21	271	6.82	74.43	9.55	1.21	10.41
		NoFR	864	32.50	3.45	27.86	81.12	268	6.90	74.03	9.64	1.27	10.41
Dry	Flex		745	30.77	3.34	29.03	80.64	286	5.65	74.64	9.13	1.31	10.04
Dry	RR		723	32.81	3.97	27.08	81.77	266	7.66	73.15	10.07	1.11	10.41
Irr	Flex		944	31.99	2.86	29.11	80.71	274	6.23	74.94	9.12	1.47	10.28
Irr	RR		1033	34.02	3.49	26.64	81.54	251	7.89	74.19	10.06	1.09	10.93
Dry		FR	739	31.71	3.59	28.27	81.32	279	6.61	73.87	9.56	1.21	10.12
Dry		NoFR	729	31.87	3.73	27.84	81.09	273	6.70	73.93	9.64	1.21	10.32
Irr		FR	979	32.87	3.18	27.86	81.10	262	7.03	75.00	9.54	1.22	10.71
Irr		NoFR	998	33.14	3.17	27.89	81.15	263	7.10	74.13	9.64	1.33	10.50
	Flex	FR	839	31.22	3.08	29.21	80.76	282	5.92	75.11	9.05	1.31	10.02
	Flex	NoFR	850	31.53	3.12	28.93	80.59	278	5.96	74.47	9.20	1.47	10.30
	RR	FR	879	33.36	3.69	26.92	81.66	259	7.72	73.76	10.04	1.12	10.81
	RR	NoFR	877	33.48	3.78	26.80	81.64	258	7.83	73.59	10.08	1.08	10.53
Dry	Flex	FR	740	30.59	3.29	29.36	80.86	289	5.59	74.83	9.03	1.25	9.72
Dry	Flex	NoFR	750	30.94	3.39	28.70	80.42	282	5.71	74.44	9.23	1.37	10.36
Dry	RR	FR	739	32.82	3.88	27.18	81.78	268	7.63	72.90	10.09	1.16	10.52
Dry	RR	NoFR	708	32.80	4.06	26.97	81.76	264	7.69	73.41	10.05	1.06	10.29
Irr	Flex	FR	938	31.85	2.87	29.06	80.65	275	6.25	75.39	9.07	1.37	10.31
Irr	Flex	NoFR	949	32.12	2.85	29.16	80.77	274	6.21	74.49	9.17	1.56	10.25
Irr	RR	FR	1019	33.90	3.49	26.67	81.55	250	7.81	74.62	10.00	1.08	11.10
Irr	RR	NoFR	1047	34.15	3.49	26.62	81.53	253	7.98	73.77	10.11	1.11	10.76
	Source of variation												
	Irrigation (I)		*	**	***	**	NS	***	**	**	NS	NS	NS
	Variety (V)		NS	***	***	***	***	***	***	***	***	***	***
	I x V		*	NS	NS	***	NS	NS	**	NS	NS	NS	NS
	Removal (R)		NS	NS	NS	***	NS	NS	NS	NS	NS	NS	NS
	I x R		NS	NS	*	***	NS	*	NS	NS	NS	NS	NS
	V x R		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
	I x V x R		NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS

* significant at P = 0.10 ** significant at P =0.05 *** significant at P = 0.01 NS = not significant

Table 5. Lint yield, lint percentage, and high volume instrument (HVI) fiber micronaire, staple length, length uniformity, strength, elongation, color, area% not cotton, and short fiber content at the Gibbs Farm located in Tifton, GA in 2005.

Treatment Effects													
Irrigation	Variety	Removal	Lint Yield	Lint Pct.	Micronaire	Staple	Uniformity	Strength	ELO	Color Rd	Color +b	Area	SFC
			kg ha^{-1}	%		mm		kN kg^{-1}				%	%
Dry			1317	33.97	4.18	28.98	82.77	266	6.40	75.67	9.08	0.56	4.98
Irr			1462	34.37	4.01	29.38	82.77	265	6.68	75.70	8.86	0.72	5.35
	Flex		1355	32.35	3.95	29.67	82.86	271	6.55	75.78	8.84	0.62	4.91
	RR		1425	36.00	4.23	28.70	82.68	261	6.54	75.59	9.10	0.66	5.41
		FR	1382	34.00	4.08	29.19	82.79	266	6.58	75.74	9.02	0.67	5.06
		NoFR	1397	34.34	4.11	29.17	82.75	265	6.50	75.63	8.92	0.60	5.26
Dry	Flex		1292	32.13	4.06	29.44	82.85	271	6.45	75.84	9.12	0.54	4.76
Dry	RR		1342	35.82	4.31	28.53	82.69	262	6.36	75.50	9.04	0.57	5.19
Irr	Flex		1417	32.57	3.85	29.90	82.87	272	6.64	75.72	8.56	0.69	5.05
Irr	RR		1507	36.17	4.16	28.87	82.66	259	6.72	75.69	9.15	0.74	5.64
Dry		FR	1283	33.79	4.17	29.00	82.85	266	6.46	75.65	9.04	0.64	4.78
Dry		NoFR	1351	34.15	4.20	28.96	82.70	267	6.34	75.69	9.12	0.47	5.17
Irr		FR	1480	34.21	3.99	29.39	82.73	267	6.71	75.82	9.00	0.70	5.34
Irr		NoFR	1444	34.53	4.02	29.38	82.80	264	6.65	75.58	8.72	0.73	5.35
	Flex	FR	1338	32.23	3.93	29.80	82.95	273	6.59	75.96	8.88	0.63	4.63
	Flex	NoFR	1371	32.47	3.98	29.54	82.77	270	6.50	75.60	8.80	0.61	5.19
	RR	FR	1425	35.78	4.23	28.59	82.62	260	6.58	75.52	9.15	0.71	5.49
	RR	NoFR	1424	36.21	4.24	28.80	82.73	261	6.50	75.67	9.04	0.60	5.33
Dry	Flex	FR	1241	32.13	4.05	29.48	83.08	271	6.51	75.92	9.12	0.64	4.45
Dry	Flex	NoFR	1342	32.12	4.06	29.40	82.63	271	6.39	75.76	9.12	0.45	5.08
Dry	RR	FR	1325	35.45	4.28	28.53	82.62	261	6.41	75.38	8.96	0.65	5.11
Dry	RR	NoFR	1360	36.18	4.34	28.53	82.76	263	6.30	75.61	9.13	0.49	5.27
Irr	Flex	FR	1435	32.33	3.82	30.12	82.83	275	6.68	75.99	8.65	0.62	4.80
Irr	Flex	NoFR	1399	32.81	3.89	29.67	82.90	268	6.61	75.44	8.48	0.77	5.31
Irr	RR	FR	1525	36.10	4.17	28.66	82.63	259	6.74	75.65	9.34	0.78	5.88
Irr	RR	NoFR	1488	36.25	4.14	29.08	82.70	259	6.70	75.73	8.96	0.70	5.40
	Source of variation												
	Irrigation (I)		*	NS	NS	NS	NS	NS	**	NS	NS	NS	**
	Variety (V)		*	***	***	***	*	***	NS	*	*	NS	***
	I x V		NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
	Removal (R)		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	I x R		NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
	V x R		NS	NS	NS	*	NS	NS	NS	**	NS	NS	**
	I x V x R		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* significant at P = 0.10 ** significant at P =0.05 *** significant at P = 0.01 NS = not significant

Table 6. Lint yield, lint percentage, and high volume instrument (HVI) fiber micronaire, staple length, length uniformity, strength, elongation, color, area% not cotton, and short fiber content at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

