Abstract

HAMM, GARY STEPHEN. Agronomics of Cotton Grown on a 38-cm Row Spacing in North Carolina. (Under the direction of Dr. Keith Edmisten)

Cotton (*Gossypium hirsutum*) planted in a 38-cm row configuration is an innovative idea that has come about in the past few years. There has been some interest in narrow-row cotton due to the availability of a new harvester capable of harvesting cotton on 38-cm rows. Producers have raised questions regarding changing their cotton production strategies in order to maximize yield potential for cotton grown on 38-cm rows. Agronomic practices that allow for maximum yield potential have yet to be determined for narrow-row cotton. Four separate field experiments were conducted in 2005, 2006 and 2007 at the Upper Coastal Plain Research Station, near Rocky Mount, NC, Central Crops Research Station, Clayton, NC, and on-farm in Duplin County, NC in order to define these agronomic practices. Cotton was planted on 38-cm row spacings using a vacuum planter. One experiment was conducted to observe the effects of seven nitrogen rates ranging from 0-196 kg N ha^{-1} on yield potential, plant uptake of nitrogen, growth habits, fiber quality, and economic returns of narrow-row cotton. The second experiment was conducted to look at the effects of fourteen different plant growth regulator application methods on plant height control, yield, and fiber quality. The strategies consisted of making applications to narrow-row cotton at certain growth stages with different rates of mepiquat pentaborate. The third experiment consisted of making a herbicidal defoliation application to narrow-row cotton at six different percent open boll stages ranging from 0-100 % open bolls to determine yield and fiber quality parameters. The fourth experiment was conducted to determine if narrow-row cotton could be planted

in a double-crop situation with wheat, which is an uncommon practice in North Carolina. For this experiment, narrow-row cotton was planted in comparison with wide-row cotton for yield and economic potential at five different planting dates ranging from May to July. The last two planting dates ranging from mid-June to July were conducted so that cotton could be planted into harvested wheat stubble for an economic evaluation of wheat yield plus cotton yield for profit potential.

The nitrogen experiment determined that yields and economic returns declined at nitrogen rates higher than 67 kg N ha^{-1}; although, plant uptake of nitrogen rose as nitrogen rate was increased. There were negative effects observed in plant height and node numbers from increases in nitrogen rate. The second experiment determined that plant growth regulators being applied at the 8-leaf stage, regardless rate or application strategy, gave the most adequate height control of all methods. There were no benefits seen with applications being made earlier than the 6-leaf stage. Yield data suggested that current recommendations for plant growth regulators can be used for 38-cm cotton along with earlier application timings without affecting yields. The defoliation study showed that as defoliation was delayed until later timings, there was a trend for increase in yields. Data suggested that prolonging defoliation yielded less than desirable fiber quality. Defoliation efficacy improved as timings were delayed. Yield data from the double crop study suggested as planting date was delayed, yield declines were observed in both wide and narrow-rows. Data also suggested that optimal yields can be obtained from 38-cm row cotton in a double crop situation with wheat in NC if a late frost occurs. Growing cotton in a double crop situation on 38-cm rows in areas with longer growing seasons, could be a viable option in replacing soybeans as a double cropping option. Cotton grown on a 38-cm row pattern showed higher yields and economic returns than cotton grown on 96-cm row pattern making it a better option in a double crop situation.

Agronomics of Cotton Grown on a 38-cm Row Spacing
in North Carolina

by
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Dedication

I would like to dedicate my work to my daddy, the late Mr. James Earl Hamm. My father has been the strongest influence in my life. He turned me to the love of agriculture at an early age. I spent countless hours in the field with my daddy. From the time I was old enough to ride in the front seat of our old Ford Bronco with him hauling tobacco, until I was old enough to drive him around the farm asking his advice on what to do to my own crops. These hours were my classroom for agriculture. I learned so much listening to him tell stories of crop responses to previous years' practices and weather conditions. How rain and drought could both help and hurt a crop. He taught me so much I wish I could have somehow written it all down in a book to keep and reflect on now. So many times I catch myself looking to my daddy for advice and knowing he is not there, but really wishing I could somehow get an answer directly from him. Not only did my daddy teach me about farming but he taught me about work ethic as well. I can remember numerous mornings. Daddy would wake me up with a cold hand on the back of my neck where he had already been outside getting ready for the day's work ahead. He used to say "Now how are you going to get anything done if you want to stay in bed all morning?" I would get up and the day would begin and it usually involved me doing most of the work and him telling me what to do as fathers do best. On Sunday afternoons, I would want to rest but he would roust me out of the house to go visit neighbors, ride around and look at crops, and plan our next week's work. I wouldn't trade it now for a single moment of rest if I could do it again.

My daddy taught me about life as well. He taught me how to respect and be respected, how with pride can come humility, how to care for a family, and provide for them when the cards aren't always in your favor. My daddy taught me how to plan ahead, not always act before thinking it through. He taught me how to be courteous and kind. Say yes sir or ma'am, please, and thank you. Things that I think children are not taught in today's society and should be. My daddy was a wise man. Sometimes when he was giving me some pretty hard advice, or scolding me for wrongs, I couldn't see what he was talking about. Now that I m older and more mature, I truly understand what he was saying, and see my wrongs. I often catch myself saying some of his famous quotes.

The lord decided my daddy's work on earth was done on August 23, 1998. Through his sickness, he showed the strength and composure that leaves me with an admiration that will never be forgotten. He will always be missed.

Biography

Gary Stephen Hamm, son of James Earl and Pearline Harris Hamm, was born on December 20, 1977 in Tarboro, NC. He has two older sisters, Jennifer Hamm Jones and Deborah Hamm Whaley. He grew up on the family farm gaining much experience with a large variety of crops such as tobacco, cotton, corn, soybeans, peanuts, and wheat. Shortly after graduating from Tarboro High School in 1996, he began farming with his dad. After his father's death in 1998, Gary finished out the crop year and decided to pursue other interests.

Gary decided to go to college in the spring of 2000. He attended various community colleges to achieve coursework needed to transfer to NC State University in the fall of 2001. As an undergraduate at NC State, Gary was an active member in FarmHouse Fraternity and served as secretary on the fraternity executive board for two years. He started working with the Cotton Extension and Research program at NC State in the fall of 2002 under Dr. Keith Edmisten. At the 2004 Beltwide Cotton Production and Research Conference, Gary competed as an undergraduate in the graduate poster competition and took home second place. Gary received his Bachelor of Science degree in Agronomy in the spring of 2005. He then continued on to pursue a Master of Crop Science degree with a cotton physiology concentration in the fall of 2005. During Gary's epic in the Cotton Extension and Research program, he assisted in the reorganization of the program itself.   He was a large part of the design and building of the first research cotton picker that was able to harvest cotton on a 38-cm row spacing in the country.

He has also had a hand in many other design projects such as a John Deere plot planter that is configured on 38-cm rows and specialized spray equipment for small plot research.

Other than his work at NC State, Gary also has many hobbies. He likes to hunt, fish, work in his vegetable garden, do various metal works in the shop, and work with a local farmer in Wendell, NC operating farm equipment.

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Literature Review

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Overview

Cotton (*Gossypium hirsutum* L.) is usually planted in rows spaced 76 to 96 cm apart. These row spacings have been utilized since mules and plows were the primary source of farm machinery and the rows needed to be wide enough to accommodate livestock (Williford, 1992). As farm equipment evolved, this row spacing remained a common practice in order to accommodate tractors and cultivators. In addition, there were few effective herbicides available in earlier cotton production systems that could be applied topically for weed control so cultivation was a necessary practice. Planting cotton in narrow-row patterns is now feasible due to seed technology and herbicide-resistant cotton varieties (Culpepper and York, 2000). Frequent cultivation is no longer necessary.

Research has been conducted during the past 30 years investigating the benefits of growing cotton in narrow rows. Narrow-row systems have proven to achieve higher yields (Buxton et al., 1978; Wilson et al, 2007). The problem that has been associated with narrow-row production of cotton is the ability to mechanically harvest it using a spindle picker (Williford, 1992). Previously, narrow-cotton was harvested using a finger-type stripper in which the bracts, stalk material, and leaf material were harvested with the seed cotton, causing increased trash content (Anthony et al., 2000). John Deere Company has recently developed a harvester that can spindle-harvest cotton grown in 38-cm row configurations (Wilson et al., 2007). This allows cotton to be grown in closer row spacings and harvested cleaner than previous methods (Wilson et al., 2007). Also, production practices that are more suitable with a 38-cm row spacing versus the 18-cm row spacing (ultra-narrow row) includes planting method and seed placement. Ultra-narrow row cotton is planted using a grain drill, however more advanced planters have been developed to plant in 38-cm rows. These planters have seed disks that allow for better seed placement and more precise plant population adjustments (Wilson et al., 2007). Ray and Hudspeth (1966) observed yield increases of 6 to 11% when cotton was planted in 18- to 25-cm rows when compared to wide row patterns. In a study by Wilson et al. (2007), cotton grown on a 38-cm row spacing yielded 10% higher than cotton grown on 97-cm rows. One advantage of the narrower-row configurations is increased canopy light interception (Steglich et al., 2000). Another advantage of using narrow-row spacings in cotton is to reduce evaporation of soil water (Jost and Cothren, 2000). Krieg (1996) found that up to 40% of plant available water is lost through evaporation in wide-row systems. Jost and Cothren (2000) found that 19- and 38-cm row spacings had canopy closure values of 93 and 76%, respectively, at 61 days after planting, while 76- and 102-cm row spacings only reached canopy closure of 51 and 32%, respectively. Also, the benefit of late-season weed control is achieved from shading out smaller weeds within the row middles due to more rapid canopy closure (Snipes, 1996). Culpepper and York (2000) found that many species of grass and broadleaf weeds can be controlled or suppressed better by using a narrow-row pattern when compared to a wide-row pattern. Another advantage that narrow-row cotton offers is earlier maturity due to compact fruiting resulting from increased plant populations and decreased row spacings (Bednarz and Nichols, 2005; Viator et al., 2008; Vories et al., 2001). Cotton grown in narrow-row patterns has less outer position fruit than in wide-row systems because of the reduced space between rows thus inhibiting outward monopodial and sympodial vegetative growth (Jost and Cothren, 2000). Previous research showed that boll retention was higher at greater plant populations than at lower populations (Heitholt, 1995). In a study by Fowler and Ray (1977), data suggested that there are significantly more fruiting structures in narrow-row patterns than in wide-row patterns per given unit area of land. These advantages all can be utilized when planting cotton in a 38-cm row pattern, thus leading to more efficient use of resources which can help to maximize yield potential.

Nitrogen Fertility

Nitrogen fertilization is essential in producing high-yielding cotton. Previous research by Koli and Morrill (1975) has shown that nitrogen can influence cotton yields more than any other nutrient. Too little available nitrogen in the soil can decrease both lint yield and fiber quality (Gardner and Tucker, 1967). Most agree that the growth response of cotton to nitrogen fertilization is largely dependent upon soil moisture (Jackson and Tilt, 1968). The amount of available nitrogen in the soil is usually less than required for optimal yields (Gardner and Tucker, 1967). Depending upon location or soils, optimal nitrogen rates in North Carolina may vary from farmer to farmer, from 67-224 kg N ha^{-1} (Crozier, 2008). It is important to apply the correct amount of nitrogen to a narrow-row system, because over-applying nitrogen can result in undesirable effects such as excessive plant growth and yield loss (Boquet, 2005). In a study by McConnell et al.

(2001), where nitrogen was applied from 56 to 112 kg N ha^{-1}, higher yields were found in a narrow-row spacing at lower nitrogen levels than wide-row spacings. Clawson et al. (2006) suggested that nitrogen recommendations should not be adjusted for narrow-row cotton. Koli and Morrill (1975) observed no interactions between nitrogen rate and plant populations. Also, this experiment showed that nitrate levels in the plant were proportional to the amount applied, but there was no relationship between higher nitrate levels and yields. Yields were reduced at 90 kg N ha^{-1}, whereas there was no effect on yield at the 45 kg N ha^{-1} rate (Koli and Morrill, 1975). This experiment indicated that cotton can absorb more nitrogen than is required, but there is no response in yield from this increase in nitrogen uptake. Therefore, it is important for farmers to use nitrogen efficiently and maintain an optimum return in yield for the amount of nitrogen applied.

Plant Growth Regulators

Plant growth regulators (PGRs) are commonly used throughout the cotton belt to control plant height, hasten maturity, and potentially enhance higher yields (Reddy et al., 1992). Products containing mepiquat chloride are the most widely used plant growth regulators (Kerby, 1985). Mepiquat chloride inhibits gibberellin synthesis in the plant, which regulates plant cell elongation (Reddy et al., 1992). By inhibiting cell growth, the plant’s growth rate is reduced. Plants that have been treated with mepiquat chloride are generally smaller with more compact nodes compared to untreated plants (Kerby, 1985). Research has shown positive yield responses from mepiquat chloride (York, 1983). Applications of mepiquat made to early or too late can result in yield reductions as well.

In addition, mepiquat applications made in unfavorable conditions can result in yield loss (Cathey and Meredith, 1988). Delayed or late applications can result in poor growth control (Livingston et al., 2000).

In North Carolina, there are three common application strategies used in wide-row cotton production. The early bloom strategy is a method based upon making a mepiquat application at the early bloom period (5 to 6 white blooms per 6.7 meters of row) and is used generally in four situations: 1) plant height is less than 51 cm at early bloom because of environmental stress, delay application until stress is relieved (only if application is needed after stress relief; 2) plant height is 51 cm to 61 cm at early bloom and there is potential for excessive growth beyond early bloom; 3) plant height is more than 61 cm at early bloom and cotton is growing rapidly; 4) plant heights are approaching 51 to 61 cm at early bloom and plant growth is rapid due to excessive soil moisture and rainfall (Edmisten, 2008). The second strategy is the modified early bloom strategy. This approach involves potential applications of a mepiquat 10 to 14 days prior to early bloom, at early bloom, and possibly again at 10 to 14 days after early bloom (Edmisten, 2008). The last method is the low rate multiple strategy in which potential PGR applications are made beginning at match-head square (squares are 0.3cm to 0.6 cm in diameter) followed by potential applications every 14 days (Edmisten, 2008).

For cotton grown in narrow-row configurations, it is important to maintain shorter plants so that harvest efficiency is not inhibited, especially with harvest equipment designed to harvest narrow-rows. Little research has been published that determines the most effective plant growth regulator application strategy for cotton grown on 38-cm row spacings. The only known research to date was in North Carolina during 2004 and 2005 and showed that the low rate multiple and modified early bloom strategies were best suited for cotton grown in 38-cm row spacings (Wilson et al., 2007).

There are several variables that are involved in making decisions regarding the optimal plant growth regulator application strategy for cotton grown on 38-cm row spacings. Time of season, environment, rainfall, soil type, and cotton variety are all considerable variables when determining a suitable and effective plant growth application strategy for cotton production.

Defoliation

Cotton defoliation is a practice of chemically preparing cotton for harvest by promoting boll opening and removing leafy materials that might stain or contribute trash in the harvest lint (Faircloth et al., 2004). Defoliants usually consist of hormonal and/or herbicidal modes of action that will aid in leaf abscission and boll opening (Brecke et al., 2001). Harvest aids are beneficial in promoting early harvest, but determining when to defoliate is a difficult decision for a grower to make. Deciding when to defoliate is generally determined by environmental conditions in a particular area, the proportion of open bolls to un-open bolls present on the plant, and the desired harvest date (Gwathmey et al., 2001). Optimal defoliation timings can help achieve desirable yields and lint quality. Premature defoliation can reduce yields by terminating immature bolls, whereas late defoliation can result in lint yield and fiber quality losses (Snipes and Baskin, 1994).

Snipes and Baskin (1994) conducted an experiment where cotton was defoliated at 20, 40, 60, and 80% open bolls. The results of this experiment indicated that cotton should be defoliated at 60 percent open bolls.

Some researchers suggest that the percent open boll method may not be the most appropriate method to use when deciding when to defoliate. This is because the percent open boll method is inaccurate where there is a large fruiting gap between bolls at the bottom portion of the plant and the top portion where bolls are less mature but will likely reach maturity if adequate heat units are available (Faircloth et al., 2004). If a boll is opened at less than 35 days of age, several quality parameters, such as fiber length, are affected and both seed germination of harvested seed and lint yields can be reduced (Brown and Hyer, 1956). Researchers believe that using the nodes above cracked boll (NACB) method is more appropriate for determining when to defoliate because it focuses on the un-open portion of bolls. The NACB method is used by counting nodes to the highest harvestable boll beginning at the first sympodial branch with a first position cracked boll (Kerby et al., 1992). The decision to use a particular method depends upon fruiting characteristics and environmental conditions in a particular year (Brecke et al., 2001).

As the fall season progresses, the day length is shortened and amount of hours available for harvest is greatly reduced. Also, growers are more likely faced with unfavorable weather conditions for harvest such as rain and heavy dews that will also shorten the amount of hours per day favorable for harvest (Cooke et al., 1972). Very little research has been conducted in determining the proper defoliation timing for cotton grown on 38-cm row patterns. The compact fruiting nature of the narrow-row spacing could be advantageous in the ability to make a defoliation decision. The more uniform maturity of bolls as found in narrow-row systems could allow for defoliation to be initiated sooner than in wide-row cotton.

Double Cropping

Cotton producers in the southeastern United States are interested in growing cotton double-cropped with a winter grain crop (Porter et al., 1996). The ability of cotton to be used in a double-crop situation is not yet defined (Hunt et al., 1997). Most growers in North Carolina attempt to have cotton planted before the last week of May. As planting is delayed, cotton yields usually decline (Porter et al., 1996). The concept of planting two crops in the same field in a year, or double cropping, is not a new idea (Smith and Varvil, 1981). Double-cropping is a viable option because growers are able to increase economic output per unit of land area. The double-cropping system allows for increased profitability when compared to a single-crop system because multiple crops per unit of land area can be sold for profit versus one in a single-crop system (Baker, 1987). A double-cropping system of soybeans (*Glycine max*) planted after wheat (*Triticum aestivum*) is more common than a system with cotton planted after wheat (Buntin et al., 2002).   Cotton is usually planted long before growers harvest their wheat crop. Research in Arkansas has shown that cotton grown in wide-row systems (> 76 cm) should not be used in a double-crop situation with wheat (Smith and Varvil, 1981). Planting cotton later than the last week of May shortens the growing season which can reduce yields (Porter et al., 1996). Utilizing earlier maturing cotton cultivars would allow growers to produce optimal yields while avoiding risks of yield loss due to an early frost (Smith and Varvil., 1981). Hicks et al. (1989) evaluated cotton double-cropped with wheat. Comparisons for this experiment consisted of the wheat straw being removed and the land disked for one treatment and cotton planted directly into wheat stubble for the second treatment. Cotton emergence was not affected by wheat straw remaining on the surface. Stands were decreased 9% due to allelopathic effects when the straw had been incorporated into the soil. In a study by Brown et al. (1985), the opposite affects were seen. Therefore, there are no consistent allelopathic effects of wheat straw on cotton. Using a narrow-row system may allow cotton to be double-cropped because of the potential for earlier maturity than wide-row cotton (Fowler and Ray, 1977). When double-cropped with wheat, cotton can be produced in areas where the growing season is long enough for plants to reach full maturity (Baker, 1987).

