COTTON RESPONSE TO 1-METHYLCYCLOPROPENE UNDER DIFFERENT LIGHT REGIMES AND GROWTH STAGES: LINT YIELD AND YIELD COMPONENTS

A Thesis

by

CHARLES WARREN CARDEN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2010

Major Subject: Agronomy

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Approved by:

Chair of Committee,	J. Tom Cothren
Committee members,	Scott A. Senseman
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ABSTRACT

Cotton Response to 1-Methylcyclopropene Under Different Light Regimes and Growth Stages: Lint Yield and Yield Components. (August 2010)

Charles Warren Carden, B.S., Texas A&M University

Chair of Advisory Committee: Dr. J. Tom Cothren

Low photosynthetic photon flux density (PPFD) during certain growth periods of cotton (*Gossypium hirsutum L.*) has been shown to impact yield, ethylene synthesis, and fiber quality. Previous research with shading has shown that lint yield can be significantly reduced in the latter stages of growth. This two-year field study was conducted at the Texas A&M AgriLife Research Farm in Burleson County, Texas, in 2008 and 2009. The study evaluated the impact of an 8-day period of shade (63% reduction of PPFD) on cotton yield parameters, fiber quality, and the impact of 1-methylcyclopropene (1-MCP), an ethylene inhibitor, to alter detrimental cotton responses when applied as a foliar spray under shaded and non-shaded conditions. Shade and 1-MCP were imposed at four developmental stages of growth: pinhead square (PHS), first flower (FF), peak flower (PF), and boll development (BD). Data pooled over both years indicated that there were no significant differences in yield for 1-MCP treatments; however, numerical differences existed. Shade applied during the

BD stage of development showed significantly lower yield than the untreated control. These results showed a decline in seed cotton and ginned seed cotton by 522 and 207 kg ha^{-1}, respectively. To further analyze further yield components, box-mapping was conducted during both years. However, this data failed to explain consistent patterns of the observed yield responses. Data was also collected to determine the amount of fibers per seed and seed weights. Cotton fiber data did not show consistent correlations with the numerical increases and significant decreases in yield. Electrolyte leakage and stomatal conductance data also were collected. Electrolyte leakage showed no statistical differences when compared to the untreated control. Stomatal conductance measurements showed no consistency for treatments during both years.

DEDICATION

This thesis is dedicated to my brilliant and beautiful wife, Rebecca, without whom I would be nothing. She always comforts and consoles, never complains or interferes, asks nothing, and endures all.

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I would like to extend my gratitude to all those who made contributions toward this endeavor. Dr. Scott Senseman, and Dr. David Reed served on my graduate committee and are recognized for their advice and support on this project. AgroFresh is also acknowledged for providing funding for this study. I would like to thank Josh Bynum for his positive influence through friendship, knowledge, and wisdom. Appreciation is also extended to all of the members of the Cotton Physiology Workgroup at Texas A&M University for their incalculable hours spent maintaining, and collecting data from a most time consuming research study. I am also very grateful for advice and assistance from Dr. Eric Hequet. My special thanks is extended to my mentor Dr. Tom Cothren for providing purpose, direction, and words of wisdom.

TABLE OF CONTENTS

Page

ABSTRACT..... iii

DEDICATION..... v

ACKNOWLEDGEMENTS..... vi

TABLE OF CONTENTS..... vii

LIST OF TABLES..... ix

CHAPTER

I INTRODUCTION..... 1

II LITERATURE REVIEW..... 3

Ethylene..... 3
Ethylene Synthesis..... 3
Ethylene Perception and Signal Transduction..... 4
Ethylene and Abscission..... 5
Stress Induced Ethylene..... 6
Effects of Lower Light (Shade)..... 6
1-Methylcyclopropene..... 7
Effects of 1-Methylcyclopropene..... 7
Cotton Fiber Development and Quality..... 8
Objectives 9