Treatment Effects													
Irrigation	Variety	Removal	Lint Yield	Lint Pct.	Micronaire	Staple	Uniformity	Strength	ELO	Color Rd	Color +b	Area	SFC
			kg ha^{-1}	%		mm		kN kg^{-1}				%	%
Dry			1160	34.20	4.28	28.18	81.70	257	6.49	75.45	8.87	0.47	8.39
Irr			1201	32.90	4.05	28.33	82.17	263	6.58	76.68	8.87	0.46	6.80
	Flex		1140	32.01	3.87	28.85	81.93	267	6.52	75.85	8.71	0.49	7.56
	RR		1221	35.09	4.47	27.66	81.94	254	6.55	76.28	9.04	0.44	7.63
		FR	1243	33.47	4.13	28.31	82.04	262	6.54	76.39	9.08	0.47	7.32
		NoFR	1118	33.63	4.20	28.21	81.84	259	6.54	75.73	8.67	0.46	7.87
Dry	Flex		1127	32.47	3.99	28.84	81.75	263	6.50	75.40	8.62	0.48	8.15
Dry	RR		1193	35.92	4.58	27.53	81.65	251	6.49	75.50	9.12	0.46	8.63
Irr	Flex		1153	31.54	3.75	28.87	82.11	271	6.55	76.30	8.80	0.49	6.96
Irr	RR		1249	34.26	4.35	27.80	82.24	256	6.61	77.05	8.95	0.42	6.63
Dry		FR	1212	34.32	4.29	28.26	81.73	259	6.48	75.87	9.07	0.45	8.03
Dry		NoFR	1108	34.08	4.28	28.11	81.67	255	6.51	75.03	8.67	0.48	8.75
Irr		FR	1274	32.63	3.98	28.36	82.35	265	6.60	76.92	9.08	0.48	6.60
Irr		NoFR	1128	33.18	4.12	28.31	82.00	262	6.56	76.43	8.67	0.44	6.99
	Flex	FR	1244	32.09	3.82	28.95	82.10	270	6.53	76.60	8.86	0.50	7.02
	Flex	NoFR	1036	31.92	3.91	28.76	81.75	264	6.52	75.10	8.56	0.47	8.09
	RR	FR	1242	34.85	4.45	27.67	81.97	254	6.55	76.19	9.29	0.44	7.62
	RR	NoFR	1200	35.33	4.49	27.66	81.92	253	6.55	76.36	8.78	0.44	7.64
Dry	Flex	FR	1199	32.65	3.97	29.01	81.86	265	6.51	76.34	8.80	0.46	7.57
Dry	Flex	NoFR	1055	32.30	4.01	28.67	81.63	261	6.48	74.45	8.44	0.49	8.73
Dry	RR	FR	1225	35.98	4.61	27.51	81.59	253	6.45	75.39	9.34	0.45	8.50
Dry	RR	NoFR	1161	35.86	4.55	27.55	81.71	249	6.53	75.60	8.90	0.47	8.77
Irr	Flex	FR	1289	31.54	3.68	28.89	82.34	275	6.55	76.85	8.92	0.53	6.47
Irr	Flex	NoFR	1017	31.55	3.82	28.85	81.87	266	6.55	75.74	8.68	0.46	7.46
Irr	RR	FR	1258	33.71	4.28	27.83	82.35	255	6.65	76.99	9.24	0.43	6.73
Irr	RR	NoFR	1239	34.80	4.43	27.77	82.12	258	6.58	77.12	8.66	0.41	6.52
	Source of variation												
	Irrigation (I)		NS	***	NS	NS	NS	***	NS	***	NS	NS	***
	Variety (V)		*	***	***	***	NS	***	NS	NS	**	*	NS
	I x V		NS	NS	NS	*	NS	NS	NS	NS	NS	NS	*
	Removal (R)		**	NS	NS	NS	NS	*	NS	*	***	NS	**
	I x R		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	V x R		*	NS	NS	NS	NS	NS	NS	**	NS	NS	**
	I x V x R		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

* significant at P = 0.10 ** significant at P =0.05 *** significant at P = 0.01 NS = not significant

Table 7. Total boll weight (g m^{-2}) by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2004.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			10.37	3.44	1.04
Irr			15.15	4.46	1.09
	Flex		13.75	3.30	0.85
	RR		11.76	4.61	1.29
		FR	12.23	4.61	1.02
		NoFr	13.29	3.30	1.12
Dry	Flex		12.35	2.85	0.67
Dry	RR		8.39	4.03	1.42
Irr	Flex		15.16	3.75	1.02
Irr	RR		15.13	5.18	1.16
Dry		FR	9.58	4.51	0.91
Dry		NoFR	11.15	2.37	1.17
Irr		FR	14.88	4.71	1.13
Irr		NoFR	15.42	4.22	1.06
	Flex	FR	13.20	4.60	0.92
	Flex	NoFR	14.31	2.00	0.77
	RR	FR	11.26	4.62	1.12
	RR	NoFR	12.26	4.60	1.46
Dry	Flex	FR	11.57	4.18	0.80
Dry	Flex	NoFR	13.13	1.51	0.53
Dry	RR	FR	7.60	4.83	1.03
Dry	RR	NoFR	9.18	3.23	1.81
Irr	Flex	FR	14.83	5.01	1.05
Irr	Flex	NoFR	15.50	2.48	1.00
Irr	RR	FR	14.92	4.40	1.21
Irr	RR	NoFR	15.34	5.97	1.12
	Source of variation				
	Irrigation (I)		***	NS	NS
	Variety (V)		**	***	*
	I x V		**	NS	NS
	Removal (R)		NS	***	NS
	I x R		NS	**	NS
	V x R		NS	***	NS
	I x V x R		NS	*	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 8. Total boll weight (g m^{-2}) by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			14.09	7.06	2.62
Irr			13.63	7.01	3.15
	Flex		13.87	7.13	2.80
	RR		13.86	6.95	2.97
		FR	13.49	7.59	3.37
		NoFr	14.23	6.48	2.40
Dry	Flex		13.98	6.79	2.27
Dry	RR		14.21	7.33	2.96
Irr	Flex		13.76	7.47	3.33
Irr	RR		13.51	6.56	2.98
Dry		FR	13.60	7.26	3.16
Dry		NoFR	14.58	6.86	2.08
Irr		FR	13.39	7.92	3.58
Irr		NoFR	13.88	6.10	2.72
	Flex	FR	13.39	7.70	3.24
	Flex	NoFR	14.35	6.55	2.37
	RR	FR	13.60	7.48	3.51
	RR	NoFR	14.11	6.42	2.43
Dry	Flex	FR	13.48	6.83	2.73
Dry	Flex	NoFR	14.48	6.74	1.82
Dry	RR	FR	13.72	7.69	3.59
Dry	RR	NoFR	14.69	6.98	2.34
Irr	Flex	FR	13.30	8.58	3.74
Irr	Flex	NoFR	14.23	6.35	2.92
Irr	RR	FR	13.49	7.26	3.42
Irr	RR	NoFR	13.53	5.86	2.53
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		NS	NS	NS
	I x V		NS	NS	NS
	Removal (R)		NS	**	*
	I x R		NS	NS	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 9. Total boll weight (g m^{-2}) by sympodial position averaged over main stem nodes at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			14.26	6.57	2.11
Irr			12.18	6.32	2.42
	Flex		13.36	5.39	1.89
	RR		13.09	7.50	2.64
		FR	13.52	7.00	2.57
		NoFr	12.92	5.89	1.96
Dry	Flex		14.75	6.05	1.96
Dry	RR		13.77	7.10	2.27
Irr	Flex		11.97	4.72	1.81
Irr	RR		12.40	7.91	3.02
Dry		FR	13.84	7.59	2.60
Dry		NoFR	14.68	5.56	1.62
Irr		FR	13.20	6.40	2.54
Irr		NoFR	11.17	6.23	2.29
	Flex	FR	13.92	6.04	2.37
	Flex	NoFR	12.80	4.73	1.40
	RR	FR	13.12	7.95	2.76
	RR	NoFR	13.05	7.05	2.52
Dry	Flex	FR	14.26	7.19	2.36
Dry	Flex	NoFR	15.24	4.91	1.56
Dry	RR	FR	13.43	7.99	2.84
Dry	RR	NoFR	14.12	6.21	1.69
Irr	Flex	FR	13.58	4.89	2.38
Irr	Flex	NoFR	10.36	4.56	1.25
Irr	RR	FR	12.82	7.92	2.69
Irr	RR	NoFR	11.98	7.90	3.34
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		NS	***	**
	I x V		NS	**	NS
	Removal (R)		NS	**	NS
	I x R		**	*	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 10. Total boll weight (g m^{-2}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2004.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	17	1.26	0.56	NS
	16	1.52	0.37	NS
	15	2.76	1.35	NS
	14	4.92	4.29	NS
	13	11.16	9.54	NS
	12	16.35	14.58	*
	11	26.33	20.38	***
	10	27.64	24.60	**
	9	30.20	24.20	***
	8	26.82	20.56	***
	7	23.93	15.90	***
	6	16.56	7.92	***
	5	4.41	1.91	*
Irrigated	17	3.42	1.68	NS
	16	3.15	2.46	NS
	15	6.89	6.24	NS
	14	11.77	13.35	NS
	13	18.87	23.17	***
	12	22.99	26.88	***
	11	29.87	29.64	NS
	10	31.26	33.57	*
	9	32.51	35.24	**
	8	29.73	26.69	**
	7	22.18	18.68	***
	6	13.38	8.53	***
	5	5.18	2.01	**