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Defining Optimal Nitrogen Rates for Cotton Grown on a 38-cm Row Configuration

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Abstract

HAMM, GARY STEPHEN. Defining Optimal Nitrogen Rates for Cotton Grown on a 38-cm Row Configuration. (Under the direction of Dr. Keith Edmisten)

Cotton (*Gossypium hirsutum* L.) planted in a 38-cm row configuration is an innovative idea that has come about in the past few years. Producers have raised questions regarding changing their cotton production strategies in order to maximize yield potential for cotton grown on 38-cm rows. One production strategy that has yet to be defined is targeting the optimal nitrogen rates due to the increased leaf area and root interception per unit total ground area associated with a 38-cm row configuration. Field experiments were conducted in 2005, 2006, and 2007 at Upper Coastal Plain Research Station, near Rocky Mount, NC in order to define these optimal nitrogen rates. Cotton was planted on 38-cm row patterns using a vacuum planter. Treatments consisted of nitrogen rates of 0, 34, 67, 98, 131, 164, and 196 kg N ha^{-1}. Treatments were arranged in a randomized complete block design and replicated four times.

Data collected in this experiment consisted of petiole samples to determine nitrogen uptake in plants, plant heights, number of nodes, lint yield, fiber quality, and an economic analysis. The four middle rows of the six-row plots were spindle-harvested using a cotton picker capable of harvesting cotton on 38-cm rows. Seed cotton samples were collected for ginning and submitted for HVI analysis. For economic analysis, input costs were determined by combining costs of equipment, seed, pest control, plant growth regulators, phosphorus and potassium fertilizers, and defoliation. Economic returns

were based on \$1.59 per kilogram which is the average market price per kilogram of lint as of December, 2008. Using SAS Version 9.1.3 data were analyzed using a linear and quadratic regression analysis (SAS Institute Inc., Cary, NC). Data were pooled over years.

The 67 kg N ha^{-1} rate resulted in the highest lint yield. Lint yield and economic returns declined steadily when nitrogen rates greater than 67 kg N ha^{-1} were applied. Petiole samples indicated there was an increase in nitrate levels as nitrogen rate increased across treatments, however there was no yield response to rates higher than 67 kg N ha^{-1}.

Introduction

Cotton is usually planted in rows spaced 76 to 96 cm apart. Planting cotton in narrow-row patterns is now feasible due to seed technology and herbicide-resistant cotton varieties (Culpepper and York, 2000). Research has been conducted during the past 30 years investigating the benefits of growing cotton in narrow rows. Narrow-row systems have proven to achieve higher yields (Buxton et al., 1978). Previously, narrow-cotton was harvested using a finger-type stripper in which the bracts, stalk material, and leaf material were harvested with the seed cotton, causing increased trash content (Anthony et al., 2000).

John Deere Company has recently developed a harvester to spindle-harvest cotton grown in 38-cm row configurations (Wilson et al., 2007). This allows cotton to be grown in closer row spacings and harvested cleaner than previous methods (Wilson et al., 2007). Also, production practices more suitable with a 38-cm row spacing versus the 18-cm row spacing (ultra-narrow row) include planting method and seed placement. Ultra-narrow row cotton is planted using a grain drill, however more advanced planters have been developed to plant in 38-cm rows. These planters have seed disks that allow for better seed placement and more precise plant population adjustments (Wilson et al., 2007).

Ray and Hudspeth (1966) observed yield increases of 6 to 11% when cotton was planted in 18- to 25-cm rows compared to 76- and 96-cm rows. In a study by Wilson et al. (2007), cotton grown on 38-cm rows yielded 10% higher than cotton grown on 97-cm rows. With an increase in plant populations, less plant growth is required to produce comparable yields, therefore less nitrogen may be required (Marois et al., 2004). In higher plant populations, there are also more roots within a given area of soil, and uptake efficiency or interception by the plant could be increased so less nitrogen may be required.

It is important to apply the correct amount of nitrogen to a narrow-row system. Over applications of nitrogen will promote excessive plant growth and potential yield loss (Boquet, 2005). Koli and Morrill (1975) observed no interactions between nitrogen levels and plant populations. Also, this study showed that nitrate levels in the plant were proportional to the amount elemental nitrogen applied, but there was no relationship between increasing nitrate levels and yields. Cotton yield was reduced at 90 kg N ha^{-1}, but at the 45 kg N ha^{-1} rate, there was no reduction or increase in lint yields when compared to the untreated check (Koli and Morrill, 1975). Nitrogen recommendations have yet to be determined for cotton grown on a 38-cm row pattern. Most agree that the growth response of cotton to nitrogen fertilization is largely dependent upon soil moisture (Jackson & Tilt, 1968). The amount of available nitrogen in the soil is usually limited, therefore requiring additional nitrogen fertilization (Gardner and Tucker, 1967). Cotton in NC usually requires 67 to 87 kg of elemental nitrogen per hectare (Crozier, 2008). The objective of this study was to determine the optimum nitrogen rate required for cotton grown on a 38-cm row configuration.

Materials and Methods

Experiments were conducted at Upper Coastal Plain Research Station near Rocky Mount, NC during 2005, 2006, and 2007 on a Goldsboro fine sandy loam soil (fine-loamy, siliceous, subactive, thermic Aquic Paleudult). The cotton variety ST 5599 BR® (Stoneville®, Bayer Crop Science, Memphis, Tennessee) was planted. Cotton seed were treated with abamectin, thiamethoxam, and azoxystrobin (Avicta Complete Pac®, Syngenta Crop Protection, Greensboro, NC) to help avoid early season western flower thrip (*Frankliniella occidentalis*) infestations and early seedling diseases. Cotton was planted at a rate of 6.6 seed per meter of row. Plots were 9 m in length and 2.3 m wide containing six 38-cm rows, and treatments were replicated four times in a randomized complete block design. A six-row vacuum planter was used for planting. Plant populations determined by stand counts at the end of the season equaled to approximately 148,000 plants per hectare. Treatments consisted of 0, 34, 67, 98, 131, 164, and 196 kg N ha^{-1}.The nitrogen treatments were applied at the match-head square growth stage each year using 32% UAN which is a mixture of ammonium nitrate and urea.

Weed control practices consisted of pendimethalin (Prowl 3.3 EC; BASF Ag Products; Research Triangle Park, NC) at 1110 g a.i. ha^{-1} tank mixed with fluometuron (Cotoran 4L; MANA Inc; Raleigh, NC) at 1120 g a.i. ha^{-1} being applied pre-emergence. At the 4^{th} true leaf stage , glyphosate potassium salt (Roundup WeatherMax; Monsanto Co.; St. Louis, MO) was applied at 865 g a.i. ha^{-1} tank mixed with *S*-metolachlor (Dual Magnum; Syngenta Crop Protection; Greensboro, NC) at 1390 g a.i. ha^{-1}.

Petioles of the upper-most fully expanded leaves were collected at physiological maturity (five nodes above white flower) and analyzed for nitrate levels by the North Carolina Department of Agriculture, Agronomic Division. Plant heights and total nodes were taken at the end of the season before harvest. Cotton was defoliated at 60% percent open boll using a mixture of tribufos {*S*,*S*,*S*-tributyl phosphorotrithioate} (Def, Bayer Crop Science, Research Triangle Park N.C.) at 840 g a. i. ha^{-1}, ethephon {2-chloroethyl phosphonic acid} (Prep, Bayer Crop Science, Research Triangle Park N.C.) at 1120 g a. i. ha^{-1}, and thiadiazuron {*N*-phenyl-*N*'-1,2,3-thiadiazol-5-ylurea} (Dropp 50 WP, Bayer Crop Science, Research Triangle Park N.C.) at 110 g a. i. ha^{-1} . The center four rows of the plots were harvested using a cotton picker retrofitted with spindle picker heads designed to harvest narrow-row cotton. Cotton was harvested on October 12, 2005, October 19, 2006, and October 10, 2007. A subsample of seed cotton was collected from each plot and ginned using a tabletop saw tooth gin to determine lint yield percentage. The lint was then sent to Cotton Incorporated for High Volume

Instrumentation analysis to determine fiber quality. Economic data were determined from production cost estimates for conventional cotton from the 2008 Cotton Production guide that were calculated to a per hectare basis. Nitrogen cost was subtracted from the total estimate because nitrogen costs varied in the experiment. The nitrogen cost per hectare for each treatment was then added back to the base production estimate to determine an overall input cost per hectare per treatment. Nitrogen input cost per hectare for this experiment was based upon a price of $1.01 per kilogram of elemental N. The price of nitrogen was quoted from Crop Production Services in Tarboro, NC. Gross profit data were based upon the average price of $1.59 per kilogram for lint yield in December, 2008 and determined from lint yield data. Data were analyzed using a linear and quadratic regression analyses in SAS version 9.1.3 (SAS Institute Inc., Cary, NC). There was no year by treatment interaction, therefore data were pooled over years. A linear regression analysis is the process where a slope equation is found for a straight line to determine how well plotted data fits to that line to show an increase or decrease in variables. A quadratic regression analysis is the process in which an equation of a curve is best fit to plotted data to determine how well the data fits to that particular curve to show an increase or decrease in variables.

Results and Discussion

Petiole Nitrate Content.

Petiole sample data suggested that across all three years, there was a direct correlation with uptake of nitrogen and rate of nitrogen applied. As nitrogen rate increased, there was a linear response to nitrogen with a p-value of .0007 and R^2 of .9153 for the linear model (Figure 2.1).

Plant Height.

End-of-season plant height data implied a significant difference when means for heights were averaged for years 2005, 2006, and 2007. The data best fits a quadratic model with a quadratic p-value of .0058 with an R^2 of .9536 (Figure 2.2). The model suggests that as nitrogen rate increased to 131 kg N ha^{-1} plant height increased then peaked with higher rates. This is a typical response in which lower N rates result in limited vegetative growth.

Total nodes.

Total nodes in all three years were least when no nitrogen was applied (Figure 2.3). Significant differences were seen in both the linear and quadratic models with p-values $\leq$ .05 (Figure 2.3). Data better fit the quadratic model with an R^2 value of .8781. Differences among treatments were minimal when being observed for practical implications.

Yield.

Yield data indicated the 67 kg N ha^{-1} rate resulted in the highest lint yield among all treatments when means were pooled over years (mean 1455 kg/ha) (Table 2.1), but there was no significant difference among yields in both the linear and quadratic models. P-values were greater than 0.05 (Figure 2.1). The R^2 value for the linear model is .3672 and .4363 for the quadratic model. There was a steady decline in lint yield across treatments beyond the 67 kg N ha^{-1} rate. As more nitrogen was applied, no yield increase was observed. This response is generally expected. Plants in general usually reach a certain point in which they are not able to capitalize on increased nitrogen to achieve higher yield.

Fiber Quality.

Linear and quadratic models showed no significant differences for micronaire with p-values greater than 0.05. Data better fit the quadratic model with a R^2 value of .4923 (Figure 2.4). The premium micronaire range is between 3.8 and 4.2. Micronaire values were well above premium ranges for this experiment. There were no nitrogen rate effects on staple length, fiber uniformity, and fiber strength in the linear regression or the quadratic regression (data not shown).

Economics.

Economic returns diminished as nitrogen rates increased above 67 kg ha^{-1}. The 67 kg ha^{-1} rate yielded the optimum returns at $1,064 per hectare. (Table 2.1) At this rate, sufficient nitrogen was applied for optimum yields to be obtained. Nitrogen applied beyond 67 kg ha^{-1} did not benefit yield or increase economic returns.

Conclusions

The highest yield was observed at 67 kg N ha^{-1}. Although petiole data showed an increase in uptake of nitrogen as rate increased, the yield data showed a decline in yield with no significant difference beyond 67 kg N ha^{-1} as shown by the linear and quadratic terms. This means that the plants absorbed the nitrogen but were unable to utilize it to increase yields. Economic data confirmed that profits declined when nitrogen rates were increased above 67 kg N ha^{-1} in 38-cm cotton. Fiber quality was not affected by nitrogen rate. Environmental conditions in this experiment were extremely hot and dry, and this may have had an effect on plant nitrogen uptake. With rainfall being a limiting factor in this experiement, cotton in irrigated conditions could have shown a different response to increased nitrogen. There is a possibility that cotton grown on a 38-cm row configuration requires less nitrogen to achieve optimum yield, due to the increased area of soil being occupied by plant roots, therefore maximizing nitrogen uptake. When making nutrient management decisions in cotton production environmental conditions and soil type can be a limiting factor in nitrogen uptake.

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Table 2.1. Net profit returns for combined mean lint yield.

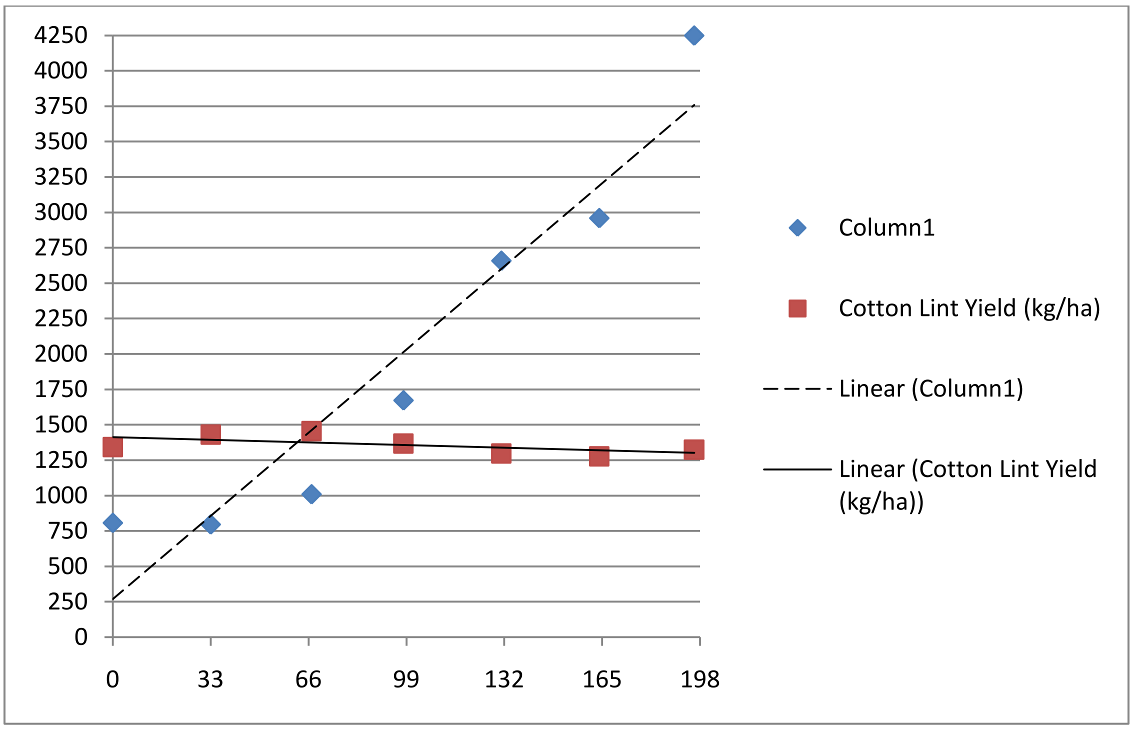
Nitrogen Rate kg N ha^{-1}	Cotton Lint Yield kg/ha	Nitrogen Cost	Gross Return dollars/ha	Net Return
0	1343	$0	$2135	$955
33	1430	$34	$2274	$1059
67	1455	$68	$2312	$1064
98	1368	$99	$2175	$895
131	1297	$133	$2062	$749
164	1277	$166	$2030	$684
196	1325	$199	$2106	$726

- Input cost per/hectare was based upon production cost minus nitrogen input from the 2008 Cotton Production guide production costs equaling $1180 per hectare

-Nitrogen input/hectare was based upon a price of $1.01 per kilogram.

-Gross profit was based upon the average price of $1.59 per kilogram for lint yield in December, 2008.

Petiole Nitrate Content & Cotton Lint Yield

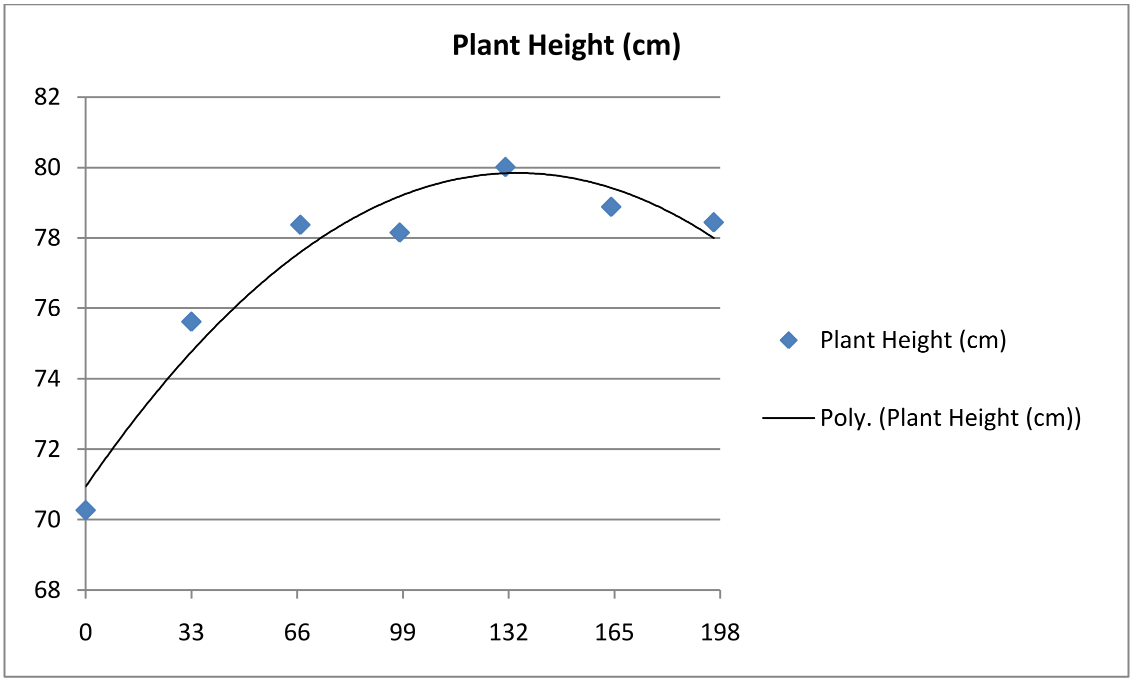


Petiole Nitrate Content Linear Regression Equation: y = 17.71x +272.24
Cotton Lint Yield Linear Regression Equation: y = -0.56 + 1411.62

Treatment kg N ha^{-1}	**0**	**33**	**67**	**98**	**131**	**164**	**198**
Cotton Lint Yield kg ha^{-1}	1343	1430	1455	1368	1297	1277	1325
Petiole Nitrate Content ppm	807	796	1009	1672	2658	2959	4248

	Petiole Nitrate	**Cotton Lint Yield**
Linear P Value	**.0007**	**.1539**
R^2	**.9155**	**.3607**
	Quadratic Model	**Quadratic Model**
Linear P Value	**.7612**	**.8426**
Quad P Value	**.0214**	**.5321**
R^2	**.9806**	**.4275**

Figure 2.1. Correlation of petiole nitrate content and cotton lint yield of pooled data for 2005, 2006, and 2007.