III MATERIAL AND METHODS..... 11

IV RESULTS AND DISCUSSION..... 17

Plant Height and Total Nodes..... 17
Electrolyte Leakage..... 25
Stomatal Conductance..... 27
Yield and Fiber Quality..... 35

CHAPTER Page

Box-mapping....43
Fibers and Seed....66

V CONCLUSIONS....73

REFERENCES....76

APPENDIX A....84

APPENDIX B....86

VITA....128

LIST OF TABLES

TABLE		Page
1	List of treatments, rates, and growth stages of application for 2008 and 2009	12
2-a	Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during PHS, 2008	18
2-b	Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during FF, 2008	18
2-c	Effect of 1-methycyclopropene (1-MCP) and shade on plant height and total number of nodes during PF, 2008	19
2-d	Effect of 1-methycyclopropene (1-MCP) and shade on plant height and total number of nodes during BD, 2008	19
3-a	Effect of 1-methycyclopropene (1-MCP) and shade on plant height and total number of nodes during PHS, 2009	20
3-b	Effect of 1-methycyclopropene (1-MCP) and shade on plant height and total number of nodes during FF, 2009	20
3-c	Effect of 1-methycyclopropene (1-MCP) and shade on plant height and total number of nodes during PF, 2009	21
3-d	Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during BD, 2009	21
4-a	Effect of shade on plant heights, and total nodes prior to harvest, 2008	23
4-b	Effect of 1-methylcyclopropene (1-MCP) on plant heights, and total nodes prior to harvest, 2008	23

TABLE Page

4-c Effect of 1-methylcyclopropene (1-MCP) and shade on plant heights, and total nodes prior to harvest, 2008…….……..…..…....23

5-a Effect of shade on plant heights, and total nodes prior to harvest, 2009……....……..24

5-b Effect of 1-methylcyclopropene (1-MCP) on plant heights, and total nodes prior to harvest, 2009……...…...……..24

5-c Effect of 1-methylcyclopropene (1-MCP) and shade on plant heights, and total nodes prior to harvest, 2009……..…...24

6 Effect of 1-methycyclopropene (1-MCP) and shade on electrolytic leakage during boll development (BD), 2008 and 2009…….....…….26

7-a Effect of shade on electrolytic leakage prior to defoliation, 2008 and 2009……..……...28

7-b Effect of 1-methylcyclopropene (1-MCP) on electrolytic leakage at prior to defoliation, 2008 and 2009…….…..….28

7-c Effect of 1-methylcyclopropene (1-MCP) and shade on electrolytic leakage prior to defoliation, 2008 and 2009……..…..…28

8 Stomatal conductance taken during first flower (FF), 2008…….…...29

9 Stomatal conductance taken during first flower (FF), 2009…….....29

10 Stomatal conductance taken during peak flower (PF), 2008…….31

TABLE Page

11 Stomatal conductance taken during peak flower (PF), 2009……...31

12 Stomatal conductance taken during boll development (BD), 2008……..31

13 Stomatal conductance taken during boll development (BD), 2009…….....32

14-a Effect of shade on stomatal conductance prior to defoliation, 2008……..33

14-b Effect of 1-methylcyclopropene (1-MCP) on stomatal conductance prior to defoliation, 2008…….……..33

14-c Effect of 1-methylcyclopropene (1-MCP) and shade on stomatal conductance prior to defoliation, 2008…….……..33

15-a Effect of shade on stomatal conductance prior to defoliation, 2009……....……..34

15-b Effect of 1-methylcyclopropene (1-MCP) on stomatal conductance prior to defoliation, 2009……....……...34

15-c Effect of 1-methylcyclopropene (1-MCP) and shade on stomatal conductance prior to defoliation, 2009…….……..34

16-a Effect of shade on seed cotton yield, gin turnout, and lint yield, 2008……....……...36

16-b Effect of 1-methylcyclopropene (1-MCP) on seed cotton yield, gin turnout, and lint yield, 2008…….……36