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 11. Total boll weight (g m^{-2}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	3.40	3.61	NS
	19	4.16	4.77	NS
	18	3.90	4.95	NS
	17	5.32	8.03	*
	16	9.48	6.77	*
	15	11.62	13.11	NS
	14	15.07	14.45	NS
	13	19.26	19.15	NS
	12	21.40	20.48	NS
	11	23.34	23.73	NS
	10	25.02	26.29	NS
	9	28.99	28.83	NS
	8	27.38	28.81	NS
	7	22.08	25.89	***
	6	16.44	14.98	NS
	5	9.08	5.84	**
	4	2.96	1.76	NS
Irrigated	21	1.60	2.09	NS
	20	2.16	4.09	NS
	19	3.44	5.51	NS
	18	6.32	6.02	NS
	17	9.93	8.85	NS
	16	10.39	10.22	NS
	15	10.29	11.64	NS
	14	12.26	13.71	NS
	13	17.14	16.50	NS
	12	19.61	17.85	NS
	11	21.53	21.60	NS
	10	26.58	20.93	***
	9	25.15	24.62	NS
	8	28.44	25.74	*
	7	21.98	24.16	*
	6	15.15	19.47	***
	5	11.80	9.36	*

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 12. Total boll weight (g m^{-2}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	0.24	2.00	NS
	19	1.73	3.18	NS
	18	3.22	5.43	*
	17	6.78	7.18	NS
	16	9.27	8.77	NS
	15	11.76	15.67	***
	14	17.23	18.15	NS
	13	20.56	23.54	**
	12	24.70	29.38	***
	11	27.27	30.17	**
	10	28.06	23.77	***
	9	32.24	27.19	***
	8	29.36	24.20	***
	7	21.28	14.21	***
	6	13.73	7.33	***
	5	7.57	1.51	***
Irrigated	21	2.16	1.09	NS
	20	1.74	2.52	NS
	19	2.59	4.80	*
	18	5.01	8.95	***
	17	8.23	11.00	*
	16	10.89	11.74	NS
	15	11.74	15.35	***
	14	18.51	21.30	*
	13	23.00	30.85	***
	12	29.08	31.60	*
	11	23.86	24.84	NS
	10	17.60	16.43	NS
	9	22.24	15.05	***
	8	19.63	10.15	***
	7	8.56	7.95	NS
	6	5.25	2.40	*

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 13. Number of bolls per 10 plants by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2004.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			2.00	0.63	0.08
Irr			2.61	0.88	0.10
	Flex		2.50	0.74	0.07
	RR		2.11	0.77	0.10
		FR	2.28	0.86	0.13
		NoFr	2.33	0.65	0.05
Dry	Flex		2.25	0.61	0.06
Dry	RR		1.76	0.64	0.09
Irr	Flex		2.75	0.87	0.08
Irr	RR		2.47	0.89	0.11
Dry		FR	1.98	0.78	0.11
Dry		NoFR	2.02	0.47	0.05
Irr		FR	2.57	0.93	0.14
Irr		NoFR	2.65	0.83	0.05
	Flex	FR	2.47	0.93	0.11
	Flex	NoFR	2.53	0.54	0.03
	RR	FR	2.09	0.78	0.14
	RR	NoFR	2.14	0.75	0.06
Dry	Flex	FR	2.20	0.79	0.10
Dry	Flex	NoFR	2.31	0.42	0.03
Dry	RR	FR	1.77	0.77	0.12
Dry	RR	NoFR	1.74	0.52	0.07
Irr	Flex	FR	2.74	1.07	0.13
Irr	Flex	NoFR	2.75	0.67	0.04
Irr	RR	FR	2.40	0.80	0.16
Irr	RR	NoFR	2.54	0.98	0.06
	Source of variation				
	Irrigation (I)		**	**	NS
	Variety (V)		***	NS	NS
	I x V		NS	NS	NS
	Removal (R)		NS	***	**
	I x R		NS	NS	NS
	V x R		NS	***	NS
	I x V x R		NS	*	NS

*significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 14. Number of bolls per 10 plants by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			3.04	1.56	0.60
Irr			2.88	1.49	0.65
	Flex		3.01	1.59	0.59
	RR		2.91	1.46	0.66
		FR	2.77	1.59	0.71
		NoFr	3.15	1.46	0.54
Dry	Flex		3.01	1.52	0.52
Dry	RR		3.06	1.60	0.68
Irr	Flex		3.01	1.67	0.65
Irr	RR		2.75	1.32	0.64
Dry		FR	2.81	1.57	0.70
Dry		NoFR	3.26	1.54	0.51
Irr		FR	2.73	1.61	0.73
Irr		NoFR	3.03	1.38	0.57
	Flex	FR	2.74	1.63	0.64
	Flex	NoFR	3.28	1.56	0.54
	RR	FR	2.80	1.56	0.79
	RR	NoFR	3.02	1.37	0.54
Dry	Flex	FR	2.68	1.44	0.57
Dry	Flex	NoFR	3.34	1.59	0.47
Dry	RR	FR	2.94	1.71	0.82
Dry	RR	NoFR	3.19	1.49	0.54
Irr	Flex	FR	2.79	1.81	0.70
Irr	Flex	NoFR	3.22	1.53	0.60
Irr	RR	FR	2.66	1.41	0.76
Irr	RR	NoFR	2.84	1.24	0.53
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		NS	NS	NS
	I x V		NS	**	NS
	Removal (R)		***	NS	*
	I x R		NS	NS	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 15. Number of bolls per 10 plants by sympodial position averaged over main stem nodes at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			2.58	1.18	0.29
Irr			2.47	1.20	0.41
	Flex		2.59	1.06	0.27
	RR		2.46	1.32	0.43
		FR	2.45	1.26	0.37
		NoFr	2.59	1.12	0.32
Dry	Flex		2.63	1.07	0.22
Dry	RR		2.53	1.29	0.35
Irr	Flex		2.55	1.06	0.31
Irr	RR		2.39	1.35	0.51
Dry		FR	2.45	1.32	0.34
Dry		NoFR	2.71	1.04	0.23
Irr		FR	2.46	1.20	0.41
Irr		NoFR	2.48	1.21	0.41
	Flex	FR	2.56	1.17	0.30
	Flex	NoFR	2.61	0.96	0.23
	RR	FR	2.35	1.35	0.45
	RR	NoFR	2.58	1.29	0.41
Dry	Flex	FR	2.55	1.26	0.25
Dry	Flex	NoFR	2.70	0.89	0.19
Dry	RR	FR	2.35	1.39	0.43
Dry	RR	NoFR	2.71	1.19	0.28
Irr	Flex	FR	2.57	1.07	0.35
Irr	Flex	NoFR	2.52	1.04	0.28
Irr	RR	FR	2.34	1.32	0.47
Irr	RR	NoFR	2.44	1.39	0.55
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		NS	***	**
	I x V		NS	NS	NS
	Removal (R)		NS	NS	NS
	I x R		NS	*	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS =not significant