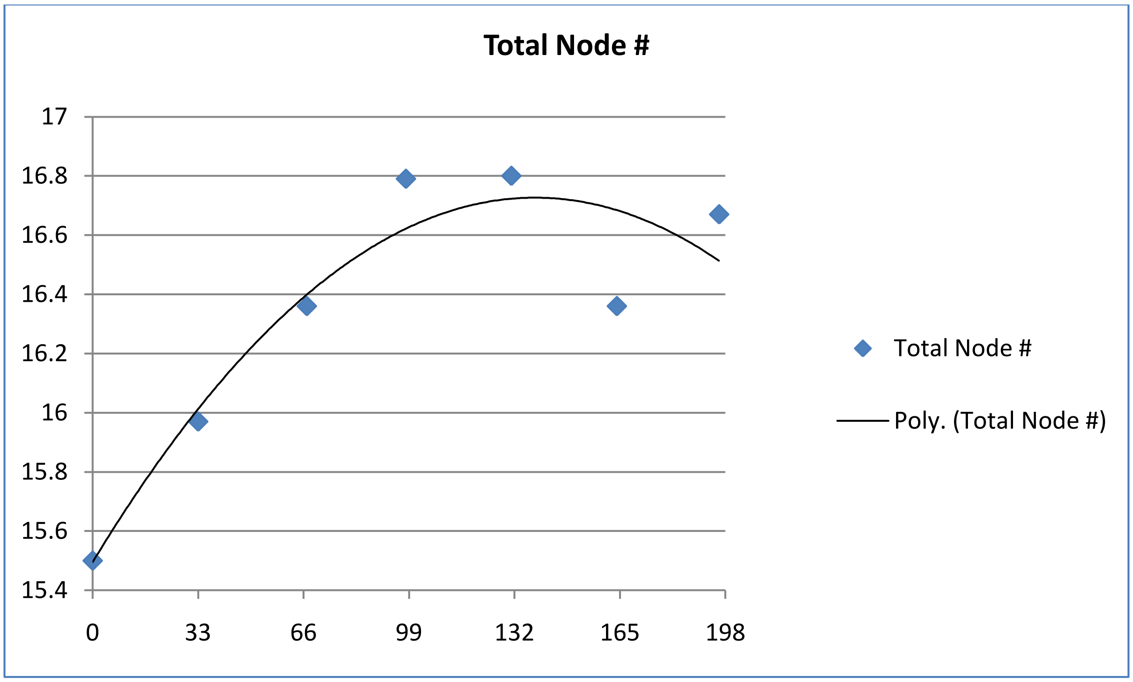


Plant Height Quadratic Regression Equation: $y = -0.0005x^2 + 0.13x + 70.89$

Treatment kg N ha^{-1}	**0**	**33**	**67**	**98**	**131**	**164**	**198**
Plant Height cm	70.3	75.6	78.4	78.2	80.0	78.9	78.4

Quadratic Model	**Plant Height**
Linear P Value	**.0017**
Quad P Value	**.0050**
R^2	**.9565**

Figure 2.2. Plant height pooled data for 2005, 2006, and 2007.

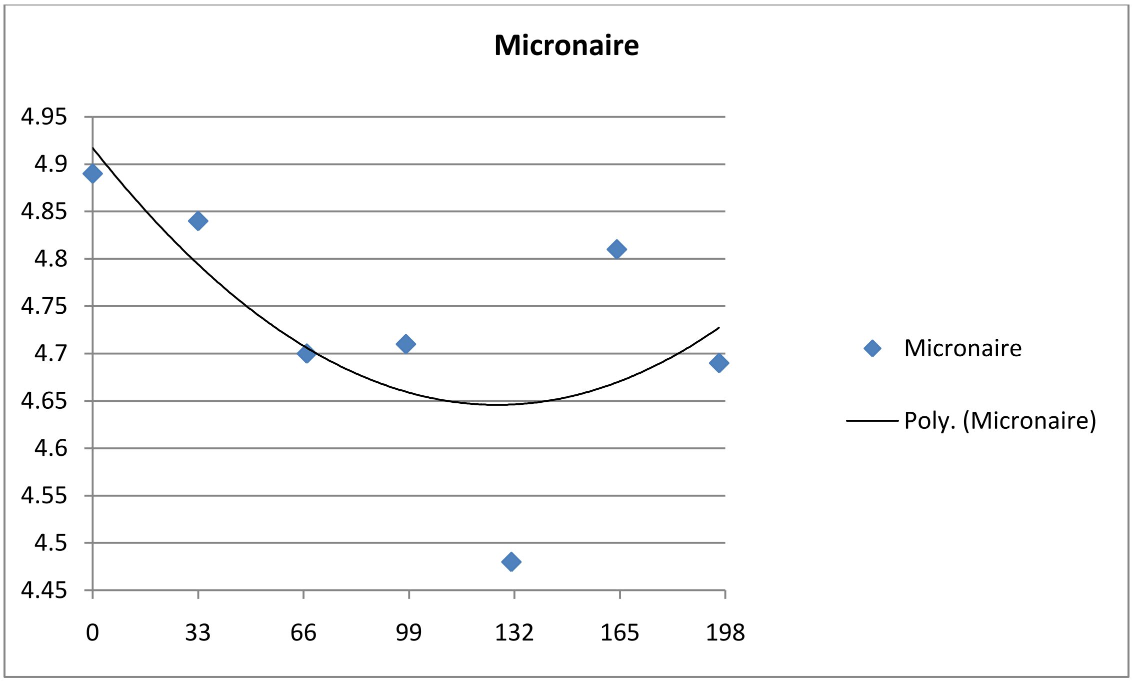


Total Node # Quadratic Regression Equation: $y = -0.00006x^2 + 0.018x + 15.50$

Treatment kg N ha^{-1}	**0**	**33**	**67**	**98**	**131**	**164**	**198**
Total Node #	15.5	16.0	16.4	16.8	16.8	16.4	16.7

Quadratic Model	**Total Node #**
Linear P Value	**.0143**
Quad P Value	**.0374**
R^2	**.8747**

Figure 2.3. Total nodes pooled data for 2005, 2006, and 2007.



Micronaire Quadratic Regression Equation: $y = 0.00001x^2 - 0.004x + 4.91$

Treatment kg N ha^{-1}	**0**	**33**	**67**	**98**	**131**	**164**	**198**
Micronaire	4.9	4.8	4.7	4.7	4.5	4.8	4.7

	Micronaire
Quadratic Model	
Linear P Value	**.1598**
Quad P Value	**.2363**
R^2	**.4923**

Figure 2.4. Micronaire pooled data for 2005, 2006, and 2007.

Application Strategies for Plant Growth Regulators in Cotton Grown on a 38-cm Row Configuration

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Abstract

HAMM, GARY STEPHEN. Application Strategies for Plant Growth Regulators in Cotton Grown on a 38-cm Row Configuration. (Under the direction of Dr. Keith Edmisten)

The has been some interest in narrow-row cotton (*Gossypium hirsutum* L.) in recent years. It is not known if current PGR recommendations for wide-row cotton can be applied to cotton grown on 38-cm rows. The purpose of this experiment was to determine the optimum PGR strategy in 38-cm cotton in terms of yield and maturity. Field experiments were conducted in 2006 and 2007 at Upper Coastal Plain Research Station, near Rocky Mount, NC and at an on-farm location in Duplin County, NC.

Treatments for both locations consisted of a non-treated control (UTC), early applications of 6 g a.i. ha^{-1} and 12 g a.i. ha^{-1} of mepiquat pentaborate applied at the 4-, 6-, and 8-leaf stages. A modified-modified early bloom application strategy consisting of applications of 6 g a.i. ha^{-1} of mepiquat pentaborate being applied at the 4-, 6-, and 8-leaf stages followed by 30 g a.i. ha^{-1} applied at early bloom and applications of 12 g a.i. ha^{-1} of mepiquat pentaborate being applied at the 4-, 6-, and 8-leaf stages followed by 24 g a.i. ha^{-1} applied at early bloom. A modified early bloom application which consists of an application at 10 to 14 days after first fruiting square, followed by an application at early bloom was applied. For this treatment, a rate of 18 g a.i. ha^{-1} was applied at 10 to 14 days after first-square and at early bloom as well. The last treatment for this experiment was an application of 36 g a.i. ha^{-1} being applied at early bloom.

Data collected consisted of plant heights, number of nodes, and nodes above white

flower taken in mid-August 3 weeks after early bloom treatments were applied (3 WAEB). Plant heights and number of nodes were collected at the end of season. Plant height data and total node data at 3 WAEB were consistent in showing that four-leaf applications, regardless of rate or strategy, was not effective in controlling plant height or reducing node number compared to all other treatments. Data showed that plant heights were generally taller at 3 WAEB from earlier applications at both locations. In Duplin County, nodes above white flower data showed a slight delay in maturity from early application timings. There was no significant difference at the Rocky Mount location for nodes above white flower. End of season plant height data showed that the eight-leaf and modified-modified early bloom strategies had moderate height control. In Duplin County, early and modified-modified early bloom strategies showed a slight trend with increase in first position fruit and retention. In Rocky Mount, no significant differences were seen among treatments regarding first and second boll position retention. There was no significant effect on yield o fiber quality due to PGR application.

Making a plant growth regulator application decision can be critical in cotton production. The data suggest that current recommendations for plant growth regulators can be used for 38-cm cotton along with earlier application timings without affecting yields or quality

Introduction

Cotton is usually planted in rows spaced 76 to 96 cm apart. Planting cotton in narrow-row patterns is now feasible due to seed technology and herbicide resistant cotton varieties (Culpepper and York, 2000). Research has been conducted during the past 30 years investigating the benefits of growing cotton in narrow rows. Narrow-row systems have proven to achieve higher yields in North Carolina (Wilson et al., 2007). Previously, narrow-cotton was harvested using a finger-type stripper in which the bracts, stalk material, and leaf material were harvested with the seed cotton, causing increased trash content (Anthony et al., 2000). John Deere Company has recently developed a harvester that can spindle-harvest cotton grown in 38-cm row configurations (Wilson et al., 2007). This allows cotton to be grown in closer row spacings and harvested cleaner than previous methods (Wilson et al., 2007). Also, production practices that are more suitable with a 38-cm row spacing versus the 18-cm row spacing (ultra-narrow row) include planting method and seed placement. Ultra-narrow row cotton is planted using a grain drill, however more advanced planters have been developed to plant in 38-cm rows. These planters have seed disks that allow for better seed placement and more precise plant population adjustments (Wilson et al., 2007). Ray and Hudspeth (1966) observed yield increases of 6 to 11% when cotton was planted in 18 to 25-cm rows when compared to wide row patterns. In a study by Wilson et al. (2007), cotton grown on 38-cm rows, yielded 10% higher than cotton grown on 97-cm rows.

Plant growth regulators (PGRs) are commonly used throughout the cotton belt to control plant height, hasten maturity, and potentially improve yields (Reddy et al., 1992). Products containing mepiquat chloride are the most widely used plant growth regulators (Kerby, 1985). Mepiquat chloride inhibits gibberellin synthesis in the plant, which regulates plant cell elongation (Reddy et al., 1992). By inhibiting cell growth, it slows the plant's growth (Reddy et al., 1992). Plants that have been treated with mepiquat are generally smaller with more compact nodes compared to untreated plants (Kerby, 1985). Research has shown positive yield responses from PGRs (York, 1983). PGR applications made to late or too early can result in yield losses as well. Applying PGRs when conditions are unfavorable, can result in stunting of plants (Beck and Searcy, 2001). Delayed or late applications can result in poor growth control (Livingston et al., 2000). Decisions on when to apply PGRs can be critical (Wilson et al., 2007). In NC, there are three common application strategies used in wide-row cotton production. The early bloom strategy is a method based upon making a mepiquat application at the early bloom period (5 to 6 white blooms per 6.7 meters of row) and is used generally in four situations: 1) plant height is less than 51 cm at early bloom because of environmental stress, delay application until stress is relieved (only if application is needed after stress relief 2) plant height is 51 cm to 61 cm at early bloom and there is potential for excessive growth beyond early bloom 3) plant height is more than 61 cm at early bloom and growing rapidly 4) plant heights are approaching 51-61cm at early bloom and growth is rapid due to excessive soil moisture and rainfall (Edmisten, 2008). The second strategy is the modified early bloom strategy. This approach involves potential applications of a mepiquat 10 to 14 days prior to early bloom, at early bloom, and possibly again at 10 to 14 days after early bloom (Edmisten, 2008). The last method is the low rate multiple strategy in which potential PGR applications are made beginning at match-head square (squares are 0.3cm to 0.6 cm in diameter) followed by potential applications every 14 days (Edmisten, 2008). For cotton grown in narrow-row configurations, it is important to maintain shorter plants so that harvest efficiency is not inhibited, especially with harvest equipment designed to harvest narrow-rows. Little research has been published to date that addresses or defines the most appropriate PGR application strategy in cotton grown in a 38-cm rows (Wilson, 2007). Research in NC indicated that the low rate multiple and modified early bloom strategies were best suited for cotton grown in 38-cm row spacings (Wilson, 2007). There are several variables that are involved in making decisions regarding the optimal PGR application strategy for use in 38-cm cotton.

Materials and Method

Field experiments were conducted in 2006 and 2007 at Upper Coastal Plain Research Station, near Rocky Mount, NC and at an on-farm location in Duplin County, NC. The cotton (*Gossypium hirsutum*) variety DP 143 BGRF® (Delta Pine and Land, Monsanto Co.; St. Louis, MO) was planted on May 4, 2006 and May 14, 2007 at Rocky Mount and May 12, 2006 and May 2, 2007 in Duplin County. Cotton seed were treated with abamectin, thiamethoxam, and azoxystrobin (Avicta Complete Pac®, Syngenta Crop Protection, Greensboro, NC) to help avoid early season western flower thrip (*Frankliniella occidentalis*) infestations and early seedling diseases. Cotton was planted in 38-cm rows in plots that were 9.1 m in length and 2.3 m wide, which were arranged in a randomized complete block design. This variety was chosen because of its high yield capacity and it glyphosate resistance at any growth stage. Cotton was planted using a six row vacuum planter at a rate of 6.6 seed per meter of row. Plant populations determined by stand counts at the end of the season were approximately 148,000 plants per hectare. At the Upper Coastal Plains Research Station experiments were conducted on a Goldsboro fine sandy loam soil (Fine-loamy, siliceous, subactive, thermic, Aquic Paleudult). In Duplin County experiments were planted on a Norfolk fine sandy loam (Fine-loamy, siliceous, thermic, Typic Kandiudult).

Treatments for both locations consisted of a non-treated control (UTC), single applications of 6 g a.i. ha^{-1} and 12 g a.i. ha^{-1} of mepiquat pentaborate (N,N-dimethylpiperidinium pentaborate) (Pentia™; BASF Ag Products; Research Triangle Park, NC) applied at the 4-, 6-, and 8-leaf stages. A modified-modified early bloom application strategy consisting of applications of 6 g a.i. ha^{-1} being applied at the 4-, 6-, and 8-leaf stages followed by 30 g a.i. ha^{-1} applied at early bloom and applications of 12 g a.i. ha^{-1} being applied at the 4-, 6-, and 8-leaf stages followed by 24 g a.i. ha^{-1} applied at early bloom. A modified early bloom strategy which consists of an application 10 to 14 days after first fruiting square, followed by an application at early bloom. For this treatment, a rate of 18 g a.i. ha^{-1} was applied at 10 to 14 days after first-square (10-11 leaf stage) and at early bloom as well. The last treatment for this experiment was an application of 36 g a.i. ha^{-1} being applied at early bloom. Early bloom is defined as a measurement of 5 to 6 white blooms per 6.7 meters of row. A CO_2 pressurized back-pack sprayer with flat fan nozzles calibrated to deliver 136 L ha^{-1} at a pressure of 124 kPa was used to make all PGR applications.

Weed control practices consisted of pendimethalin (Prowl 3.3 EC; BASF Ag Products; Research Triangle Park, NC) at 1110 g a.i. ha^{-1} tank-mixed with fluometuron (Cotoran 4L; MANA Inc; Raleigh, NC) at 1120 g a.i. ha^{-1} being applied pre-emergence. At the 4th true leaf stage, glyphosate potassium salt (Roundup WeatherMax; Monsanto Co.; St. Louis, MO) was applied at 865 g a.i. ha^{-1} tank mixed with *S*-metolachlor (Dual Magnum; Syngenta Crop Protection; Greensboro, NC) at 1390 g a.i. ha^{-1}.

Plant height, total nodes and nodes above white flower (NAWF) data were collected during mid-August, three weeks after early bloom treatments were applied (3 WAEB). Cotton was defoliated at 60% percent open boll using a mixture of tribufos {*S*,*S*,*S*-tributyl phosphorotrithioate} (Def, Bayer Crop Science, Research Triangle Park N.C.) at 840 g a. i. ha^{-1}, ethephon {2-chloroethyl phosphonic acid} (Prep, Bayer Crop Science, Research Triangle Park N.C.) at 1120 g a. i. ha^{-1} rate, and thiadiazuron {*N*-phenyl-*N*'-1,2,3-thiadiazol-5-ylurea} (Dropp 50 WP, Bayer Crop Science, Research Triangle Park N.C.) at 110 g a. i. ha^{-1} . Six plants were removed from each plot at harvest for box mapping. Box mapping consisted of grouping 1st and 2nd position bolls into specific node zones: 3-5, 6-10, 11-15, and 16-20 and taking total seed cotton weights for each node zone by position and determining an average weight per boll by position and node zone. Box mapping data included recording total boll number per plant, boll retention percentage, total plant height, and total node number. The center four rows of the plots were harvested using a cotton picker retrofitted with spindle picker heads designed to harvest narrow-row cotton. Cotton was harvested on October 19, 2006, and October 10, 2007 in Rocky Mount and

October 22, 2006 and October 12, 2007 in Duplin County. A subsample of seed cotton was collected from each plot and ginned using a tabletop saw tooth gin to determine lint yield percentage. The lint was then sent to Cotton Incorporated for High Volume Instrumentation analysis to determine fiber quality.

All data were analyzed using the general linear model procedure in SAS Version 9.1.3 (SAS Institute Inc., Cary, NC). Treatment means were separated by Fisher's Protected LSD at $\alpha \leq 0.05$.