TABLE Page

16-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed cotton yield, gin turnout, and lint yield, 2008……...36

17-a Effect of shade on seed cotton yield, gin turnout, and lint yield, 2009……...37

17-b Effect of 1-methylcyclopropene (1-MCP) on seed cotton yield, gin turnout, and lint yield, 2009…….…….37

17-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed cotton yield, gin turnout, and lint yield, 2009……...37

18-a Effect of shade on seed cotton yield, gin turnout, and lint yield, 2008 and 2009…….…….38

18-b Effect of 1-methylcyclopropene (1-MCP) on seed cotton yield, gin turnout, and lint yield, 2008 and 2009…….…38

18-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed cotton yield, gin turnout, and lint yield, 2008 and 2009……..38

19-a Effect of shade on lint quality parameters, 2008……...40

19-b Effect of 1-methylcyclopropene (1-MCP) on lint quality parameters, 2008…….……...40

19-c Effect of 1-methylcyclopropene (1-MCP) and shade on lint quality parameters, 2008……..40

20-a Effect of shade on lint quality parameters, 2009……...41

20-b Effect of 1-methylcyclopropene (1-MCP) on lint quality parameters, 2009……41

TABLE Page

20-c Effect of 1-methylcyclopropene (1-MCP) and shade on lint quality parameters, 2009……..41

21-a Effect of shade on lint quality parameters, 2008 and 2009……..42

21-b Effect of 1-methylcyclopropene (1-MCP) on lint quality parameters, 2008 and 2009…….……..42

21-c Effect of 1-methylcyclopropene (1-MCP) and shade on lint quality parameters, 2008 and 2009……..42

22-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2008…….……44

22-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2008…….44

22-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2008…….45

23-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2009…….……46

23-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2009…….46

23-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total weight per plant for sympodial branches 6 through 10 in first position, 2009…….47

TABLE Page

24-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2008……49

24-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2008……...49

24-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total weight per plant for sympodial branches 6 through 10 in second position, 2008……...50

25-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2009……...……..51

25-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2009……...51

25-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2009……...52

26-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in thrid position, 2008……53

26-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in thrid position, 2008……...53

TABLE Page

26-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2008……...54

27-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2009……...……..55

27-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in thrid position, 2009……...55

27-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2009……...56

28-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2008……..57

28-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2008…….57

28-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 first position, 2008……...58

29-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2009……...……..59

TABLE Page

29-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2009…….59

29-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 first position, 2009……...60

30-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2008…….62

30-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2008……...62

30-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 second position, 2008……..63

31-a Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2009…….64

31-b Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2009……...64

31-c Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 second position, 2009……..65

32-a Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2008……..67

TABLE Page

32-b Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2008……67

32-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2008…….……67

33-a Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2009…..……..69

33-b Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2009……69

33-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2009…….….69

34-a Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2008…….70

34-b Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2008……...70

34-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2008…….……...70

35-a Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2009…..…71

TABLE Page

35-b Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2009……..…..71

35-c Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2009……..……...71

CHAPTER I

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is subject to variable lint yield due to its high susceptibility to shed reproductive organs during the growing season (Guinn, 1982). Several factors can contribute to lower lint yield, such as extreme temperatures (Reddy et al., 1999; Zhao et al., 2005); moisture deficits (Pettigrew, 2004); poor fertility (Hake et al., 1989); drought stress (Guinn, 1982; Hake et al., 1992b; McMichael, 1979; McMichael and Jordan, 1973); and insect pressure (Holman and Oosterhuis, 1999). Previous studies have also shown that lower light conditions usually represented by cloud cover and extreme vegetative growth can reduce cotton lint yield (Baker, 1966; Eaton and Rigler, 1945; Goodman, 1955; Guinn, 1981; Zhao and Oosterhuis, 1998; Zhao and Oosterhuis, 2000). Zhao and Oosterhuis (2000) demonstrated that shade for 8-days (a 63% reduction in photosynthetic photon flux density) can decrease leaf weight, dry matter accumulation, lint yield, and fiber micronaire and strength during the latter stages of development. Light also directly affects the conversion of ACC into ethylene (Rikin et al., 1984) and is correlated with increased ethylene synthesis at lower light intensities (Vandenbussche et al., 2003). Recent studies