Table 16. Number of bolls per 10 plants at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2004.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	17	0.08	0.13	NS
	16	0.13	0.18	NS
	15	0.56	0.28	*
	14	0.99	0.74	*
	13	2.01	1.63	*
	12	3.00	2.42	***
	11	4.71	3.55	***
	10	5.07	4.10	***
	9	5.50	4.56	***
	8	4.93	4.43	***
	7	4.42	3.42	***
	6	3.44	1.93	***
	5	1.09	0.61	***
Irrigated	17	0.34	0.12	NS
	16	0.56	0.41	NS
	15	1.51	1.39	NS
	14	2.36	2.24	NS
	13	3.45	3.76	*
	12	4.15	4.06	NS
	11	5.44	4.71	***
	10	5.82	5.04	***
	9	6.05	5.86	NS
	8	5.83	5.18	***
	7	4.50	3.99	***
	6	2.73	2.14	***
	5	1.08	0.54	***

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table17. Number of bolls per 10 plants at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	0.46	0.89	*
	19	1.28	1.21	NS
	18	1.20	1.47	NS
	17	1.30	2.26	***
	16	2.20	1.63	*
	15	2.83	2.79	NS
	14	3.48	3.34	NS
	13	4.18	4.18	NS
	12	4.40	4.40	NS
	11	4.86	4.85	NS
	10	5.39	5.47	NS
	9	5.73	5.53	NS
	8	5.62	6.06	*
	7	4.92	5.65	***
	6	3.48	3.40	NS
	5	2.34	1.51	***
	4	0.38	0.15	NS
Irrigated	21	0.20	0.27	NS
	20	0.44	0.80	NS
	19	0.92	1.19	NS
	18	1.10	1.19	NS
	17	2.32	1.92	*
	16	2.52	1.92	**
	15	2.22	2.15	NS
	14	2.82	3.01	NS
	13	4.02	2.94	***
	12	4.36	3.66	**
	11	4.37	4.26	NS
	10	5.23	4.18	***
	9	5.51	4.90	**
	8	5.79	5.18	**
	7	4.97	5.30	NS
	6	3.63	4.05	*
	5	3.24	2.17	***

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 18. Number of bolls per 10 plants at first sympodial position by main stem node in irrigated and non-irrigated treatments at the CM Stripling Irrigation Park located in Camilla, GA in 2005.
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		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	0.11	0.45	*
	19	0.28	0.69	*
	18	0.91	1.19	NS
	17	1.69	1.82	NS
	16	1.96	1.87	NS
	15	2.18	2.96	***
	14	3.14	3.07	NS
	13	3.50	3.98	*
	12	4.11	4.64	**
	11	4.76	4.89	NS
	10	4.78	4.44	NS
	9	5.38	4.76	***
	8	5.26	4.71	**
	7	4.19	3.55	***
	6	2.73	1.82	***
	5	1.77	0.64	***
Irrigated	21	0.27	0.42	NS
	20	0.23	0.78	**
	19	0.80	1.57	***
	18	1.56	2.34	***
	17	2.36	2.65	NS
	16	2.63	2.35	NS
	15	2.52	2.89	*
	14	3.56	3.55	NS
	13	4.10	5.10	***
	12	5.36	5.48	NS
	11	4.44	4.27	NS
	10	4.01	3.13	***
	9	4.55	3.58	***
	8	4.27	2.17	***
	7	1.96	1.95	NS
	6	1.56	0.65	***

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 19. Total boll number (m^{-2}) by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2004.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			2.75	0.96	0.40
Irr			3.92	1.48	0.45
	Flex		3.67	1.19	0.43
	RR		2.99	1.25	0.42
		FR	3.17	1.40	0.46
		NoFr	3.49	1.04	0.39
Dry	Flex		3.16	0.90	0.40
Dry	RR		2.34	1.02	0.40
Irr	Flex		4.18	1.48	0.47
Irr	RR		3.65	1.49	0.44
Dry		FR	2.54	1.26	0.43
Dry		NoFR	2.96	0.66	0.37
Irr		FR	3.80	1.55	0.49
Irr		NoFR	4.03	1.42	0.41
	Flex	FR	3.51	1.56	0.49
	Flex	NoFR	3.83	0.82	0.38
	RR	FR	2.83	1.25	0.43
	RR	NoFR	3.16	1.26	0.41
Dry	Flex	FR	2.92	1.27	0.47
Dry	Flex	NoFR	3.40	0.52	0.32
Dry	RR	FR	2.16	1.24	0.38
Dry	RR	NoFR	2.51	0.80	0.43
Irr	Flex	FR	4.11	1.84	0.51
Irr	Flex	NoFR	4.26	1.11	0.43
Irr	RR	FR	3.50	1.25	0.48
Irr	RR	NoFR	3.80	1.72	0.40
	Source of variation				
	Irrigation (I)		***	**	NS
	Variety (V)		***	NS	NS
	I x V		NS	NS	NS
	Removal (R)		NS	***	NS
	I x R		NS	**	NS
	V x R		NS	***	NS
	I x V x R		NS	**	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 20. Total boll number (m^{-2}) by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			2.90	1.58	0.70
Irr			2.90	1.62	0.79
	Flex		2.95	1.67	0.73
	RR		2.85	1.53	0.76
		FR	2.77	1.70	0.82
		NoFr	3.03	1.50	0.67
Dry	Flex		2.95	1.58	0.64
Dry	RR		2.84	1.58	0.75
Irr	Flex		2.94	1.76	0.82
Irr	RR		2.86	1.48	0.76
Dry		FR	2.75	1.62	0.78
Dry		NoFR	3.05	1.55	0.62
Irr		FR	2.79	1.79	0.86
Irr		NoFR	3.02	1.45	0.71
	Flex	FR	2.78	1.76	0.80
	Flex	NoFR	3.11	1.58	0.66
	RR	FR	2.75	1.65	0.84
	RR	NoFR	2.96	1.42	0.67
Dry	Flex	FR	2.79	1.59	0.72
Dry	Flex	NoFR	3.12	1.57	0.57
Dry	RR	FR	2.71	1.65	0.84
Dry	RR	NoFR	2.98	1.52	0.67
Irr	Flex	FR	2.78	1.93	0.88
Irr	Flex	NoFR	3.10	1.59	0.75
Irr	RR	FR	2.79	1.65	0.84
Irr	RR	NoFR	2.94	1.31	0.68
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		NS	NS	NS
	I x V		NS	NS	NS
	Removal (R)		*	*	NS
	I x R		NS	NS	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 21. Total boll number (m^{-2}) by sympodial position averaged over main stem nodes at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			3.18	1.53	0.58
Irr			2.82	1.55	0.66
	Flex		3.15	1.39	0.56
	RR		2.85	1.68	0.68
		FR	3.01	1.66	0.67
		NoFr	2.99	1.41	0.57
Dry	Flex		3.42	1.46	0.55
Dry	RR		2.93	1.59	0.60
Irr	Flex		2.88	1.33	0.56
Irr	RR		2.77	1.77	0.76
Dry		FR	3.03	1.74	0.64
Dry		NoFR	3.33	1.31	0.51
Irr		FR	3.00	1.58	0.69
Irr		NoFR	2.65	1.51	0.63
	Flex	FR	3.25	1.56	0.63
	Flex	NoFR	3.05	1.23	0.49
	RR	FR	2.78	1.76	0.70
	RR	NoFR	2.92	1.60	0.66
Dry	Flex	FR	3.28	1.71	0.56
Dry	Flex	NoFR	3.57	1.21	0.54
Dry	RR	FR	2.78	1.76	0.72
Dry	RR	NoFR	3.09	1.41	0.48
Irr	Flex	FR	3.21	1.40	0.69
Irr	Flex	NoFR	2.54	1.25	0.43
Irr	RR	FR	2.79	1.76	0.68
Irr	RR	NoFR	2.76	1.78	0.84
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		**	**	NS
	I x V		*	NS	NS
	Removal (R)		NS	**	NS
	I x R		***	NS	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	*