Results and Discussion

3 Weeks After Early Bloom Data.

Plant height data, taken in mid-August three weeks after early bloom (3 WAEB) at the Rocky Mount location, generally showed taller plants when single applications of mepiquat pentaborate was applied at the 4-leaf stage (Treatments 2 & 5) (Table 3.1). Data for these treatments showed taller plant heights than the non-treated control (Treatment 1). The 6- and 8-leaf single applications (Treatments 3, 4, 6, & 7) showed plant heights comparable to the non-treated control. Modified-modified early bloom treatments (Treatments 8-13) when compared to the non-treated control yielded moderate plant height control (Table 3.1). Duplin County data for both 2006 and 2007 showed similar trends in plant height control (Table 3.2). The 4-leaf stage applications regardless of rate (Treatments 2 & 5) resulted in poor growth suppression compared to other treatments (Table 3.1 & 3.2). This could be due to less leaf surface area at the 4-leaf stage resulting in poor uptake of the applied material into the plant or low residual levels of mepiquat later during more rapid growth conditions. A separate analysis was made in which treatments were combined. Single applications of mepiquat pentaborate made at the 4-, 6-, or 8-leaf stages were considered as early and all other treatments were considered as late.

In the comparison of early versus late application timings, Rocky Mount showed no differences for 2006 or 2007 among treatments (Table 3.16). Duplin County showed significant differences for years combined in which early applications timings resulted in taller plants (Table 3.17).

Total node data taken 3 WAEB at Rocky Mount was unaffected by PGR treatment for years combined (Table 3.3). In Duplin County, there were some differences seen among treatments with total node numbers in 2006, but no differences were observed in 2007 (Table 3.4). In Duplin County, the earlier application timings (Treatments 2-7) tended to have higher node numbers and the modified early bloom (Treatment 14) and early bloom strategies (Treatment 15) showed a trend of having lower node numbers for 2006, but this was not observed in 2007 (Table 3.4).

In the analysis of early versus late timings at Rocky Mount, there were no differences observed among treatments for years combined (Table 3.16). The same effects were observed in Duplin County as well (Table 3.17).

Nodes above white flower (NAWF) data 3 WAEB in Rocky Mount was not affected by PGR treatment for years combined (Table 3.3). In Duplin County, the 4-leaf application timings (Treatments 2-7) showed a slight delay in maturity with nodes above white flower counts in 2006, but not in 2007 (Table 3.5).

For the early versus late comparisons, the earlier application timings resulted in greater NAWF in Rocky Mount and Duplin County for combined years (Table 3.16 & 3.17).

End of Season Data.

The 4-leaf stage, regardless of rate (Treatments 2 & 5) resulted in end of season plant heights taller than the non-treated control for both Rocky Mount and Duplin County in 2006 and 2007 (Treatment 1) (Table 3.6 & 3.7). The 8-leaf, modified-modified early bloom treatments (except treatments including 4- and 6-leaf applications) (Treatment 4, 7, 12-15) respectively resulted in efficient plant height control (Table 3.6 & 3.7).

When comparing early versus late application timings, the early application timings in Rocky Mount showed a trend of having taller plants in 2006 but not in 2007. In Duplin County it was observed that the earlier timings resulted in taller plants for years combined (Table 3.16 & 3.17).

Total nodes were unaffected by mepiquat pentaborate treatments at Rocky Mount for years combined (Table 3.8). Total nodes at end of season were affected by mepiquat pentaborate treatments in Duplin County for both years for practical implications (Table 3.9). The 4-leaf applications, regardless rate (Treatments 2 & 5) was comparable to the non-treated control (Treatment 1) in 2006, but differences were minimal in 2007 (Table 3.9).

Comparisons of early versus late application timings indicated a trend in having higher node numbers with earlier application strategies in Duplin County but this was not observed at Rocky Mount (Table 3.16 & Table 3.17).

Box Mapping Data.

At Rocky Mount, the number of 1st and 2nd position bolls and fruit retention were unaffected by mepiquat pentaborate treatments (Table 3.10). In Duplin County, a trend was observed with the early and modified-modified early bloom strategies (Treatments 2, 3, 5, 6, & 8-11) yielding slightly higher total 1st position bolls and 1st position percent boll retention than the modified early bloom and early bloom strategies (Treatments 14 & 15) (Table 3.11). For total 2nd position boll and 2nd position percent retention data for Duplin County a trend was observed in which the modified-modified early bloom strategies that included the 146 ml at the 4- and 6-leaf stages (Treatments 8-10) showed slightly higher boll numbers in 2006 (Table 3.12). In 2007, all of the modified-modified early bloom strategies yielded a trend of slightly higher second position boll numbers and retention.

There were no effects observed from mepiquat pentaborate applications on boll numbers and retention in comparisons made of early versus late application timings at Rocky Mount (Table 3.16). A significant difference was shown in Duplin County in which 1st position boll numbers and percent retention were higher with earlier timings when combined over years (Table 3.17).

Yield.

In Rocky Mount, no differences were observed among treatments for years combined. Years were combined due to non-significance in year by treatment interaction (p-value

=.9798). This same interaction was seen in Duplin County as well for lint yield (p value = .3023). There were no effects from mepiquat pentaborate applications on lint yield observed for both locations (Table 3.13). The early, modified-modified early bloom, modified early bloom and early bloom strategies (Treatments 2-15) did affect lint yields when compared to the non-treated control (Treatment 1) but differences were non-significant.

In the comparison of the early versus late application strategies, there were no differences observed in either location for years combined at each location (Table 3.16 & 3.17).

Fiber Quality.

Micronaire was not affected by treatment at Rocky Mount (Table 3.14). At Duplin County micronaire was affected by treatment in 2006 but not in 2007. There were significant differences in micronaire due to treatment but no specific pattern could be determined from the data (Table 3.15). In addition, no significant differences were found in staple length (UHM), fiber uniformity (UI), and fiber strength (STR) as well and no significant differences were found (data not shown). In Rocky Mount, the p-values for each variable were: staple length (UHM) - .2868, fiber uniformity (UI) -.6668, fiber strength (STR) - .9579. In Duplin County, the p-value for each was: staple length (UHM) - .4773, fiber uniformity (UI) -.1748, fiber strength (STR) - .5599.

In the early versus late comparisons, no effects were seen in Rocky Mount or Duplin on fiber quality from treatments (Table 3.16 & 3.17).

Conclusion

Data indicated that earlier applications of plant growth regulators did not adversely affect yield. There were no benefits associated with the 4-leaf applications in controlling plant height. Boll counts at the first positions and fruit retention showed trends that were higher with early and modified-modified early bloom strategies than the later application timings. Benefits for controlling plant height were seen more with applications at the 6- and 8-leaf stage, regardless the application strategy (early or modified-modified early bloom strategy) and the modified early bloom strategy. In a study by Wilson et al., it was found that the low rate multiple and modified early bloom strategy had more efficient height control when compared to the early bloom application strategy. Data suggests that current recommendations for plant growth regulators can be used for 38-cm cotton along with earlier application timings without affecting yields. Making PGR applications prior to the 8-leaf stage is generally not recommended in wide-row cotton. Being able to control plant height and fruiting habits in 38-cm cotton can be critical in maintaining harvest ability.

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Table 3.1. Plant height data 3 WAEB at Rocky Mount, NC in 2006 & 2007.

Treatment #	Rate of Pentia	Timing	2006		2007
1	UTC	-	82.3 ab	cm	59.5 a
2	6 g a.i. ha^{-1}	4 Leaf	95.9 a		58.7 ab
3	6 g a.i. ha^{-1}	6 Leaf	82.0 abc		53.3 abcd
4	6 g a.i. ha^{-1}	8 Leaf	74.8 bcde		52.7 abcd
5	12 g a.i. ha^{-1}	4 Leaf	87.6 ab		54.8 abc
6	12 g a.i. ha^{-1}	6 Leaf	75.8 bcde		49.3 cdef
7	12 g a.i. ha^{-1}	8 Leaf	68.6 cdef		47.1 def
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	78.5 bcd		51.2 cdef
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	69.8 cdef		53.3 abcd
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	67.4 def		50.8 cdef
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	79.3 bcd		47.5 def
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	68.3 cdef		50.4 cdef
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	50.3 g		45.4 ef
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	58.0 fg		44.3 f
15	36 g a.i. ha^{-1}	Early Bloom	62.3 efg		52.2 bcde
	$LSD^{0.05}$		14.46		6.91
	P>F		<.0001		.0020

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.2. Plant height data 3 WAEB in 2006 and 2007 at Duplin County, NC.

Treatment #	Rate of Pentia	Timing	2006		2007
1	UTC	-	122.8 abcd	——— cm ———	99.3
2	6 g a.i. ha^{-1}	4 Leaf	137.7 a		116.8
3	6 g a.i. ha^{-1}	6 Leaf	104.3 cde		148.5
4	6 g a.i. ha^{-1}	8 Leaf	97.5 ef		104.7
5	12 g a.i. ha^{-1}	4 Leaf	136.0 ab		107.9
6	12 g a.i. ha^{-1}	6 Leaf	112.5 cde		106.3
7	12 g a.i. ha^{-1}	8 Leaf	92.5 ef		101.0
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	124.2 abc		104.8
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	100.1 def		101.7
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	96.3 ef		102.1
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	113.3 bcde		103.0
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	78.4 f		105.8
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	78.0 f		97.9
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	92.0 ef		97.0
15	36 g a.i. ha^{-1}	Early Bloom	95.6 ef		100.0
	$LSD^{0.05}$		22.78		NS
	P>F		<.0001		.4311

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.3. Total node and NAWF average mean data 3 WAEB for years combined in Rocky Mount, NC.

Treatment #	Rate of Pentia	Timing	Node #	NAWF
1	UTC	-	15.5	1.8
2	6 g a.i. ha^{-1}	4 Leaf	15.5	2.1
3	6 g a.i. ha^{-1}	6 Leaf	16.0	2.0
4	6 g a.i. ha^{-1}	8 Leaf	15.2	1.7
5	12 g a.i. ha^{-1}	4 Leaf	15.4	1.9
6	12 g a.i. ha^{-1}	6 Leaf	16.0	1.8
7	12 g a.i. ha^{-1}	8 Leaf	15.6	1.4
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	15.5	1.4
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	15.6	1.3
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	15.5	1.4
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	15.0	1.5
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	15.4	1.5
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	14.9	1.2
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	15.2	1.2
15	36 g a.i. ha^{-1}	Early Bloom	15.1	1.4
	$LSD^{0.05}$		NS	NS
	P>F		.7694	.1340

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.4. Total node measurements 3 WAEB for Duplin County, NC in 2006 & 2007.

Treatment #	Rate of Pentia	Timing	2006	2007
			——— Node # ———	
1	UTC	-	18.7 abc	17.1
2	6 g a.i. ha^{-1}	4 Leaf	19.5 ab	17.0
3	6 g a.i. ha^{-1}	6 Leaf	18.1 bcd	17.3
4	6 g a.i. ha^{-1}	8 Leaf	17.2 cde	18.0
5	12 g a.i. ha^{-1}	4 Leaf	20.2 a	17.6
6	12 g a.i. ha^{-1}	6 Leaf	17.8 bcd	17.0
7	12 g a.i. ha^{-1}	8 Leaf	17.0 cde	17.5
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	18.2 bcd	17.0
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	16.7 de	17.1
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	17.2 cde	17.2
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	18.3 abcd	17.3
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	15.8 e	17.5
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	15.4 e	17.0
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	16.7 de	16.6
15	36 g a.i. ha^{-1}	Early Bloom	16.8 de	17.7
	$LSD^{0.05}$		1.90	NS
	P>F		.0003	.3783

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.5. Nodes above white flower data 3 WAEB for Duplin County, NC in 2006 & 2007.

Treatment #	Rate of Pentia	Timing	2006		2007
1	UTC	-	3.7 bcd	NAWF	3.1 abcde
2	6 g a.i. ha^{-1}	4 Leaf	5.0 ab		3.5 a
3	6 g a.i. ha^{-1}	6 Leaf	4.1 abc		3.2 abcd
4	6 g a.i. ha^{-1}	8 Leaf	3.3 cde		3.4 ab
5	12 g a.i. ha^{-1}	4 Leaf	5.3 a		3.3 abc
6	12 g a.i. ha^{-1}	6 Leaf	3.8 abcd		3.0 bcdef
7	12 g a.i. ha^{-1}	8 Leaf	3.3 cde		3.3 abc
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	4.9 ab		2.3 g
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	2.4 def		2.9 cdef
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	2.7 cde		2.6 efg
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	3.8 bcd		3.1 abcde
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	1.9 ef		2.8 defg
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	2.2 ef		2.3 g
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	1.1 f		2.5 fg
15	36 g a.i. ha^{-1}	Early Bloom	2.5 def		2.7 efg
	$LSD^{0.05}$		1.49		.51
	P>F		<.0001		<.0001

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.6. End of season plant height data for Rocky Mount, NC in 2006 & 2007.

Treatment #	Rate of Pentia	Timing	2006		2007
1	UTC	-	72.5 bcd	——— cm———	53.6
2	6 g a.i. ha^{-1}	4 Leaf	91.3 a		59.4
3	6 g a.i. ha^{-1}	6 Leaf	79.1 bc		54.1
4	6 g a.i. ha^{-1}	8 Leaf	66.5 de		52.3
5	12 g a.i. ha^{-1}	4 Leaf	84.0 bc		57.2
6	12 g a.i. ha^{-1}	6 Leaf	69.4 cde		51.0
7	12 g a.i. ha^{-1}	8 Leaf	62.7 def		49.9
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	74.2 bcd		51.1
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	64.5 def		50.8
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	59.0 ef		51.2
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	72.8 bcd		49.6
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	59.9 ef		51.0
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	53.9 f		45.9
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	57.9 ef		49.2
15	36 g a.i. ha^{-1}	Early Bloom	58.4 ef		54.1
	$LSD^{0.05}$		11.79		NS
	P>F		<.0001		.0592

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.7. End of season plant height data for Duplin County, NC in 2006 & 2007.

Treatment #	Rate of Pentia	Timing	2006		2007
1	UTC	-	113.6 bc	——— cm ———	103.3 a
2	6 g a.i. ha^{-1}	4 Leaf	135.8 a		106.0 a
3	6 g a.i. ha^{-1}	6 Leaf	96.1 cde		100.7 a
4	6 g a.i. ha^{-1}	8 Leaf	90.0 ef		98.5 a
5	12 g a.i. ha^{-1}	4 Leaf	132.1 ab		104.7 a
6	12 g a.i. ha^{-1}	6 Leaf	98.1 cde		94.5 a
7	12 g a.i. ha^{-1}	8 Leaf	92.3 de		99.6 a
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	115.6 abc		96.7 a
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	86.6 ef		95.0 a
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	90.1 ef		90.5 a
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	112.7 bcd		95.8 a
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	71.2 f		98.6 a
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	71.3 f		91.0 a
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	79.6 ef		74.4 b
15	36 g a.i. ha^{-1}	Early Bloom	90.3 ef		92.1 a
	$LSD^{0.05}$		20.65		15.58
	P>F		<.0001		.0462

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.8. End of season total node mean data for years combined in Rocky Mount, NC.

Treatment #	Rate of Pentia	Timing	Node #
1	UTC	-	18.1
2	6 g a.i. ha^{-1}	4 Leaf	18.0
3	6 g a.i. ha^{-1}	6 Leaf	17.2
4	6 g a.i. ha^{-1}	8 Leaf	17.3
5	12 g a.i. ha^{-1}	4 Leaf	17.5
6	12 g a.i. ha^{-1}	6 Leaf	17.4
7	12 g a.i. ha^{-1}	8 Leaf	16.8
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	16.8
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	16.9
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	16.6
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	16.7
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	16.7
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	17.5
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	17.0
15	36 g a.i. ha^{-1}	Early Bloom	17.5
	$LSD^{0.05}$		NS
	P>F		.1631

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.9. End of season total node data for Duplin County, NC in 2006 & 2007.

Treatment #	Rate of Pentia	Timing	2006		2007
1	UTC	-	18.4 abcd	Node #	17.3 ab
2	6 g a.i. ha^{-1}	4 Leaf	19.4 a		16.9 ab
3	6 g a.i. ha^{-1}	6 Leaf	18.8 abc		17.0 ab
4	6 g a.i. ha^{-1}	8 Leaf	17.4 cdef		16.9 ab
5	12 g a.i. ha^{-1}	4 Leaf	19.6 a		16.5 bcd
6	12 g a.i. ha^{-1}	6 Leaf	17.8 cdef		16.7 ab
7	12 g a.i. ha^{-1}	8 Leaf	16.7 efgh		17.6 a
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	19.1 ab		16.6 bc
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	17.1 defg		16.5 bcd
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	17.5 cdef		16.5 bcd
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	18.3 abcd		17.0 ab
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	15.7 gh		16.6 bc
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	15.5 h		16.7 ab
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	16.2 fgh		15.7 cd
15	36 g a.i. ha^{-1}	Early Bloom	17.3 def		15.6 d
	$LSD^{0.05}$		1.48		0.93
	P>F		<.0001		.0102

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.10.First and second position total boll and percent boll retention average mean data from six plants in Rocky Mount, NC for years combined.

			1st Position		2nd Position	
Treatment #	**Rate of Pentia**	**Timing**	**# Bolls**	**% Retention**	**#Bolls**	**% Retention**
1	**UTC**	**-**	**28.6**	**26.5**	**4.4**	**4.1**
2	**6 g a.i. ha^{-1}**	**4 Leaf**	**30.0**	**27.8**	**4.3**	**3.9**
3	**6 g a.i. ha^{-1}**	**6 Leaf**	**30.1**	**27.9**	**4.0**	**3.7**
4	**6 g a.i. ha^{-1}**	**8 Leaf**	**30.6**	**28.4**	**6.1**	**5.7**
5	**12 g a.i. ha^{-1}**	**4 Leaf**	**29.3**	**27.1**	**3.3**	**2.8**
6	**12 g a.i. ha^{-1}**	**6 Leaf**	**27.8**	**25.7**	**4.3**	**3.9**
7	**12 g a.i. ha^{-1}**	**8 Leaf**	**27.5**	**25.5**	**4.3**	**3.9**
8	**6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}**	**4 Leaf + Early Bloom**	**28.3**	**26.2**	**3.3**	**3.0**
9	**12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}**	**6 Leaf + Early Bloom**	**29.8**	**27.6**	**5.3**	**4.9**
10	**6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}**	**8 Leaf + Early Bloom**	**29.1**	**27.0**	**5.1**	**4.8**
11	**12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}**	**4 Leaf + Early Bloom**	**28.9**	**26.7**	**51**	**4.8**
12	**6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}**	**6 Leaf + Early Bloom**	**31.3**	**28.9**	**5.4**	**5.0**
13	**12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}**	**8 Leaf + Early Bloom**	**28.0**	**25.9**	**5.9**	**5.4**
14	**18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}**	**10-11 Leaf + Early Bloom**	**31.1**	**28.8**	**5.0**	**4.6**
15	**36 g a.i. ha^{-1}**	**Early Bloom**	**26.4**	**24.4**	**6.8**	**6.3**
	$LSD^{0.05}$		**NS**	**NS**	**NS**	**NS**
	P>F		**.8898**	**.8898**	**.7757**	**.7757**

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.11. First position total boll and percent boll retention data from six plants in Duplin County, NC for years combined.

Treatment #	Rate of Pentia	Timing	# Bolls	% Retention
1	UTC	-	32.5 abc	30.1 abc
2	6 g a.i. ha^{-1}	4 Leaf	34.6 ab	32.1 ab
3	6 g a.i. ha^{-1}	6 Leaf	27.8 cd	25.7 cd
4	6 g a.i. ha^{-1}	8 Leaf	31.8 abcd	29.4 abc
5	12 g a.i. ha^{-1}	4 Leaf	33.4 abc	30.9 abcd
6	12 g a.i. ha^{-1}	6 Leaf	28.0 cd	25.9 cd
7	12 g a.i. ha^{-1}	8 Leaf	31.1 abcd	28.8 abcd
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	36.3 a	33.6 a
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	32.3 abc	29.9 abc
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	31.8 abcd	29.4 abcd
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	32.3 abc	29.9 abc
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	30.9 abcd	28.6 abcd
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	28.9 bcd	26.7 bcd
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	26.1 d	24.1 d
15	36 g a.i. ha^{-1}	Early Bloom	27.8 cd	25.7 cd
	$LSD^{0.05}$		5.84	5.41
	P>F		.0031	.0031

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.12. Second position total boll and percent boll retention data from six plants in Duplin County, NC for 2006 and 2007.

			2006		2007	
Treatment #	**Rate of Pentia**	**Timing**	**# Bolls**	**% Retention**	**#Bolls**	**% Retention**
1	UTC	-	10.0 cd	9.3 cd	3.5	3.2
2	6 g a.i. ha^{-1}	4 Leaf	9.3 cd	8.6 cd	1.5	1.4
3	6 g a.i. ha^{-1}	6 Leaf	10.0 cd	9.3 cd	3.0	2.8
4	6 g a.i. ha^{-1}	8 Leaf	7.3 d	6.7 d	3.3	3.0
5	12 g a.i. ha^{-1}	4 Leaf	8.3 d	7.6 d	2.5	2.3
6	12 g a.i. ha^{-1}	6 Leaf	7.0 d	6.5 d	3.8	3.5
7	12 g a.i. ha^{-1}	8 Leaf	9.5 cd	8.8 cd	4.8	4.4
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	14.5 a	13.4 a	1.5	1.4
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	10.0 cd	9.3 cd	5.3	4.9
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	14.3 ab	13.2 ab	5.0	4.6
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	7.3 d	6.7 d	4.8	4.4
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	7.8 d	7.2 d	3.8	3.5
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	10.3 bcd	9.5 d	5.3	4.9
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	10.8abcd	10.0 abcd	2.3	2.1
15	36 g a.i. ha^{-1}	Early Bloom	12.5 abc	11.6 abc	2.5	2.3
	$LSD^{0.05}$		4.22	3.91	NS	NS
	P>F		.0097	.0097	.4111	.4111

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.13. Lint yield average mean data for combined years in Rocky Mount and Duplin County, NC.

Treatment #	Rate of Pentia	Timing	RM		Duplin
1	UTC	-	1182	kg ha^{-1}	1218
2	6 g a.i. ha^{-1}	4 Leaf	1268		1182
3	6 g a.i. ha^{-1}	6 Leaf	1167		1231
4	6 g a.i. ha^{-1}	8 Leaf	1156		1172
5	12 g a.i. ha^{-1}	4 Leaf	1195		1079
6	12 g a.i. ha^{-1}	6 Leaf	1191		1136
7	12 g a.i. ha^{-1}	8 Leaf	1192		1171
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	1319		1218
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	1284		1198
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	1300		1360
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	1154		1127
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	1221		1141
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	1008		1216
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	1219		1149
15	36 g a.i. ha^{-1}	Early Bloom	1220		1170
	$LSD^{0.05}$		NS		NS
	P>F		.1978		.4310

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.14. Micronaire data for combined years in Rocky Mount, NC.

Treatment #	Rate of Pentia	Timing	Micronaire
1	UTC	-	4.2
2	6 g a.i. ha^{-1}	4 Leaf	4.4
3	6 g a.i. ha^{-1}	6 Leaf	4.3
4	6 g a.i. ha^{-1}	8 Leaf	4.3
5	12 g a.i. ha^{-1}	4 Leaf	4.2
6	12 g a.i. ha^{-1}	6 Leaf	4.3
7	12 g a.i. ha^{-1}	8 Leaf	4.4
8	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	4 Leaf + Early Bloom	4.3
9	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	6 Leaf + Early Bloom	4.4
10	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	8 Leaf + Early Bloom	4.3
11	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	4 Leaf + Early Bloom	4.5
12	6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}	6 Leaf + Early Bloom	4.3
13	12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}	8 Leaf + Early Bloom	4.4
14	18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}	10-11 Leaf + Early Bloom	4.2
15	36 g a.i. ha^{-1}	Early Bloom	4.4
	$LSD^{0.05}$		NS
	P>F		.8242

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.15. Micronaire data in Duplin County, NC for 2006 and 2007.

Treatment #	Rate of Pentia	Timing	2006	2007
1	**UTC**	**-**	**3.9 abc**	**3.7**
2	**6 g a.i. ha^{-1}**	**4 Leaf**	**3.4 ef**	**3.8**
3	**6 g a.i. ha^{-1}**	**6 Leaf**	**3.6 abcd**	**3.7**
4	**6 g a.i. ha^{-1}**	**8 Leaf**	**4.0 ab**	**3.7**
5	**12 g a.i. ha^{-1}**	**4 Leaf**	**3.4 def**	**3.7**
6	**12 g a.i. ha^{-1}**	**6 Leaf**	**3.8 abcd**	**3.5**
7	**12 g a.i. ha^{-1}**	**8 Leaf**	**3.9 ab**	**3.8**
8	**6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}**	**4 Leaf + Early Bloom**	**3.1 f**	**3.7**
9	**12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}**	**6 Leaf + Early Bloom**	**3.8 abcd**	**3.5**
10	**6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}**	**8 Leaf + Early Bloom**	**4.0 ab**	**3.6**
11	**12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}**	**4 Leaf + Early Bloom**	**3.5 cdef**	**3.8**
12	**6 g a.i. ha^{-1} + 30 g a.i. ha^{-1}**	**6 Leaf + Early Bloom**	**4.2 a**	**3.7**
13	**12 g a.i. ha^{-1} + 24 g a.i. ha^{-1}**	**8 Leaf + Early Bloom**	**4.0 ab**	**3.7**
14	**18 g a.i. ha^{-1} + 18 g a.i. ha^{-1}**	**10-11 Leaf + Early Bloom**	**3.8 abcd**	**3.7**
15	**36 g a.i. ha^{-1}**	**Early Bloom**	**4.0 ab**	**3.9**
	$LSD^{0.05}$		**.38**	**NS**
	P>F		**<.0001**	**.9186**

Treatments 2-7 are an early application strategy
Treatments 8-13 are a modified-modified early bloom strategy
Treatment 14 is a modified early bloom strategy
Treatment 15 is an early bloom strategy

Table 3.16. P-values of comparisons of early versus late applications of mepiquat pentaborate in Rocky Mount, NC.

Data Collected	2006	2007	Years Combined
Plant Height 3 WAEB*	**<.0001**	**.0097**	**-**
Total Node 3 WAEB*	**-**	**-**	**.7694**
NAWF 3 WAEB*	**-**	**-**	**.1340**
End of Season Plant Height	**<.0001**	**.1266**	**-**
End of Season Total Node	**-**	**-**	**.1631**
1st Position # Bolls	**-**	**-**	**.4499**
1st Position % Retention	**-**	**-**	**.4499**
2nd Position # Bolls	**-**	**-**	**.0279**
2nd Position % Retention	**-**	**-**	**.0279**
Lint Yield	**-**	**-**	**.4736**
Micronaire	**-**	**-**	**.7008**

Earlier timings were considered as the one application of 6 g a.i. ha^{-1} and 12 g a.i. ha^{-1} Pentia (mepiquat pentaborate) at the 4-, 6-, and 8-leaf stages and the late timings were considered as the modified-modified early bloom treatments, the modified early bloom treatments, and the early bloom treatments.

Data is reported by year or years combined, depending if year by treatment interaction was present in analysis.

If the p-value ≤ 0.05, then average means were significantly higher for early application strategies than late application strategies.

*3 WAEB - data taken in mid-august three weeks after the early bloom treatments were applied

Table 3.17. P-values of comparisons of early versus late applications of mepiquat pentaborate in Duplin County, NC.

Data Collected	Years Combined
Plant Height 3 WAEB*	**.0246**
Total Node 3 WAEB*	**.0808**
NAWF 3 WAEB*	**.0027**
End of Season Plant Height	**.0068**
End of Season Total Node	**.0120**
1st Position # Bolls	**.0216**
1st Position % Retention	**.0216**
2nd Position # Bolls	**.2558**
2nd Position % Retention	**.2558**
Lint Yield	**.9916**
Micronaire	**.1750**

Earlier timings were considered as the one application of 6 g a.i. ha^{-1} and 12 g a.i. ha^{-1} Pentia (mepiquat pentaborate) at the 4-, 6-, and 8-leaf stages and the late timings were considered as the modified-modified early bloom treatments, the modified early bloom treatments, and the early bloom treatments.

If the p-value ≤ 0.05, then average means were significantly higher for early application strategies than late application strategies.

*3 WAEB - data taken in mid-august three weeks after the early bloom treatments were applied

Defoliation Strategies for Cotton Grown on a 38-cm Row Configuration

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Abstract

HAMM, GARY STEPHEN. Defoliation Strategies for Cotton Grown on a 38-cm Row Configuration. (Under the direction of Dr. Keith Edmisten)

Defoliation is the process of chemically inducing senescence in the cotton (*Gossypium hirsutum* L.) plant in order to promote leaf abscission and enhance boll opening. This process allows growers to minimize the amount of trash (leaves and stems) in harvested lint. Cotton in North Carolina is normally defoliated at 60% open bolls and harvested soon after. Defoliation timing can greatly influence cotton yield potential.

Cotton grown on 38-cm row spacings tends to have a compact fruiting nature due to decrease in row spacing. In turn, defoliation management decisions may be easier because of the reduced variability in boll maturity due to the ability to set fruit over fewer nodes. Therefore, cotton grown on a 38-cm row configuration might could be defoliated before the recommended 60% open bolls without compromising yields. Experiments were conducted in 2006 and 2007 at Upper Coastal Plain Research Station near Rocky Mount, NC to determine the optimum defoliation timing for 38-cm cotton. Cotton was planted on 38-cm rows using a vacuum planter. Treatments consisted of defoliation targeted at 0, 20, 40, 60, 80 and 100% open bolls.

Data collection consisted of nodes above cracked boll at defoliation, percentage open boll and visual percent defoliation 2 weeks after defoliation treatment was applied, lint yield, and micronaire data. The middle four rows of each six-row plot were harvested

using a four-row spindle picker capable of harvesting 38-cm rows. Data were analyzed using a linear and quadratic regression analysis in SAS version 9.1.3 (SAS Institute Inc., Cary, NC).

Lint yield increased as defoliation was delayed. Micronaire was increased above the premium range of 3.8 to 4.2 when defoliation occurred at 40% open bolls or later. Defoliation efficacy improved as defoliation was delayed until 40-60% open bolls. In conclusion, defoliation guidelines for cotton production on wide-row spacings appear to also apply to cotton grown on a 38-cm row configuration.

Introduction

Cotton is usually planted in rows spaced 76 to 96 cm apart. Planting cotton in narrow-row patterns is now feasible due to seed technology and herbicide resistant cotton varieties (Culpepper and York, 2000). Research has been conducted during the past 30 years investigating the benefits of growing cotton in narrow rows. Narrow-row systems have proven to achieve higher yields (Buxton et al., 1978).

Previously, narrow-cotton was harvested using a finger-type stripper in which the bracts, stalk material, and leaf material were harvested with the seed cotton, causing increased trash content (Anthony et al., 2000). John Deere Company has recently developed a harvester that can spindle-harvest cotton grown in 38-cm row configurations (Wilson, 2006). This allows cotton to be grown in closer row spacings and harvested cleaner than previous methods creating some interest in cotton grown on 38-cm row configurations. Cotton defoliation is usually initiated two to three weeks prior to harvest to promote boll opening and rid plants of leafy material that might stain or contribute to trash in harvested cotton lint.

Defoliants usually are categorized as hormonal or herbicidal materials that aid in leaf abscission and boll opening (Collins, 2006). Defoliation timings in North Carolina, are generally determined by environmental conditions in a particular area, the proportion of open harvestable bolls on the plant, and the desired harvest date (Edmisten, 2008). Initiating defoliation too early may halt the development of immature bolls while prolonging defoliation can cause loss of lint yield and affect fiber quality due to weathering (Faircloth et al., 2004b).

Snipes and Baskin (1994) conducted a study where cotton was defoliated at 20, 40, 60, and 80% open bolls. The 60% open boll stage was the most optimum defoliation timing. However, some researchers argue that the percent open boll method is not always the appropriate method to determine defoliation timing, especially when a large fruiting gap is present (Faircloth et al., 2004a). Nodes above cracked boll is a method used by beginning at the first sympodial branch with a first position cracked boll and counting nodes to the highest harvestable boll (Kerby et al., 1992). Researchers believe that using the nodes above cracked boll method is more accurate for determining defoliation timing because the focus is shifted toward the maturity of un-open bolls.

Defoliating cotton as early in the season as possible without hurting crop yield can be beneficial. As harvest is delayed later into the fall, the day length is shortened and the number of hours available for harvest is greatly reduced. Also, later into the growing season growers are likely to face weather conditions that are unfavorable for harvest, such as rain and heavy dew, which will also shorten the amount of hours per day favorable for harvest (Cooke et al., 1972).

Very little research has been conducted to determine the proper defoliation timing for cotton grown on a 38-cm row configuration. Defoliation decisions could be easier in narrow-row cotton due to its potential for a more uniform and compact fruiting habit.

Materials and Methods

Experiments were conducted at Upper Coastal Plain Research Station near Rocky Mount, NC during 2006 and 2007 on a Goldsboro fine sandy loam soil (fine-loamy, siliceous, subactive, thermic Aquic Paleudults). DP 444 BGRR® (Delta Pine and Land, Monsanto Co.; St. Louis, MO), an early maturing cultivar, was planted on a 38-cm row configuration. Cotton seed were treated with abamectin, thiamethoxam, and azoxystrobin (Avicta Complete Pac®, Syngenta Crop Protection, Greensboro, NC) to help avoid early season western flower thrip (*Frankliniella occidentalis*) infestations and early seedling diseases. Plots consisted of six 38-cm rows and were 9.1 m long and 2.3 m wide. Treatments were arranged in a randomized complete block design and were replicated four times. A six-row vacuum planter was used for planting. Cotton was planted at a rate of 6.6 seed per meter of row. Plant populations determined by stand counts at the end of the season equaled to approximately 148,000 plants per hectare.

Treatments consist of defoliant applications at 0, 20, 40, 60, 80 and 100% open boll stage. In 2005, the defoliation period ranged from September 4 until October 10. In

2006, the defoliation period ranged from September 8 until October 15, and in 2007 it ranged from August 27 until September 12. On the day of defoliation, percent open bolls in one meter of row were recorded. Nodes above cracked boll were recorded from six plants as well. A CO_2 pressurized back-pack sprayer with flat fan nozzles calibrated to deliver 136 L ha^{-1} at a pressure of 124 kPa was used to make all defoliation treatments. The defoliation treatments consisted of using a mixture of tribufos {*S,S,S*-tributyl phosphorotrithioate} (Def, Bayer Crop Science, Research Triangle Park N.C.) at 840 g a. i. ha^{-1}, ethephon {2-chloroethyl phosphonic acid} (Prep, Bayer Crop Science, Research Triangle Park N.C.) at 1120 g a. i. ha^{-1} rate, and thiadiazuron {*N*-phenyl-*N*'-1,2,3-thiadiazol-5-ylurea} (Dropp 50 WP, Bayer Crop Science, Research Triangle Park N.C.) at 110 g a. i. ha^{-1} .

Two weeks after defoliation treatments were applied, percent defoliation visual ratings and percent open boll counts in one meter of row were taken. The center four rows of the six-row plots were harvested using a cotton picker retrofitted with the spindle-type heads designed to harvest narrow-row cotton. The harvest dates consisted of October 19, 2006 and October 10, 2007. A subsample of seed cotton was collected from each plot and ginned using a tabletop saw tooth gin to determine lint yield percentage. The lint was then sent to Cotton Incorporated for High Volume Instrumentation analysis to determine fiber quality. Using SAS Version 9.1.3, data were analyzed using a linear and quadratic regression analyses (SAS Institute Inc., Cary, NC). There was a treatment by year interaction, therefore data are reported by year for this experiment. A linear regression analysis is the process where a slope equation is found for a straight line to determine how well plotted data fits to that line to show an increase or decrease in variables. A quadratic regression analysis is the process in which an equation of a curve is best fit to plotted data to determine how well the data fits to that particular curve to show an increase or decrease in variables.

Results and Discussion

Percent Defoliation.

In 2006, percent defoliation was greatest when defoliation was delayed until 60% open bolls (Figure 4.1). Defoliation timings had an effect on percent defoliation two weeks after treatment in 2007; all were greater than 97 percent. There was a significant difference among treatments by the linear analysis but the differences shown are minimal and cannot be applied for practical implications (Figure 4.1). The R^2 value for the linear term was .3755 in 2006 and .2301 in 2007. There were different environmental factors that might have caused this response. In 2006, environmental conditions were favorable, with adequate soil moisture and mild to moderate temperatures at the time of defoliation, potentially slowing the rate of senescence. In 2007, environmental conditions were hot and dry with higher temperatures and very low soil moisture and the plants were able to reach senescence more rapidly.

Percent Open Bolls.

Percent open bolls at two weeks after defoliation 2006 was greater when cotton was defoliated at 40% open bolls or later as indicated by the significant linear term

(Figure 4.2). In 2007, there were not any differences observed among treatments. The R^2 value for the linear term was .3193 in 2006 and .0585 in 2007. In 2007, environmental conditions were hot and dry with higher temperatures and very low soil moisture which were favorable for boll opening.

Lint Yield and Nodes Above Cracked Boll.

Lint yields increased as defoliation was initiated beyond 60 percent open bolls in 2006. (Figure 4.3). Lint yield data did not show a quadratic response in 2006 with a quadratic p-value of .6069 but did in 2007 with a quadratic p-value of .0336. The R^2 values for lint yield quadratic analysis were .5329 in 2006 and .6313 in 2007. Yields were decreased when defoliants were applied before 40% open boll and increased after this timing (Figure 4.5). There was a correlation in yield and nodes above cracked boll data in both 2006 and 2007 in which nodes above cracked boll was used as a decision tool. Nodes above cracked boll data showed that when defoliation was delayed until five nodes above cracked boll, a trend for an increase in yield was observed in both 2006 and 2007 (Figure 4.4 & 4.6).