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 22. Total boll number (m^{-2}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2004.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	17	0.36	0.04	NS
	16	0.33	0.13	NS
	15	0.75	0.26	*
	14	1.33	1.04	NS
	13	2.69	2.30	NS
	12	4.05	3.44	*
	11	6.46	5.06	***
	10	7.00	5.88	***
	9	7.50	6.46	***
	8	6.71	6.31	NS
	7	6.10	4.84	***
	6	4.77	2.83	***
	5	1.51	0.79	**
Irrigated	17	1.09	0.48	*
	16	0.93	0.77	NS
	15	2.08	1.94	NS
	14	3.30	3.09	NS
	13	4.84	5.24	NS
	12	5.88	5.70	NS
	11	7.71	6.60	***
	10	8.25	7.00	***
	9	8.57	8.18	NS
	8	8.25	7.28	***
	7	6.39	5.53	***
	6	3.95	3.01	***
	5	1.74	0.97	**

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 23. Total boll number (m^{-2}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	0.95	1.11	NS
	19	1.17	1.31	NS
	18	1.12	1.30	NS
	17	1.26	2.02	***
	16	2.02	1.48	*
	15	2.60	2.51	NS
	14	3.23	3.00	NS
	13	3.86	3.77	NS
	12	4.13	3.95	NS
	11	4.62	4.35	NS
	10	5.11	4.93	NS
	9	5.47	4.98	*
	8	5.38	5.47	NS
	7	4.66	5.11	*
	6	3.72	3.09	*
	5	2.20	1.35	***
	4	0.68	0.42	NS
Irrigated	21	0.55	0.68	NS
	20	0.75	1.15	NS
	19	1.00	1.63	*
	18	1.45	1.63	NS
	17	2.45	1.84	*
	16	2.33	2.18	NS
	15	2.06	2.47	NS
	14	2.60	2.87	NS
	13	3.72	3.32	NS
	12	4.08	3.54	*
	11	4.08	4.17	NS
	10	4.89	4.13	***
	9	5.16	4.84	NS
	8	5.43	5.11	NS
	7	4.66	5.29	**
	6	3.66	4.08	*
	5	2.96	2.20	***

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 24. Total boll number (m^{-2}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	0.25	0.72	NS
	19	0.69	1.07	NS
	18	1.12	1.56	*
	17	2.06	2.02	NS
	16	2.42	2.11	NS
	15	2.69	3.36	**
	14	3.86	3.45	*
	13	4.31	4.44	NS
	12	5.11	5.16	NS
	11	5.92	5.43	*
	10	5.92	4.93	***
	9	6.68	5.34	***
	8	6.55	5.25	***
	7	5.20	3.90	***
	6	3.45	2.15	***
	5	2.34	0.70	***
Irrigated	21	0.80	0.51	NS
	20	0.64	0.85	NS
	19	1.12	1.70	*
	18	1.75	2.60	***
	17	2.65	2.96	NS
	16	3.00	2.60	*
	15	2.87	3.23	NS
	14	3.95	3.95	NS
	13	4.53	5.65	***
	12	5.88	6.05	NS
	11	4.84	4.75	NS
	10	4.31	3.45	***
	9	4.89	3.95	***
	8	4.53	2.38	***
	7	2.69	2.44	NS
	6	1.46	0.97	*

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 25. Average boll weight (g boll^{-1}) by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2004.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			3.52	3.46	2.80
Irr			3.37	3.08	2.52
	Flex		3.38	2.90	2.27
	RR		3.51	3.64	3.05
		FR	3.45	3.34	2.40
		NoFr	3.44	3.20	2.93
Dry	Flex		3.56	3.10	2.09
Dry	RR		3.48	3.82	3.52
Irr	Flex		3.20	2.70	2.46
Irr	RR		3.53	3.46	2.59
Dry		FR	3.50	3.45	2.50
Dry		NoFR	3.55	3.47	3.11
Irr		FR	3.40	3.23	2.29
Irr		NoFR	3.33	2.93	2.75
	Flex	FR	3.43	3.00	2.19
	Flex	NoFR	3.33	2.80	2.36
	RR	FR	3.47	3.68	2.60
	RR	NoFR	3.55	3.60	3.50
Dry	Flex	FR	3.65	3.14	2.20
Dry	Flex	NoFR	3.47	3.07	1.98
Dry	RR	FR	3.34	3.76	2.80
Dry	RR	NoFR	3.63	3.88	4.23
Irr	Flex	FR	3.21	2.86	2.18
Irr	Flex	NoFR	3.20	2.54	2.73
Irr	RR	FR	3.60	3.60	2.40
Irr	RR	NoFR	3.47	3.32	2.77
	Source of variation				
	Irrigation (I)		NS	*	NS
	Variety (V)		NS	***	**
	I x V		NS	NS	*
	Removal (R)		NS	NS	NS
	I x R		NS	NS	NS
	V x R		NS	NS	NS
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 26. Average boll weight (g boll^{-1}) by sympodial position averaged over main stem nodes at the Gibbs Farm located in Tifton, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			4.50	4.18	3.64
Irr			4.44	4.10	3.83
	Flex		4.40	4.03	3.69
	RR		4.54	4.25	3.77
		FR	4.56	4.22	3.92
		NoFr	4.39	4.06	3.54
Dry	Flex		4.39	4.02	3.55
Dry	RR		4.61	4.33	3.73
Irr	Flex		4.41	4.03	3.84
Irr	RR		4.47	4.18	3.81
Dry		FR	4.53	4.25	3.86
Dry		NoFR	4.48	4.11	3.42
Irr		FR	4.59	4.19	3.99
Irr		NoFR	4.29	4.01	3.66
	Flex	FR	4.46	4.17	3.82
	Flex	NoFR	4.34	3.88	3.57
	RR	FR	4.66	4.27	4.03
	RR	NoFR	4.43	4.24	3.52
Dry	Flex	FR	4.39	4.06	3.66
Dry	Flex	NoFR	4.40	3.99	3.44
Dry	RR	FR	4.66	4.44	4.05
Dry	RR	NoFR	4.56	4.22	3.41
Irr	Flex	FR	4.53	4.28	3.98
Irr	Flex	NoFR	4.29	3.78	3.70
Irr	RR	FR	4.66	4.10	4.00
Irr	RR	NoFR	4.29	4.25	3.62
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		*	**	NS
	I x V		NS	NS	NS
	Removal (R)		**	NS	**
	I x R		NS	NS	NS
	V x R		NS	NS	NS
	I x V x R		NS	*	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 27. Average boll weight (g $boll^{-1}$) by sympodial position averaged over main stem nodes at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