Micronaire.

There was a trend for increased micronaire as defoliation was delayed (Figure 4.7). When defoliants were applied before 40% open boll, micronaire values were lower. The R^2 value for the linear term was .6047 in 2006 and .4433 in 2007. When defoliation was delayed, trends were observed in which micronaire values increased above the premium range of 3.8 – 4.2. Defoliation timing had no effect on staple length (UHM)

(R^2 - .0478 in 2006 & .0864 in 2007), fiber uniformity (UI) (R^2 - .0001 in 2006 & .0410 in 2007), and fiber strength (STR) (R^2 - .0001 in 2006 & .1413 in 2007) for both years as defined by the quadratic term (Table 4.8, 4.9, & 4.10).

Conclusions

Yield data indicates that 40 to 60% open bolls was the most optimum time to defoliate 38-cm row cotton based on yield. Delaying cotton defoliation can result in crop loss to due to unfavorable weather conditions (Snipes and Baskin, 1994). When yield was correlated with nodes above cracked boll as a defoliation decision tool, five nodes above cracked boll was the optimum time to defoliate. Defoliation efficacy was increased after 40-60 % open bolls. Fiber quality data suggested that defoliating too early (0 to 20% open bolls) resulted in poor fiber quality. Later defoliation applications (60 to 80% open bolls) resulted in less than desirable micronaire values but did not affect staple length (UHM), fiber uniformity (UI), or fiber strength (STR).

When making defoliation decisions, it is important to look at environmental factors that may affect defoliation. This experiment showed that current recommendations for wide-row cotton can be applied to cotton grown on 38-cm rows. Delaying defoliation beyond 60 % open boll resulted in yield gain but if defoliation is delayed too long, crop loss could occur due to environmental factors.

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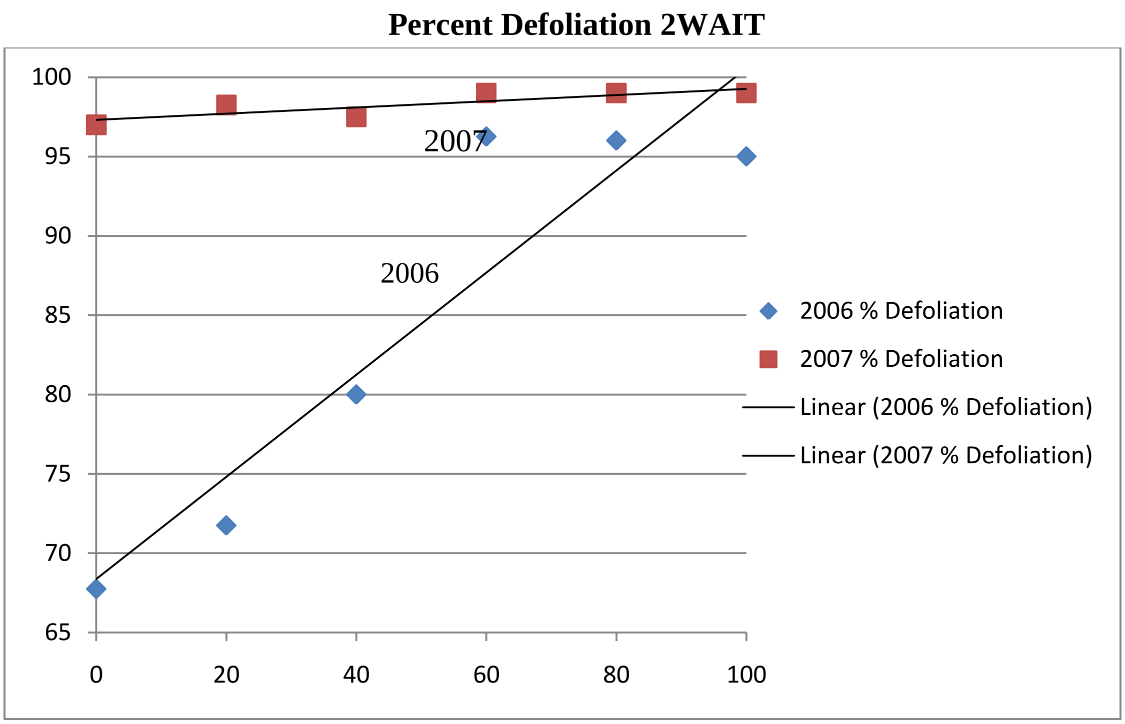


2006 Percent Defoliation Linear Regression Equation: $y = 0.32x + 68.37$

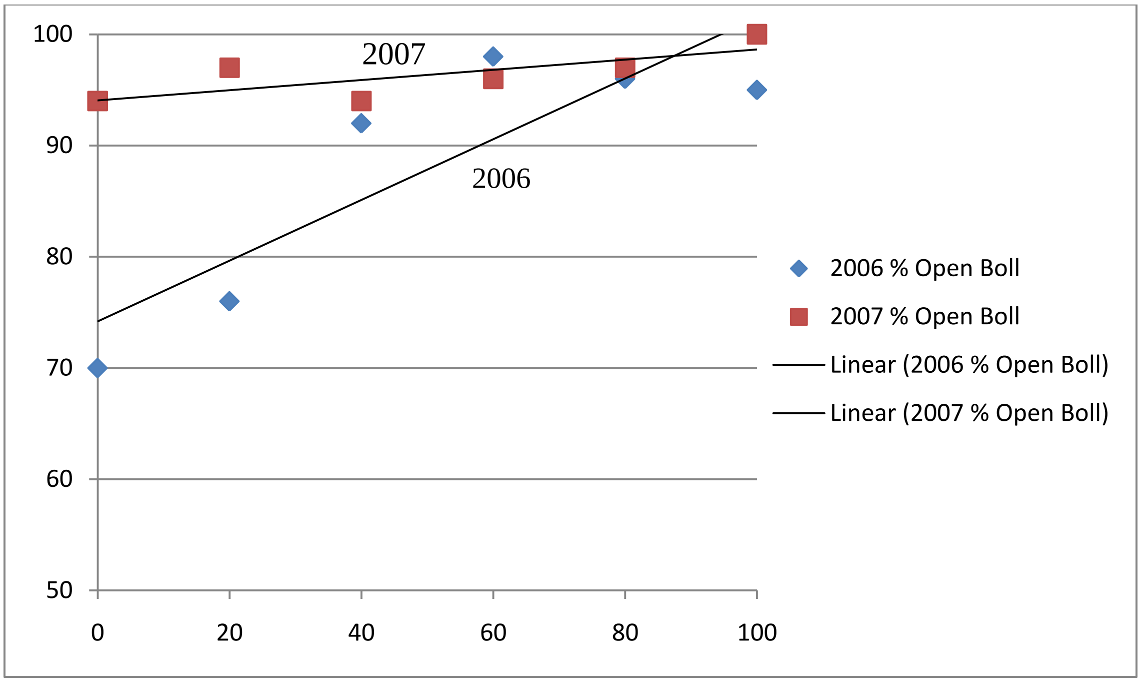
2007 Percent Defoliation Linear Regression Equation: $y = 0.02x + 97.31$

Treatment % Open Boll	**0**	**20**	**40**	**60**	**80**	**100**
Percent Defoliation 2006	67.8	71.8	80.0	96.3	96.0	95.0
Percent Defoliation 2007	97.0	98.3	97.5	99.0	99.0	99.0

	Linear Model 2006	**Linear Model 2007**
Linear P Value	**.0015**	**.0177**
R^2	**.3755**	**.2301**

Figure 4.1. Percent defoliation two weeks after initial defoliation treatment in 2006 and 2007.

Percent Open Boll 2WAIT



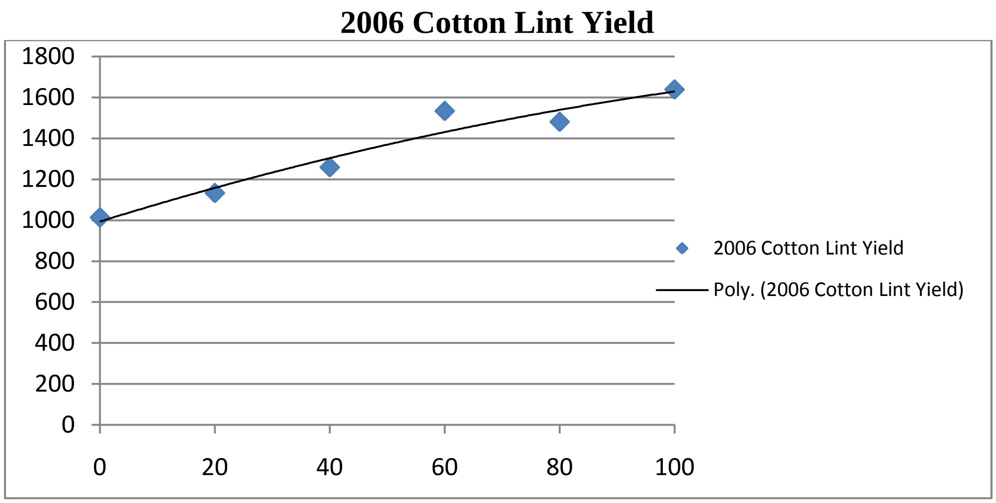
2006 Percent Open Boll 2WAIT Linear Regression Equation: $y = 0.28x + 74.23$

2007 Percent Open Boll 2WAIT Linear Regression Equation: $y = 0.04x + 94.43$

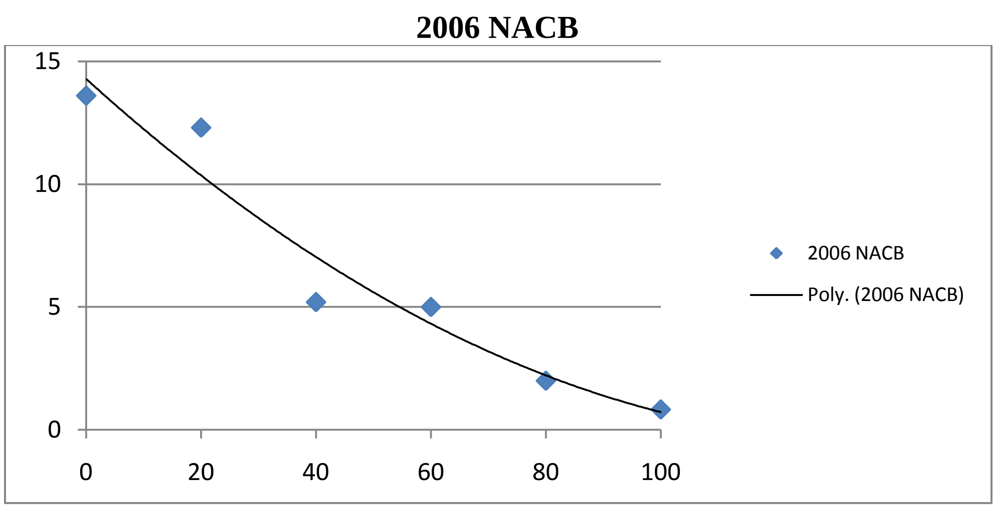
Treatment % Open Boll	0	20	40	60	80	100
Percent Open Boll 2WAIT 2006	70.0	76.0	92.5	98.5	96.8	95.5
Percent Open Boll 2WAIT 2007	94.5	97.0	94.5	96.3	97.5	100.0

	Linear Model 2006	Linear Model 2007
Linear P Value	**.0040**	**.2548**
R^2	**.3193**	**.0585**

Figure 4.2. Percent open bolls taken two weeks after the initial defoliation treatment in 2006 and 2007.



Cotton Lint Yield Quadratic Regression Equation: $y = -0.23x^2 + 8.68x + 994.20$



NACB Quadratic Regression Equation: $y = 0.0008x^2 – 0.21x + 14.28$

Treatment % Open Boll	**0**	**20**	**40**	**60**	**80**	**100**
Cotton Lint Yield kg ha^{-1}	1013	1132	1258	1533	1480	1638
NACB	13.6	12.3	5.2	5.0	2.0	0.8

	Lint Yield	**NACB**
Quadratic Model 2006		
Linear P Value	**.0761**	**<.0001**
Quad P Value	**.6069**	**.0580**
R^2	**.5329**	**.8782**

Figure 4.4. Nodes above cracked boll at initial defoliation treatment in 2006.

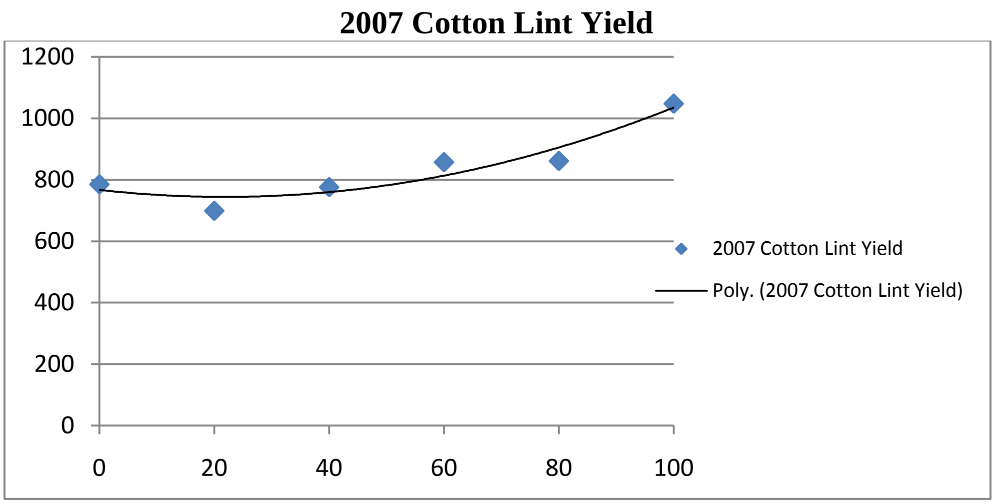
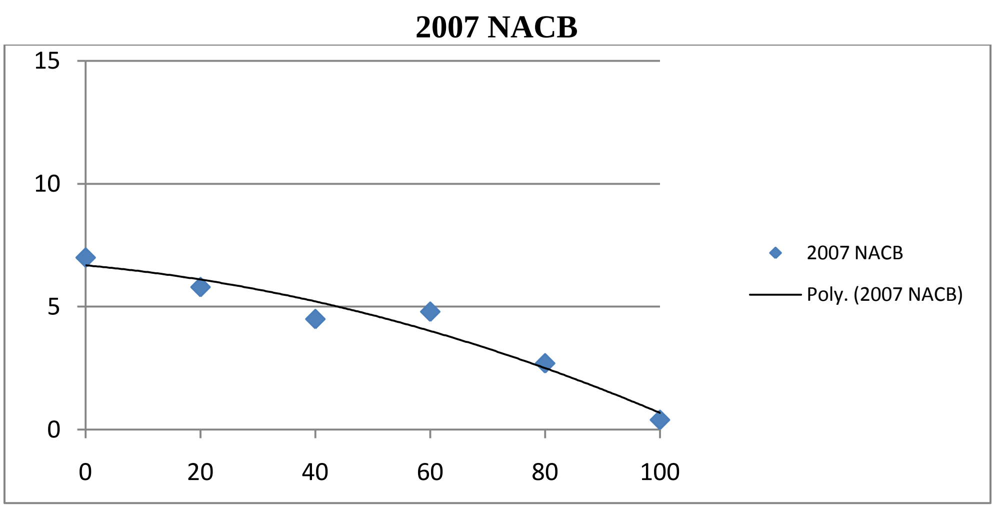


Figure 4.5. Cotton lint yield data in 2007.

Cotton Lint Yield Quadratic Regression Equation: $y = 0.04x^2 - 2.09x + 767.22$

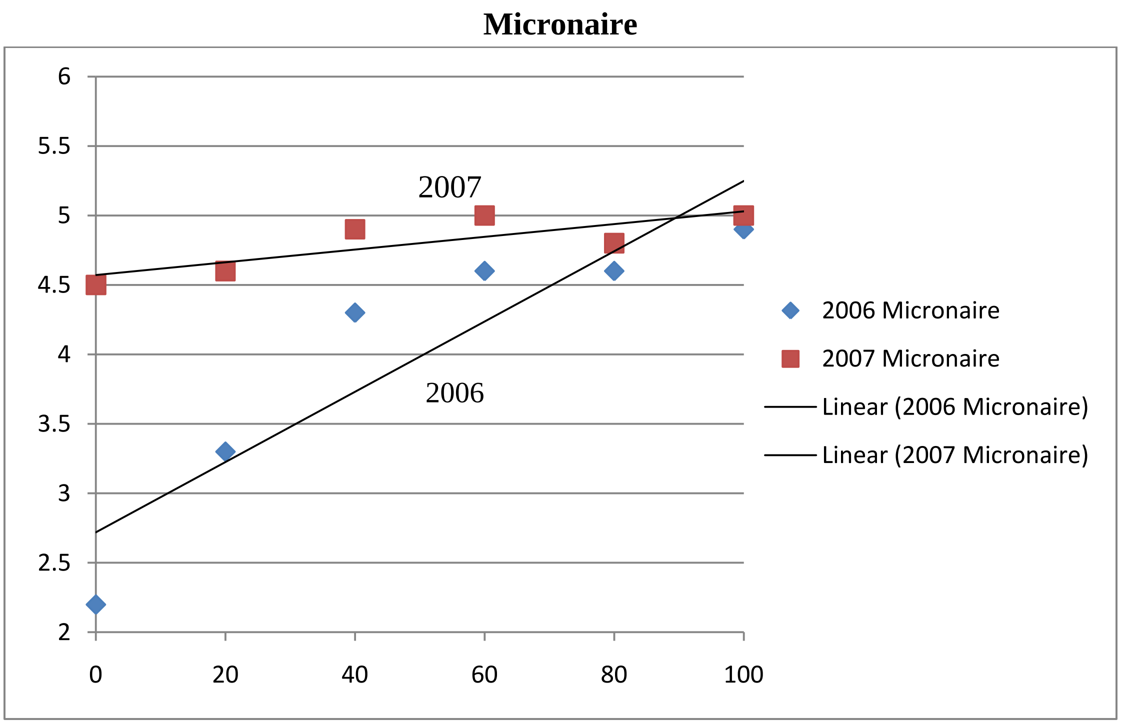


NACB Quadratic Regression Equation: $y = -0.0004x^2 - 0.02x + 6.68$

Treatment % Open Boll	**0**	**20**	**40**	**60**	**80**	**100**
Cotton Lint Yield kg ha^{-1}	785	699	776	857	861	1048
NACB	7.0	5.8	4.5	4.8	2.7	0.4

	Lint Yield	**NACB**
Quadratic Model 2007		
Linear P Value	**.0336**	**.2541**
Quad P Value	**.3405**	**.0269**
R^2	**.6313**	**.8825**

Figure 4.6. Nodes above cracked boll at initial defoliation treatment in 2007.