Treatment Effects			Least Squares Means Sympodial Position		
Irrigation	Variety	Removal	1	2	3
Dry			3.97	3.93	3.52
Irr			3.86	3.77	3.45
	Flex		3.75	3.61	3.33
	RR		4.09	4.09	3.64
		FR	4.03	3.87	3.63
		NoFr	3.80	3.83	3.35
Dry	Flex		3.85	3.81	3.46
Dry	RR		4.09	4.06	3.59
Irr	Flex		3.65	3.41	3.21
Irr	RR		4.08	4.12	3.70
Dry		FR	4.05	3.98	3.74
Dry		NoFR	3.90	3.89	3.31
Irr		FR	4.02	3.76	3.52
Irr		NoFR	3.71	3.77	3.39
	Flex	FR	3.83	3.60	3.68
	Flex	NoFR	3.67	3.62	2.99
	RR	FR	4.24	4.15	3.58
	RR	NoFR	3.94	4.04	3.70
Dry	Flex	FR	3.88	3.84	3.95
Dry	Flex	NoFR	3.82	3.78	2.97
Dry	RR	FR	4.21	4.13	3.53
Dry	RR	NoFR	3.98	3.99	3.65
Irr	Flex	FR	3.77	3.36	3.41
Irr	Flex	NoFR	3.52	3.46	3.01
Irr	RR	FR	4.26	4.16	3.64
Irr	RR	NoFR	3.90	4.08	3.76
	Source of variation				
	Irrigation (I)		NS	NS	NS
	Variety (V)		***	***	*
	I x V		NS	**	NS
	Removal (R)		*	NS	*
	I x R		NS	NS	NS
	V x R		NS	NS	**
	I x V x R		NS	NS	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 28. Average boll weight (g boll^{-1}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2004.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	17	2.62	2.93	NS
	16	4.39	3.84	NS
	15	3.97	3.95	NS
	14	3.89	4.10	NS
	13	4.31	4.07	NS
	12	4.07	4.42	NS
	11	4.03	4.03	NS
	10	3.92	3.99	NS
	9	3.57	3.86	NS
	8	3.63	3.62	NS
	7	3.41	3.68	NS
	6	3.23	3.18	NS
	5	2.99	2.92	NS
Irrigated	18	2.19	3.33	NS
	17	2.66	4.24	*
	16	3.34	2.76	NS
	15	3.33	3.12	*
	14	3.55	4.10	NS
	13	3.64	4.48	NS
	12	3.90	4.73	NS
	11	3.88	4.66	NS
	10	3.85	4.85	NS
	9	3.68	4.27	*
	8	3.72	3.33	NS
	7	3.52	3.07	NS
	6	3.25	2.66	NS
	5	2.45	1.93	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 29. Average boll weight (g boll^{-1}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the Gibbs Farm located in Tifton, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	3.51	3.07	NS
	19	3.56	3.73	NS
	18	3.41	3.79	NS
	17	4.07	3.88	NS
	16	4.85	4.51	NS
	15	4.52	5.28	**
	14	4.74	4.95	NS
	13	4.97	5.10	NS
	12	5.21	5.08	NS
	11	4.94	5.43	*
	10	4.84	5.38	*
	9	5.26	5.80	*
	8	5.06	5.28	NS
	7	4.61	5.12	*
	6	4.43	4.82	NS
	5	4.28	4.38	NS
	4	3.92	3.85	NS
Irrigated	21	3.18	3.53	NS
	20	3.04	3.57	NS
	19	3.54	3.22	NS
	18	4.63	3.72	**
	17	4.05	4.47	NS
	16	4.32	4.74	NS
	15	4.84	4.67	NS
	14	4.63	4.75	NS
	13	4.60	4.95	NS
	12	4.76	4.97	NS
	11	5.25	5.18	NS
	10	5.51	5.10	NS
	9	4.90	5.13	NS
	8	5.36	5.09	NS
	7	4.88	4.52	NS
	6	4.28	4.67	NS
	5	3.83	4.04	NS

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 30. Average boll weight (g boll^{-1}) at first sympodial position by main stem node in irrigated and non-irrigated treatments at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

		Least Squares Means		
Treatment	Node	Flex	RR	P>|t|
Dryland	20	1.93	2.60	**
	19	3.01	2.47	***
	18	2.46	3.55	***
	17	3.13	3.47	*
	16	3.67	4.18	***
	15	4.30	4.48	NS
	14	4.43	5.32	***
	13	4.82	5.30	***
	12	4.91	5.69	***
	11	4.61	5.59	***
	10	4.73	4.82	NS
	9	4.79	5.05	*
	8	4.48	4.61	NS
	7	4.14	3.76	**
	6	3.92	3.64	*
Irrigated	21	2.39	2.23	NS
	20	2.57	2.96	*
	19	2.02	2.95	***
	18	2.88	3.49	***
	17	3.10	3.68	***
	16	3.49	4.70	***
	15	3.98	4.83	***
	14	4.69	5.40	***
	13	5.14	5.46	*
	12	5.00	5.21	NS
	11	4.90	5.23	*
	10	4.01	4.84	***
	9	4.47	4.00	***
	8	4.15	4.38	*
	7	3.29	3.32	NS
	6	3.68	2.20	***

* significant at P = 0.10
** significant at P = 0.05
*** significant at P = 0.01
NS = not significant

Table 31. 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 by weight [SFC(w)], fineness (Fine), and maturity ratio at the Gibbs Farm located in Tifton, GA in 2004.

Treatment Effects								
Irrigation	Variety	Removal	L(w)	L(w) CV	UQL(w)	SFC(w)	Fine	Maturity ratio
			mm	%	mm	%	mg km^{-1}	
Dry			24.96	34.91	30.24	10.22	164	0.78
Irr			24.05	37.75	29.63	10.61	159	0.75
	Flex		25.25	37.75	31.27	10.16	154	0.76
	RR		23.76	34.91	28.60	10.67	169	0.77
		FR	24.59	36.27	30.05	10.41	161	0.76
		NoFR	24.42	36.39	29.82	10.41	162	0.76
Dry	Flex		25.63	36.39	31.47	10.04	157	0.77
Dry	RR		24.28	33.44	29.01	10.41	172	0.78
Irr	Flex		24.87	39.11	31.06	10.28	152	0.74
Irr	RR		23.24	36.38	28.19	10.93	166	0.76
Dry		FR	25.17	34.65	30.48	10.12	164	0.78
Dry		NoFR	24.74	35.18	30.00	10.32	164	0.77
Irr		FR	24.00	37.89	29.62	10.71	159	0.75
Irr		NoFR	24.10	37.61	29.64	10.50	159	0.75
	Flex	FR	25.37	37.60	31.42	10.02	154	0.76
	Flex	NoFR	25.12	37.90	31.12	10.30	154	0.75
	RR	FR	23.80	34.94	28.68	10.81	168	0.77
	RR	NoFR	23.72	34.88	28.52	10.53	169	0.77
Dry	Flex	FR	25.96	35.89	31.85	9.72	156	0.77
Dry	Flex	NoFR	25.30	36.89	31.09	10.36	157	0.77
Dry	RR	FR	24.38	33.42	29.11	10.52	171	0.78
Dry	RR	NoFR	24.18	33.46	28.91	10.29	172	0.78
Irr	Flex	FR	24.79	39.31	30.99	10.31	153	0.74
Irr	Flex	NoFR	24.94	38.91	31.14	10.25	152	0.74
Irr	RR	FR	23.22	36.47	28.24	11.10	165	0.75
Irr	RR	NoFR	23.27	36.30	28.14	10.76	166	0.76
	Source of variation							
	Irrigation (I)		***	***	***	NS	***	**
	Variety (V)		***	***	***	***	***	***
	I x V		NS	NS	**	NS	NS	NS
	Removal (R)		*	NS	***	NS	NS	NS
	I x R		***	*	***	**	NS	NS
	V x R		NS	NS	NS	NS	NS	NS
	I x V x R		NS	NS	**	NS	NS	NS

* significance at P = 0.10
** significance at P = 0.05
*** significance at P = 0.01
NS = not significant

Table 32. 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 by weight [SFC(w)], fineness (Fine), and maturity ratio at the Gibbs Farm located in Tifton, GA in 2005.