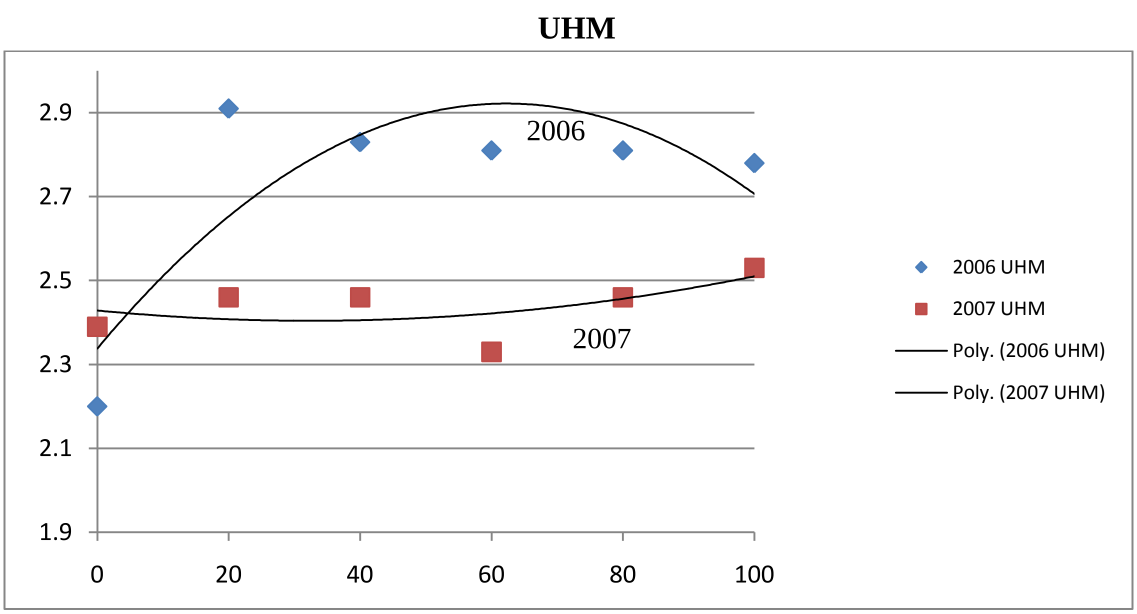
2006 Micronaire Linear Regression Equation: $y = 0.03x + 2.72$

2007 Micronaire Linear Regression Equation: $y = 0.005x + 4.55$

Treatment % Open Boll	**0**	**20**	**40**	**60**	**80**	**100**
Micronaire 2006	2.2	3.3	4.3	4.6	4.6	4.9
Micronaire 2007	4.5	4.6	4.9	5.0	4.8	5.0

	Linear Model 2006	**Linear Model 2007**
Linear P Value	**<.0001**	**.0026**
R^2	**.6047**	**.4433**

Figure 4.7. Micronaire in 2006 and 2007.



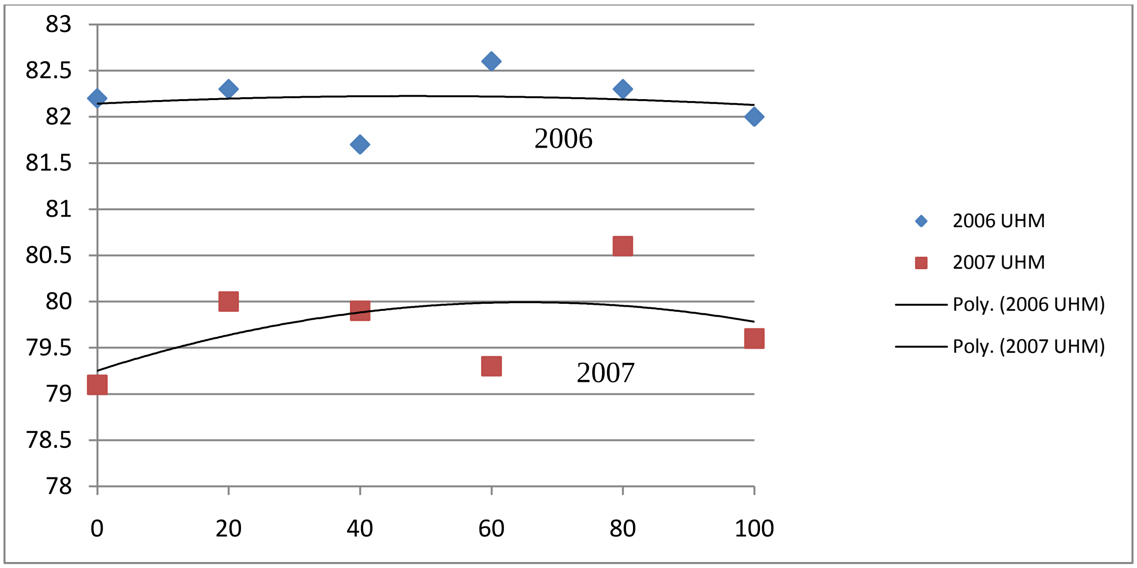
2006 UHM Quadratic Regression Equation: $y = -0.00006x^2 + 0.007x + 0.92$

2007 UHM Quadratic Regression Equation: $y = 0.000009x^2 – 0.0006 + 0.96$

Treatment % Open Boll	0	20	40	60	80	100
UHM 2006 cm	2.2	2.9	2.8	2.8	2.8	2.8
UHM 2007 cm	2.4	2.5	2.5	2.3	2.5	2.5

	Quadratic Model 2006	Quadratic Model 2007
Linear P Value	.1593	.4715
Quad P Value	.2185	.3278
R^2	.1156	.1448

Figure 4.8. Staple length (UHM) in 2006 and 2007.



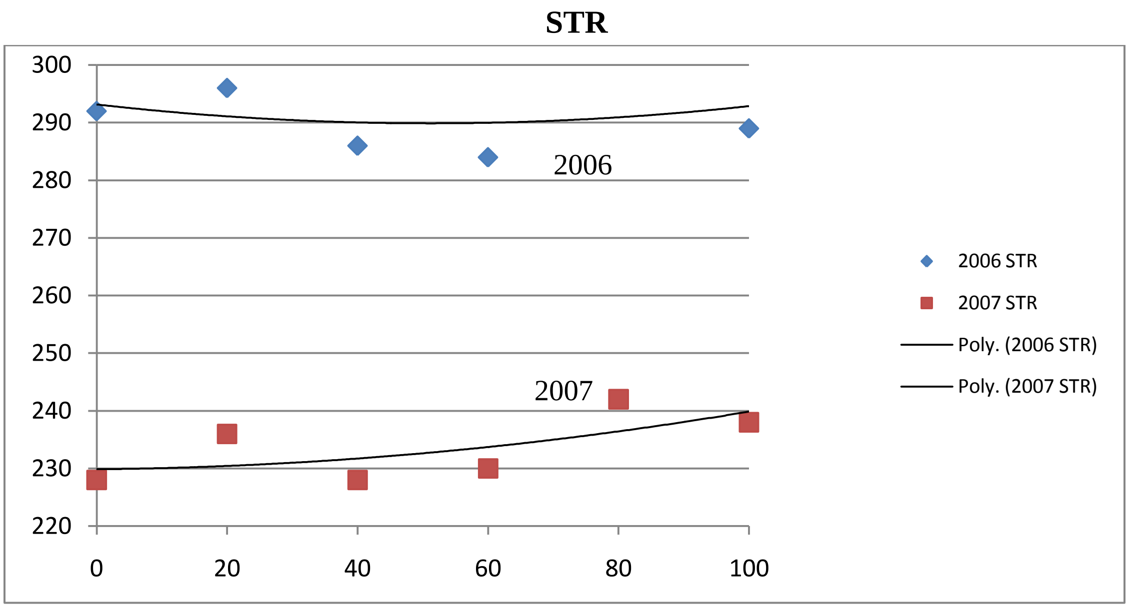
2006 UI Quadratic Regression Equation: $y = -0.00003x^2 + 0.003x + 82.15$

2007 UI Quadratic Regression Equation: $y = -0.0001x^2 + 0.021x + 79.27$

Treatment % Open Boll	**0**	**20**	**40**	**60**	**80**	**100**
UI 2006	82.2	82.3	81.7	82.6	82.3	82.0
UI 2007	79.1	80.0	79.9	79.3	80.6	79.6

	Quadratic Model 2006	**Quadratic Model 2007**
Linear P Value	**.9161**	**.3637**
Quad P Value	**.9050**	**.4721**
R^2	**.0007**	**.0746**

Figure 4.9 Fiber uniformity index (UI) in 2006 and 2007.



2006 STR Quadratic Regression Equation: $y = 0.0001x^2 - 0.01x + 29.86$

2007 STR Quadratic Regression Equation: $y = 0.00009x^2 + 0.001x + 23.43$

Treatment % Open Boll	**0**	**20**	**40**	**60**	**80**	**100**
STR 2006 kN m/kg	292	296	286	284	301	289
STR 2007 kN m/kg	228	236	228	231	242	238

	Quadratic Model 2006	**Quadratic Model 2007**
Linear P Value	**.5765**	**.9613**
Quad P Value	**.5618**	**.6875**
R^2	**.0163**	**.1508**

Figure 4.10. Fiber strength (STR) in 2006 and 2007.

Economics of Cotton Grown on a 38-cm Row Spacing Double Cropped With Wheat

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Abstract

HAMM, GARY STEPHEN. Economics of Cotton Grown on a 38-cm Row Spacing Double Cropped With Wheat. (Under the direction of Dr. Keith Edmisten)

Cotton (*Gossypium hirsutum* L.) prices have been slowly decreasing while cost for other economic inputs (equipment, seed, chemicals, etc.) have been increasing. Farmers are therefore implementing agronomic practices that maximize profitability. One such concept that can be implemented is double-cropping, in which two crops can be grown on the same piece of land in one year or growing season. This system has been widely used in the past with soybeans (*Glycine max*) and wheat (*Triticum aestivum*). Double-cropping systems that consist of wide-row cotton and wheat are not feasible in the northern part of the cotton belt. The cooler late-season temperatures and risk of early frost prohibit wide-row cotton from reaching full maturity. The growth habits of cotton grown in narrow rows seem to promote earlier maturity more so than in wide-row systems. Double-cropping cotton and wheat may be an option for growers if cotton is grown in a narrow-row system consisting of 38-cm rows planted soon after wheat harvest. Experiments were conducted at two locations during 2006 and 2007, at the Upper Coastal Plain Research Station, Rocky Mount, NC and Central Crops Research Station, Clayton, NC. Wheat was planted in the fall. In the early spring, plots that were not to be harvested were desiccated using glyphosate potassium salt. Cotton was planted in 38 cm and 96-cm rows, at various planting dates either being planted in desiccated wheat stubble or being double cropped with wheat. Planting dates in 2006 included May

11, May 24, July 5, and July 12. In 2007, five planting dates (May 14, May 28, June 11, June 21, and July 2) were used.

Data collected from this experiment consisted of wheat yields, cotton stand counts two weeks after planting, number of days to first bloom, number of days to first open boll, lint yield, and fiber quality at harvest.

The number of days to first bloom was not affected by row spacing across all planting dates. The number of days from planting to first bloom was approximately 60 days regardless of planting date or row spacing. The effect on number of days to first open boll was similar. The number of days from planting to first open boll was approximately 105 days. Yield data showed that yields declined for both wide- and narrow-row spacing as the planting date was delayed. Cotton on 38-cm rows in a double-cropping situation with wheat, at planting dates before the last week of June, showed comparable economic returns to soybeans double-cropped with wheat. Some things to consider when making the decision to double crop cotton with wheat is the length of growing season, how early the wheat or small grain can be harvested, selection of an early maturing, high yielding cultivar and its growth habits, and the amount of rainfall available during the summer months in that particular area.

Introduction

Cotton is usually planted in rows spaced 76 to 96 cm apart. Planting cotton in narrow-row patterns is now feasible due to seed technology and herbicide-resistant cotton varieties (Culpepper and York, 2000). Research has been conducted during the past 30 years investigating the benefits of growing cotton in narrow rows. Narrow-row systems have proven to achieve higher yields (Buxton et al., 1978). Previously, narrow-row cotton was harvested using a finger-type stripper in which the bracts, stalk material, and leaf material were harvested with the seed cotton, causing increased trash content (Anthony et al., 2000). John Deere Company has recently developed a harvester that can spindle-harvest cotton grown in 38-cm row configurations (Wilson, 2007). This allows cotton to be grown in closer row spacings and harvested cleaner than previous methods (Wilson, 2007). Also, production practices that are more suitable with a 38-cm row spacing versus the 18-cm row spacing (ultra-narrow row) includes planting method and seed placement. Ultra-narrow row cotton is planted using a grain drill, however more advanced planters have been developed to plant in 38-cm rows. These planters have seed disks that allow for better seed placement and more precise plant population adjustments (Wilson, 2007). Ray and Hudspeth (1966) observed yield increases of 6 to 11% when cotton was planted in 18- to 25-cm rows when compared to wide-row patterns. In a study by Wilson et al. (2007), cotton grown on 38-cm rows yielded 10% higher than cotton grown on 97-cm rows. One advantage that narrow-row cotton offers is earlier maturity due to compact fruiting resulting from increased plant populations and decreased row spacings (Bednarz and Nichols, 2005; Viator et al., 2008; Vories et al., 2001). This is due to narrow-row patterns having less outer position fruit than in wide-row systems because of the reduced space between rows, thus leading to less variation in fruit maturities (Jost and Cothren, 2000).

Cotton is usually planted well before growers harvest their wheat crop. Most cotton growers plant cotton before the last week of May in NC. As planting date is delayed, yield usually decreases (Porter et al., 1996). The concept of planting two crops on the same land in a year, or double-cropping, is not a new idea (Smith and Varvil, 1981). Advantages include the ability to increase economic output of the land. A double cropping system of soybeans planted after wheat is more common than a system with cotton planted after wheat, because soybeans can be planted at later dates than cotton while avoiding yield reductions. Cotton producers in the southeastern United States are interested in growing cotton in a double-cropped system with a winter crop (Porter et al., 1996). Research in Arkansas has shown that wide-row cotton (> 76-cm) may not be double cropped with wheat due to the growing season not being long enough for cotton to mature and be harvested (Smith and Varvil, 1981). Planting early maturing cotton varieties could allow growers to be able to achieve optimal yields and reduce risks of early-season frost (Smith and Varvil., 1981). Planting date experiments have shown that when row width was narrowed and planting dates were delayed beyond normal timings, yield increases were seen when compared to wide-row patterns (Beatty et al, 1982). Cotton in a double crop system with wheat can be produced in areas where the growing season is long enough to achieve full maturity of cotton (Baker, 1987). The ability of cotton to be planted in a double-cropped system as a viable option is not yet defined (Hunt et al., 1997). This experiment is designed to determine if cotton grown on 38-cm and 96-cm row spacings can be double-cropped with wheat and produce profitable yields.

Materials and Methods

Field experiments were conducted in 2006 and 2007 at Upper Coastal Plain Research Station, Rocky Mount, NC and Central Crops Research Station, Clayton, NC. The wheat variety Coker 9295® (AgriPro Coker, Berthoud, CO) was planted conventionally to serve as either a cover crop or harvested for yield. The wheat was planted on October 31, 2006 and on November 2, 2007 at rate of 168 kg ha^{-1}. In early spring, wheat plots, to be harvested for yield data and double-cropped with cotton, received 109 kg N ha^{-1} of 32% UAN which is a mixture of ammonium nitrate and urea. Wheat plots that were to be used for the earlier cotton planting dates were desiccated the first week of May using glyphosate potassium salt (Roundup WeatherMax; Monsanto Co.; St. Louis, MO) applied at 865 g a.i.ha^{-1}. The study was designed to compare differences in cotton planted in 38-cm and 96-cm rows in a double-crop system. Wide-row (96-cm) and narrow-row (38-cm) cotton was planted on various planting dates with two of the planting dates utilizing a double-cropped system. This study consisted of four planting dates in 2006: May 11, May 24, July 5, and July 12. In 2007, this study consisted of five planting dates: May 14, May 28, June 11, June 21, and July 2. Differences in planting dates in 2006 and 2007 are attributed to heavy rainfall in June of 2006 and planting had to be delayed. Plots were 9.1 m in length and 2.3 m wide for the narrow-row and 9.1 m in length and 3.7 m wide for the wide row. Treatments were arranged in a randomized complete block design replicated four times. Cotton was planted using a six-row planter for 38-cm rows and a two-row vacuum planter for 96-cm rows. The cotton variety DP

117 BGRF® (Delta Pine and Land, Monsanto Co.; St. Louis, MO) was planted because of its high yield capacity and its glyphosate resistance. Cotton seed were treated with abamectin, thiamethoxam, and azoxystrobin (Avicta Complete Pac®, Syngenta Crop Protection, Greensboro, NC) to help avoid early season western flower thrip (*Frankliniella occidentalis*) infestations and early seedling diseases. Cotton was planted at the Upper Coastal Plain Research Station on a Goldsboro fine sandy loam soil (Fine-loamy, siliceous, subactive, thermic, Aquic Paleudult) and Central Crops Research Station on a Johns sandy loam (Fine-loamy, siliceous, semiactive, thermic, Aquic Hapludult) soil.

Management practices

Cotton was planted at a rate of 168,00 seed per hectare for 38-cm row cotton and 140, 000 seed per hectare for 96-cm rows. Wheat was harvested on June 29, 2006 and June 12, 2007 for the double-cropped treatments and was used in the economic analysis. Heavy rainfall in June, 2006 delayed wheat harvest. A CO_2 charged backpack sprayer was used to apply acephate (Acephate 90®; MANA Inc; Raleigh, NC) at 547 grams ha^{-1} to control thrips and glyphosate potassium salt (Roundup WeatherMax; Monsanto Co.; St. Louis, MO) at 865 g a.i. ha^{-1} for weed control three weeks after each planting date and applied as needed later in the season. Cotton was monitored and 84 kilograms N ha^{-1} of 32% UAN was applied when fruiting squares were first observed for each planting date. The date of first bloom was recorded for each treatment and date of first cracked boll as well. Cotton was defoliated two weeks after first cracked boll. In 2006, the first two planting dates at each location were defoliated accordingly but the remaining planting dates never reached maturity to be defoliated chemically. Cotton was defoliated at 60% percent open boll using a mixture of tribufos {*S*,*S*,*S*-tributyl phosphorotrithioate} (Def, Bayer Crop Science, Research Triangle Park N.C.) at 840 g a. i. ha^{-1}, ethephon {2-chloroethyl phosphonic acid} (Prep, Bayer Crop Science, Research Triangle Park N.C.) at 1120 g a. i. ha^{-1}, and thiadiazuron {*N*-phenyl-*N*'-1,2,3-thiadiazol-5-ylurea} (Dropp 50 WP, Bayer Crop Science, Research Triangle Park N.C.) at 110 g a. i. ha^{-1}. Cotton was harvested on October 19, 2006 for the 1st and 2nd planting dates. The rest of the planting dates were unable to be harvested due to an early frost on October 12 prohibiting physiological maturity and optimal boll opening from being reached. The first three planting dates in 2007 were harvested on October 11 and October 17 at Rocky Mount and Clayton. The last two planting dates in 2007 at each location were harvested on November 12. The cotton plots were harvested using a cotton picker retrofitted to harvest narrow-row and wide-row cotton. A seed cotton subsample was taken from each plot to be ginned using a table-top saw tooth gin to determine lint percentage. The lint samples were then sent to Cotton Incorporated for High Volume Instrumentation analysis to determine fiber quality.