Treatment Effects								
Irrigation	Variety	Removal	L(w)	L(w) CV	UQL(w)	SFC(w)	Fine	Maturity ratio
			mm	%	mm	%	mg km^{-1}	
Dry			26.68	31.09	31.55	6.32	168	0.80
Irr			27.07	30.89	32.11	6.12	167	0.80
	Flex		27.52	31.42	32.76	6.35	164	0.80
	RR		26.23	30.55	30.90	6.09	171	0.80
		FR	26.96	30.81	31.89	6.10	167	0.80
		NoFR	26.79	31.17	31.77	6.34	168	0.80
Dry	Flex		27.23	31.64	32.41	6.51	165	0.80
Dry	RR		26.13	30.54	30.70	6.13	172	0.80
Irr	Flex		27.81	31.21	33.10	6.18	162	0.80
Irr	RR		26.33	30.57	31.11	6.05	171	0.80
Dry		FR	26.78	30.93	31.66	6.20	168	0.80
Dry		NoFR	26.59	31.26	31.45	6.44	169	0.80
Irr		FR	27.14	30.69	32.13	6.00	166	0.80
Irr		NoFR	27.00	31.09	32.09	6.23	167	0.80
	Flex	FR	27.64	31.32	32.87	6.24	163	0.80
	Flex	NoFR	27.40	31.53	32.64	6.45	164	0.80
	RR	FR	26.27	30.29	30.91	5.95	171	0.80
	RR	NoFR	26.19	30.82	30.89	6.23	172	0.80
Dry	Flex	FR	27.35	31.56	32.55	6.38	164	0.79
Dry	Flex	NoFR	27.11	31.72	32.27	6.64	165	0.80
Dry	RR	FR	26.21	30.29	30.77	6.01	172	0.80
Dry	RR	NoFR	26.06	30.79	30.62	6.25	172	0.80
Irr	Flex	FR	27.93	31.08	33.20	6.11	162	0.80
Irr	Flex	NoFR	27.68	31.33	33.01	6.26	163	0.80
Irr	RR	FR	26.34	30.29	31.06	5.89	171	0.80
Irr	RR	NoFR	26.32	30.84	31.17	6.21	171	0.80
	Source of variation							
	Irrigation (I)		**	NS	**	NS	NS	NS
	Variety (V)		***	***	***	**	***	NS
	I x V		**	NS	NS	NS	NS	NS
	Removal (R)		*	**	NS	**	NS	NS
	I x R		NS	NS	NS	NS	NS	NS
	V x R		NS	NS	NS	NS	NS	NS
	I x V x R		NS	NS	NS	NS	NS	NS

* significance at P = 0.10
** significance at P = 0.05
*** significance at P = 0.01
NS = not significant

Table 33. 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 by weight [SFC(w)], fineness (Fine), and maturity ratio at the CM Stripling Irrigation Park located in Camilla, GA in 2005.

Treatment Effects								
Irrigation	Variety	Removal	L(w)	L(w) CV	UQL(w)	SFC(w)	Fine	Maturity ratio
			mm	%	mm	%	mg km^{-1}	
Dry			25.84	33.08	30.99	8.00	172	0.81
Irr			25.86	33.25	31.13	8.05	169	0.80
	Flex		26.19	34.28	31.81	8.73	166	0.79
	RR		25.51	32.05	30.31	7.33	175	0.81
		FR	25.87	33.23	31.09	8.01	170	0.80
		NoFR	25.83	33.10	31.03	8.04	171	0.80
Dry	Flex		26.28	34.09	31.81	8.59	168	0.80
Dry	RR		25.41	32.07	30.17	7.41	176	0.81
Irr	Flex		26.10	34.46	31.80	8.86	164	0.79
Irr	RR		25.62	32.04	30.45	7.25	175	0.81
Dry		FR	25.97	32.96	31.09	7.82	172	0.81
Dry		NoFR	25.71	33.20	30.89	8.18	172	0.80
Irr		FR	25.78	33.50	31.09	8.21	167	0.80
Irr		NoFR	25.94	33.00	31.16	7.90	171	0.81
	Flex	FR	26.29	34.23	31.92	8.58	165	0.80
	Flex	NoFR	26.09	34.33	31.69	8.87	166	0.79
	RR	FR	25.46	32.23	30.26	7.44	174	0.81
	RR	NoFR	25.57	31.88	30.36	7.21	176	0.82
Dry	Flex	FR	26.50	33.94	32.04	8.32	168	0.81
Dry	Flex	NoFR	26.05	34.24	31.58	8.86	167	0.80
Dry	RR	FR	25.44	31.98	30.14	7.32	176	0.81
Dry	RR	NoFR	25.38	32.16	30.20	7.50	176	0.81
Irr	Flex	FR	26.08	34.52	31.79	8.85	162	0.79
Irr	Flex	NoFR	26.12	34.41	31.81	8.88	165	0.79
Irr	RR	FR	25.48	32.48	30.39	7.57	173	0.80
Irr	RR	NoFR	25.76	31.60	30.52	6.93	177	0.82
	Source of variation							
	Irrigation (I)		NS	NS	NS	NS	**	**
	Variety (V)		***	***	***	***	***	***
	I x V		***	NS	**	NS	NS	*
	Removal (R)		NS	NS	NS	NS	NS	NS
	I x R		***	NS	**	NS	*	**
	V x R		**	NS	**	NS	NS	*
	I x V x R		NS	NS	NS	NS	NS	NS

* significance at P = 0.10
** significance at P = 0.05
*** significance at P = 0.01
NS = not significant