Data collected from this experiment consisted of wheat yield, stand counts two weeks after planting date to determine percent seedling emergence, number of days to first bloom, number of days to first cracked boll, cotton lint yield, and fiber quality parameters. Wheat yields, cotton lint yields, input costs, and average NC double-crop soybean yields for 2006 and 2007 were used to determine economic values. Data were analyzed using the general linear model procedure in SAS 9.1.3 (SAS Institute Inc., Cary, NC). Treatment means were separated by Fisher's Protected LSD at $\alpha \leq 0.05$.

Results and Discussion

Plant Population.

Population emergence was generally lower in the 38-cm rows than the 96-cm rows. This was mainly due to the narrow-row planter being equipped with single no-till coulters and the wide-row planter being attached with row sweeps. Row sweeps are configured with spider-finger type apparatuses that remove trash from the area being planted, therefore allowing for better seed placement and soil contact than a single no-till coulter would. At Rocky Mount and Clayton, for both the 38 and 96-cm rows, a trend was observed in which population emergence percentages decreased as planting date was delayed (Table 5.1 & 5.2). Conditions in 2006 were extremely wet during planting and reduction in percent emergence could have been due to seedling diseases correlated with wet weather (Table 5.1 & 5.3). This reduction in emergence in 2007 was most likely due to decreased soil moisture at the time of planting hindering seed germination (Table 5.2 & 5.3). The decrease in emergence percentages was observed primarily in the planting dates that were double cropped with wheat. The wheat stubble could have been a factor in the decreased seed germination. There were some effects seen in these experiments in which there was not good seed/soil contact due to the heavy wheat stubble being present. In a study by Brown et al. (1985), plant emergence was reduced when cotton was planted no-till into wheat stubble versus being planted into disked wheat stubble. The wheat stubble could have had an allelopathic effect on the seed and hindered germination. In a study by Boquet et al. (2004), there were allelopathic effects seen between wheat and cotton affecting seed germination.

Maturity.

As planting date was delayed in 2006, data suggested a slight decrease in the number of days from planting until first flower (Table 5.4). This same trend was not observed in 2007 (Table 5.5). There was no difference observed between wide- and narrow-cotton regarding the number of days until bloom except at earlier planting dates in which the number of days until first bloom for the narrow rows was a few days less than that of the wide-row pattern (Table 5.4 & 5.5). As planting date was delayed, there was an increase in the number of days required for bolls to fully mature and open. This trend was seen for both years and locations (Table 5.4 & 5.5). There were no differences observed between row spacings.

Lint Yield.

In 2006, there were no significant differences in yield at either location from the treatments that were able to be harvested (Table 5.6). In 2006, no significant effects on yield were observed, however in 2007, significant differences in yield were observed. As planting date was delayed pas the middle of June, narrow-rows had significantly higher yields over wide-row cotton. Data suggested in 2007 that as planting dates were delayed from May until July, there was trend in which yields were reduced as planting date was delayed (Table 5.7).

Fiber Quality.

No significant differences were observed for micronaire at Rocky Mount or Clayton in 2006 or 2007. There was a trend observed in which the micronaire for the 38-cm rows was slightly higher than the 96 cm rows but differences were not significant (Table 5.8 & 5.9). Planting date had an effect on other fiber quality parameters in 2007, but not in 2006. Staple length (UHM), fiber uniformity (UI), and fiber strength (STR) data suggested a trend in 2007 to increase slightly in value as planting date was delayed in both the wide and narrow-rows at Rocky Mount and Clayton (Table 5.10, 5.11, & 5.12). No trend was observed in 2006 for fiber quality at these locations (data not shown).

Economic Returns.

Net profit values for both wide and narrow-row cotton were in the negative numbers when cotton yields dipped below 800 kg ha^{-1} for both years (Table 5.13 & 5.14). This is due to high input costs that are associated with equipment, seed, fertilizer, pesticides, etc. The ability to achieve profitable yields with cotton in a double-crop situation was not consistent. In 2006, due to heavy rainfall in June, the wheat was unable to be harvested until the end of June and the double-crop treatments were not able to be planted until July. The cotton in these two planting dates could not reach full maturity and was unable to be harvested. Wheat net profit returns are shown alone for these two planting dates in 2006 at both locations (Table 5.13). Cotton yields in both the wide and narrow-row Patterns were fairly low for the double-crop planting date in 2007. Although with the

38-cm cotton, higher net profit returns and yields were observed (Table 5.14). Wheat yields were a large portion of the cotton and wheat monetary values for the last two planting dates in both the 38-cm and 96-cm rows. In 2006, the average double-soybean yield in North Carolina was 1903 kg ha^{-1}. When soybean net profits were calculated to be sold at a price of $.34 per kilogram (average December market price, Chicago Board of Trade, 2008), plus wheat income of $678 (average wheat gross profit in Rocky Mount and Clayton) minus a total input cost for soybeans and wheat of $627, net income for double-crop soybeans were $641. For 2007, in a same scenario using the average double-crop soybean yield in North Carolina of 1312 kg ha^{-1} being sold at $.34 per kilogram plus adding the average wheat yield income of Clayton and Rocky Mount in 2007 of $678 then subtracting average input costs for wheat and soybeans of $627 total net income, equal $497 dollars per hectare for double-crop soybeans. Cotton double-cropped with wheat on 96-cm rows did not show profits anywhere near those of double-crop soybeans. Cotton grown on 38-cm rows did show some ability to be double-cropped and produce net profits close to that of double-crop soybeans (Table 5.14)

Conclusions

There were no differences in maturity observed between 38-cm and 96-cm rows in this experiment. In 2006, conditions were extremely wet in June delaying wheat harvest and cotton planting until July. Narrow-row cotton planted at these dates was not able to produce harvestable bolls before a seasonal frost and therefore the cotton was not able to be harvested. In 2007, wheat was harvested before middle of June and narrow-row cotton was planted at these dates and harvested for profitable yields. Data from 2006 and 2007 suggests that if wheat can be harvested before the middle of June, narrow-row cotton can be planted and harvested. If wheat harvest is delayed past the middle of June, then cotton is not the best option for a double-crop situation. Some things to consider when making the decision to double-crop cotton with wheat is the length of growing season, how early the wheat or small grain can be harvested, selection of an early maturing, high yielding variety and its growth habits, and the amount of rainfall available during the summer months in that particular area or the ability to irrigate. Data suggested that growing narrow-row cotton in a double-crop situation in more suitable areas with longer growing seasons than that of North Carolina could be a viable and economical option in replacing double-crop soybeans.

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Table 5.1. Population emergence percentages for Rocky Mount and Clayton, NC in 2006.

Planting Date	Row Spacing	Rocky Mount	Clayton
		% Emergence	
May 11, 2006	38 cm	55.6	61.3 b
	96 cm	100.0	93.1 a
May 24, 2006	38 cm	66.6	60.6 b
	96 cm	100.0	71.6 b
July 5, 2006	38 cm	68.8	90.0 a
	96 cm	80.6	88.4 a
July 12, 2006	38 cm	83.8	38.8 c
	96 cm	72.5	56.9 b
	$LSD^{0.05}$	NS	16.25
	P >F	.1740	< .0001

Table 5.2. Population emergence percentages for Rocky Mount and Clayton, NC in 2007.

Planting Date	Row Spacing	Rocky Mount	Clayton
		% Emergence	
May 14, 2006	38 cm	76.9 b	85.0 bc
	96 cm	80.3 b	94.1 ab
May 28, 2006	38 cm	80.0 b	63.1 de
	96 cm	100.0 a	71.6 cd
June 11, 2006	38 cm	99.4 a	95.0 ab
	96 cm	69.1 b	100.0 a
June 21,2006	38 cm	64.4 bc	54.4 e
	96 cm	70.9 b	59.4 de
July 2, 2006	38 cm	70.6 b	61.3 de
	96 cm	50.9 c	61.6 de
	$LSD^{0.05}$	17.95	15.08
	P > F	< .0001	< .0001

Table 5.3. Rainfall amounts during planting in Rocky Mount and Clayton, NC in 2006 and 2007.

	Rocky Mount	Clayton
	inches	
2006		
May 11th, 2006 PD		
Week of - 5/7-5/13	**2.02**	**1.69**
Week after - 5/14-5/20	**1.71**	**2.15**
May 24, 2006 PD		
Week of - 5/21-5/27	**0**	**0.15**
Week after - 5/28-6/3	**3.19**	**0.11**
Month of June		
Week of - 6/4-6/10	**1.57**	**0.98**
Week of - 6/11-6/17	**5.32**	**5.38**
Week of - 6/18-6/24	**1.07**	**0.74**
Week of – 6/25-7/1	**1.55**	**0.40**
July 5, 2006 PD		
Week of - 7/2-7/8	**3.53**	**1.05**
Week after - 7/9-7/15	**2.29**	**0.09**
July 12, 2006 PD		
Week after – 7/16-7/22	**0.01**	**0.39**
2007		
May 14, 2007 PD		
Week of - 5/13-5/19	**1.43**	**0.54**
Week after - 5/20-5/26	**0**	**0**
May 28, 2007 PD		
Week of - 5/27-6/2	**0**	**0.15**
Week after - 6/3-6/9	**2.42**	**1.45**
June 11, 2007 PD		
Week of - 6/10-6/16	**0.11**	**0.02**
Week after - 6/17-6/23	**0.07**	**0.17**
June 21, 2007 PD		
Week after - 6/24-6/30	**0.15**	**0.77**
July 2, 2007 PD		
Week of - 7/1-7/7	**0.53**	**0**
Week after – 7/8-7/1	**0.74**	**0.80**

Table 5.4. Days to first bloom and days to first cracked boll from planting date for Rocky Mount and Clayton, NC in 2006.

Planting Date	Row Spacing	RM	Clayton	RM	Clayton
		# Days to 1st Bloom		# Days to 1st Cracked Boll	
May 11, 2006	38 cm	68 b	64 c	120 c	116 d
	96 cm	71 a	71 a	120 c	120 c
May 24, 2006	38 cm	60 e	69 b	122 b	122 b
	96 cm	63 c	69 b	124 a	126 a
July 5, 2006	38 cm	59 f	56 f	-	-
	96 cm	59 f	59 e	-	-
July 12,2006	38 cm	60 e	64 c	-	-
	96 cm	62 d	62 d	-	-
	$LSD^{0.05}$	2.00	2.00	2.05	2.07
	P > F	< .0001	< .0001	<.0001	< .0001

Table 5.5. Days to first bloom and days to cracked boll from planting date for Rocky Mount and Clayton, NC in 2007

Planting Date	Row Spacing	RM	Clayton	RM	Clayton
		# Days to 1st Bloom		# Days to 1st Cracked Boll	
May 14, 2006	38 cm	54 f	53 g	92 h	94 f
	96 cm	53 g	55 e	94 g	95 e
May 28, 2006	38 cm	58 c	61 b	101 f	102 c
	96 cm	60 a	63 a	103 e	102 c
June 11, 2006	38 cm	55 e	56 d	105 d	101 d
	96 cm	57 d	57 c	105 d	101 d
June 21,2006	38 cm	59 b	61 b	106 c	110 b
	96 cm	59 b	61 b	106 c	110 b
July 2, 2006	38 cm	54 f	54 f	107 b	111 a
	96 cm	55 e	55 e	109 a	111 a
	$LSD^{0.05}$	1.00	1.00	1.00	1.00
	P > F	< .0001	< .0001	< .0001	< .0001

Table 5.6. Lint yield data for Rocky Mount and Clayton, NC in 2006.

Planting Date	Row Spacing	Rocky Mount	Clayton
		kg ha^{-1}	
May 11, 2006	38 cm	1132	985
	96 cm	761	897
May 24, 2006	38 cm	1198	737
	96 cm	1031	748
July 5, 2006	38 cm	-	-
	96 cm	-	-
July 12,2006	38 cm	-	-
	96 cm	-	-
	LSD$^{0.05}$	NS	NS
	P > F	.0932	.1176

Table 5.7. Lint yield data for Rocky Mount and Clayton, NC in 2007.

Planting Date	Row Spacing	Rocky Mount	Clayton
		kg ha^{-1}	
May 14, 2006	38 cm	1063 a	636 a
	96 cm	970 ab	646 a
May 28, 2006	38 cm	823 bc	480 abc
	96 cm	810 bc	325 bcde
June 11, 2006	38 cm	863 abc	348 bcd
	96 cm	680 c	255 cde
June 21,2006	38 cm	793 bc	556 ab
	96 cm	359 de	294 cde
July 2, 2006	38 cm	457 d	123 de
	96 cm	211 e	95 e
	$LSD^{0.05}$	217.13	247.33
	P > F	< .0001	.0002

Table 5.8. Micronaire data for Rocky Mount and Clayton, NC in 2006.

Planting Date	Row Spacing	Rocky Mount	Clayton
		Micronaire	
May 11, 2006	38 cm	4.2	4.1
	96 cm	4.2	4.0
May 24, 2006	38 cm	4.2	3.9
	96 cm	4.3	3.9
July 5, 2006	38 cm	-	-
	96 cm	-	-
July 12,2006	38 cm	-	-
	96 cm	-	-
	$LSD^{0.05}$	NS	NS
	P > F	.6759	.5583

Table 5.9. Micronaire data for Rocky Mount and Clayton, NC in 2007.

Planting Date	Row Spacing	Rocky Mount	Clayton
		Micronaire	
May 14, 2006	38 cm	5.0 a	4.8
	96 cm	4.9 abcd	4.7
May 28, 2006	38 cm	4.6 cde	4.3
	96 cm	4.6 de	4.3
June 11, 2006	38 cm	4.7 bcde	4.2
	96 cm	4.6 e	4.0
June 21,2006	38 cm	5.0 ab	4.2
	96 cm	4.9 abc	4.5
July 2, 2006	38 cm	5.0 a	4.4
	96 cm	5.0 a	4.5
	$LSD^{0.05}$	.3187	NS
	P > F	.0081	.1405

Table 5.10. Staple length (UHM) data for Rocky Mount and Clayton, NC in 2007.

Planting Date	Row Spacing	Rocky Mount	Clayton
		—— cm ——	
May 14, 2006	38 cm	2.59 e	2.46 c
	96 cm	2.69 d	2.49 c
May 28, 2006	38 cm	2.72 cd	2.62 b
	96 cm	2.72 cd	2.67 b
June 11, 2006	38 cm	2.74 bcd	2.62 b
	96 cm	2.77 bcd	2.59 bc
June 21,2006	38 cm	2.79 bc	2.85 a
	96 cm	2.92 a	2.82 a
July 2, 2006	38 cm	2.74 bcd	2.79 a
	96 cm	2.82 ab	2.87 a
	$LSD^{0.05}$	.0386	.0487
	P > F	<.0001	<.0001

Table 5.11. Fiber uniformity (UI) data for Rocky Mount and Clayton, NC in 2007.

Planting Date	Row Spacing	Rocky Mount	Clayton
		UI	
May 14, 2006	38 cm	81.2 c	80.6 cd
	96 cm	82.1 bc	80.2 d
May 28, 2006	38 cm	82.6 bc	81.0 cd
	96 cm	82.6 bc	81.5 cd
June 11, 2006	38 cm	82.4 bc	82.2 bc
	96 cm	82.2 bc	80.1 d
June 21,2006	38 cm	83.2 ab	83.9 ab
	96 cm	83.8 ab	83.8 ab
July 2, 2006	38 cm	82.9 abc	84.3 a
	96 cm	84.8 a	83.3 ab
	$LSD^{0.05}$	1.86	1.78
	P > F	.0406	<.0001

Table 5.12. Fiber strength (STR) data for Rocky Mount and Clayton, NC in 2007.

Planting Date	**Row Spacing**	**Rocky Mount**	**Clayton**
		kN m/kg	
May 14, 2006	**38 cm**	**269.7 c**	**270.7**
	96 cm	**291.3 b**	**279.5**
May 28, 2006	**38 cm**	**297.2 ab**	**298.1**
	96 cm	**303.0 ab**	**297.2**
June 11, 2006	**38 cm**	**295.2 b**	**295.2**
	96 cm	**288.3 bc**	**294.2**
June 21,2006	**38 cm**	**296.2 b**	**296.2**
	96 cm	**307.0 ab**	**291.3**
July 2, 2006	**38 cm**	**298.1 ab**	**309.9**
	96 cm	**316.8 a**	**291.3**
	$LSD^{0.05}$	**19.51**	**NS**
	P > F	**.0073**	**.0902**

Table 5.13. Net profit data for Rocky Mount and Clayton, NC in 2006.

Planting Date	Row Spacing	Rocky Mount	Clayton
		$ ha^{-1}	
May 11, 2006	38 cm	$552	$318
	96 cm	-$38	$179
May 24, 2006	38 cm	$656	-$77
	96 cm	$392	-$59
July 5, 2006	38 cm	$489	$368
	96 cm	$489	$368
July 12,2006	38 cm	$489	$368
	96 cm	$489	$368

Net profit for the first two planting dates was determined by cotton yield returns minus input costs. For the last two planting dates no cotton yield was determined so only the price of wheat yield returns minus wheat input costs is present. Wheat yield profit returns were based upon a price of $0.18/kg of wheat and an input cost of $193 ha^{-1}. Wheat yields for 2006 were 3114 kg ha^{-1} at Rocky Mount and 3786 kg ha^{-1} at Clayton.

Input cost per/hectare was based upon production costs from the 2008 Cotton Production guide for wide row equaling $1248 per hectare. Cotton price was based upon the average price of $1.59 per kilogram for lint yield in December, 2008.

Table 5.14. Net data for Rocky Mount and Clayton, NC in 2007.

Planting Date	Row Spacing	Rocky Mount	Clayton
		$ ha^{-1}	
May 14, 2006	38 cm	$442	-$237
	96 cm	$294	-$221
May 28, 2006	38 cm	$61	-$484
	96 cm	$40	-$731
June 11, 2006	38 cm	$124	-$694
	96 cm	-$167	-$842
June 21,2006	38 cm	$435	$182
	96 cm	-$255	-$235
July 2, 2006	38 cm	-$98	-$505
	96 cm	-$489	-$551

Net profit for the first three planting dates was determined by cotton yield returns alone minus cotton input costs.

For the last two planting dates net profit returns were determined by cotton yield returns + wheat yield returns – input cost for both wheat and cotton inputs. Wheat yield profit returns were based upon a price of $0.22/kg of wheat and an input cost of $193 dollars ha^{-1}. Wheat yields for 2007 were 2798 kg/ha^{-1} at Rocky Mount and 3363 kg/ha^{-1} at Clayton.

Input cost per/hectare was based upon production costs from the 2008 Cotton Production guide for wide row equaling $1248 per hectare. Cotton price was based upon the average price of $1.59 per kilogram for lint yield in December, 2008.