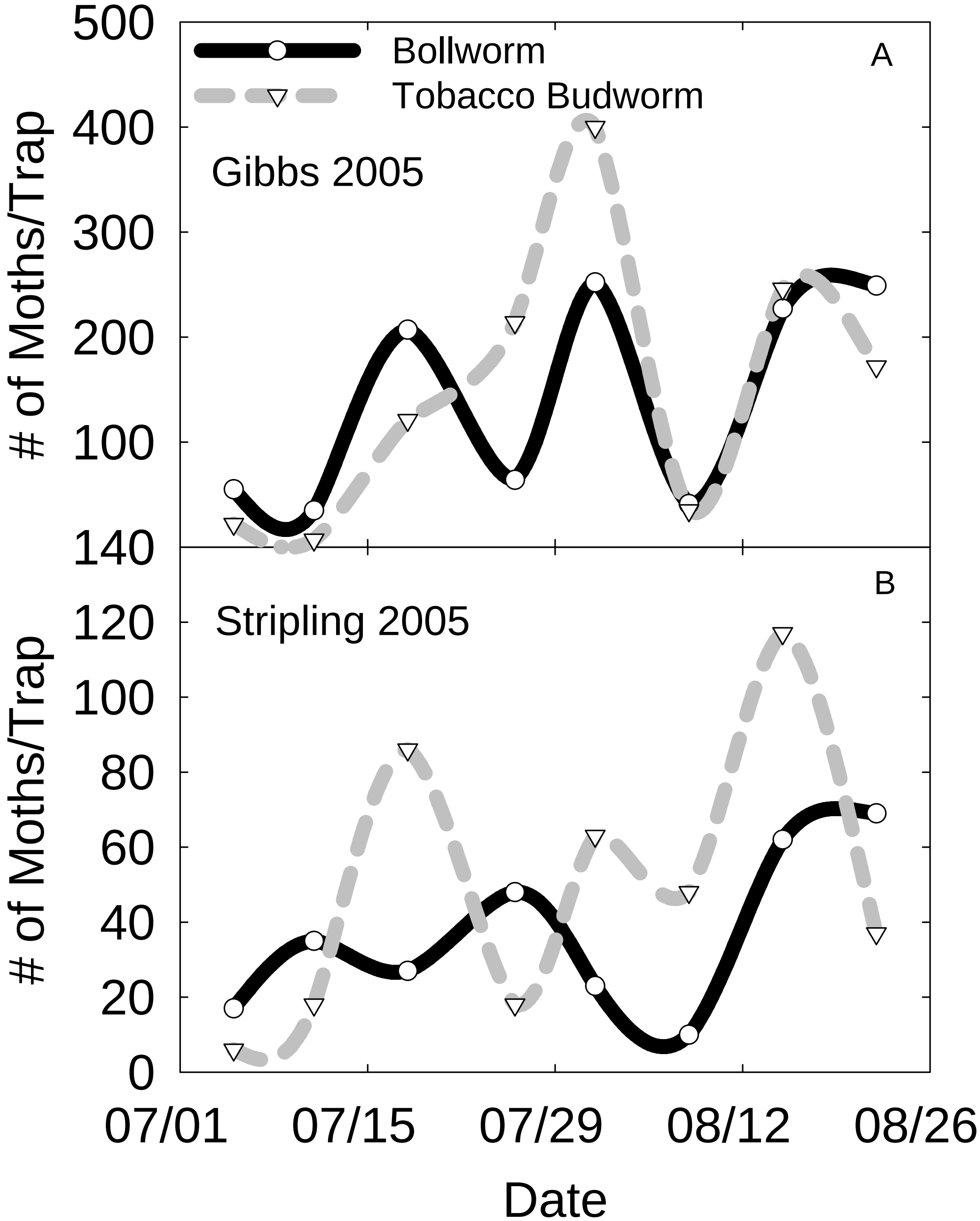

Figure 2. Tobacco budworm (*Heliothis virescens*) and bollworm (*Helicoverpa zea*) populations throughout the growing season at the Gibbs Farm, Tifton, GA in 2005 and CM Stripling Irrigation Park, Camilla, GA in 2005.

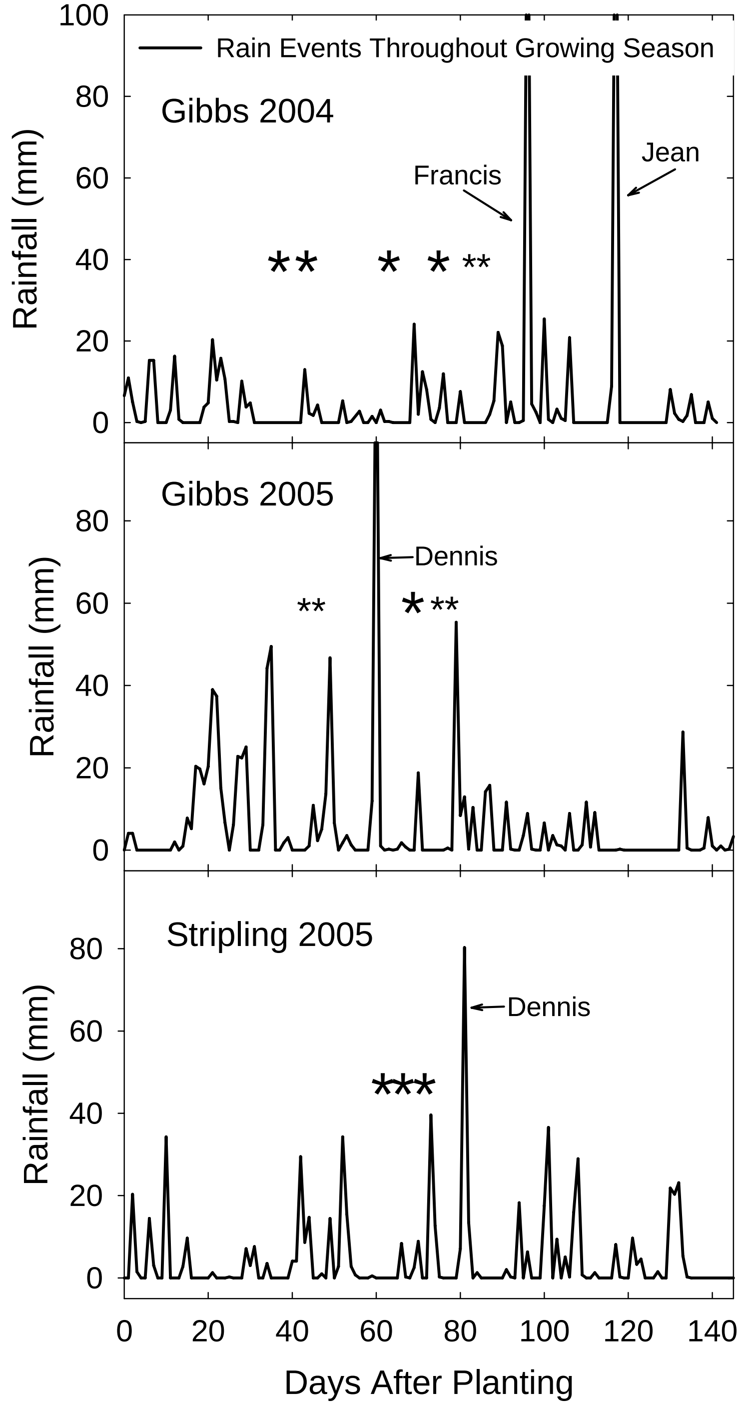

Figure 3. Rainfall events throughout the growing season at three locations: Gibbs Farm, Tifton, GA in 2004 and in 2005 (Gibbs 2004 and 2005), and CM Stripling Irrigation Park, Camilla, GA in 2005 (Stripling 2005). Irrigation events are represented by * = 25.4 mm and ** = 12.7 mm.

CHAPTER 5

CONCLUSION

The production of genetically enhanced cotton has resulted in a great change in cotton production throughout the cotton belt. These discoveries provide greater flexibility and convenience in crop production along with new challenges. These challenges and differences were discussed in this study in accordance with the current technology and future technology.

The current BG/RR cotton has arrived to certain challenges such as development of insect resistance to Bt and fruiting structures sensitive to late glyphosate applications. May et al. (2004) have shown fruit loss from excessive and late glyphosate applications in BG/RR shifting the fruiting pattern in this study. BGII/RRF consistently produced increased number and heavier bolls at the first sympodial position at the lower main stem nodes while BG/RR produced increased boll numbers on the upper main stem nodes.

BG/RR compensated for the early-season fruit loss that occurred from late glyphosate applications therefore, supporting the hyposthesis that compensation for fruit loss results in redistribution of fruit to outer sympodial positions and upper main stem nodes. In addition, while BG/RR produced fewer inner position bolls, BG/RR also compensated by producing heavier bolls at these inner fruiting positions supporting the hypothesis of an active and instantaneous response in which resources that would have been partitioned into damaged structures are partitioned into undamaged structures resulting in heavier fruits (Sadras, 1995).

The hypothesis behind BGII/RRF suggested fruit retention can be too high such that the crop cuts out prematurely especially when exposed to stress. Under the environmental conditions of this study, BGII/RRF performed better under FR treatments than in NoFR treatments, in a few instances, supporting the hypothesis that early-season fruit retention could be too high and FR may extend vegetative growth which would improve the crop's ability to acquire resources such as water, sunlight, and nitrogen (Sadras, 1995). Interestingly, early-season FR did not have a significant negative yield impact in both years and had a positive yield impact at one location.

Fiber quality was relatively different between varieties. HVI micronaire was lower in the BGII/RRF in all environments. BGII/RRF cotton had longer fiber and increased fiber strength in all environments. But AFIS reports indicated more variability in the length of fibers and short fiber content was higher. The new technology, BGII/RRF, provides additional flexibility and convenience but probably could perform better in different cultivars.

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