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This thesis follows the style of Crop Science.

have shown that 1-methylcyclopropene (1-MCP) is an effective ethylene inhibitor, and may have the potential to counter the effect of stresses that induce ethylene synthesis at lower light levels.

CHAPTER II

LITERATURE REVIEW

Ethylene

Ethylene is a hydrocarbon gas known as the fruit-ripening hormone (Theologis, 1992). Ethylene regulates a multitude of plant processes, ranging from seed germination to organ senescence (Bleeker and Kende, 2000). Its effects include inhibition of growth (Ecker, 1995), acceleration of respiration, modification of leaf and fruit pigments, abscission of leaves and fruits (Abeles and Rubinstein, 1964; Burg and Burg, 1966a; Burg and Burg, 1966b; Chadwick and Burg, 1967; De La Fuente and Leopold, 1968; Maxie and Crane, 1967), breakdown of proteins (Abeles et al., 1967; Leopold, 1967; Scott, 1967), acceleration of the rate of IAA inactivation (Shoji, 1950), and acceleration of pectin methyl esterase loss in the abscission zone (Osborne, 1955). Because boll retention is the primary factor in cotton yield (Hake et al., 1992a; Hake et al., 1992b; Wells and W.R. Meredith, 1983; Worley et al., 1974), it is important to protect a cotton crop from ethylene induced fruit shed.

Ethylene Synthesis

Ethylene is formed from methionine via S-adenosyl-L-methionine (AdoMet) and the cyclic non-protein amino acid 1-aminocyclopropane-1-carboxylic acid (ACC) (Adams and Yang, 1979). Two enzymes catalyze the conversion of AdoMet to ACC and of ACC to ethylene, ACC synthase and ACC

oxidase, respectively (Kende, 1993). ACC synthase also produces 5'-methylthioadenosine, which is utilized for the synthesis of new methionine via a modified methionine cycle (Miyazaki and Yang, 1987). This pathway preserves the methylthio group through every turn of the cycle at the cost of one ATP (adenosine triphosphate) molecule, and is therefore capable of producing high rates of ethylene even when free methionine is low in abundance (Bleeker and Kende, 2000). ACC synthase has previously been shown to require pyridoxal phosphate as a cofactor (Boller et al., 1979; Yu et al., 1979) and is thought to be encoded by medium-sized gene families that are differentially regulated by various developmental, environmental, and hormonal signals (Kende, 1993; Zarembinski and Theologis, 1994).

Ethylene Perception and Signal Transduction

The primary component in the ethylene signaling pathway is the CTR1 gene product (Kieber et al., 1993). CTR1 is a Raf-like signaling kinase that consists of an 821-amino acid protein and functions as a negative regulator (Kieber et al., 1993). When ethylene binds to a homologous two-component receptor/response regulator, a kinase cascade is produced through the CTR1 Raf-like kinase and other components to the nucleus (Johnson et al., 1998). It has been suggested that the CTR1 may be involved in modulating cellular responses to extracellular signals due to its similarity with Raf-1; however, data has not yet supported this hypothesis (Heidecker et al., 1992; Kieber et al., 1993).

Ethylene and Abscission

In the late 1800's, many varieties of plants were reported to be mysteriously defoliating in the vicinity of gas illuminated lamps (Fahnestock, 1858). Later, research found that these plants were being exposed to leaks of ethylene gas from the illuminating lamps on the streets (Doubt, 1917; Neljubow, 1901). Today, it is well known that ethylene is the gaseous plant hormone that signals abscission (Abeles, 1968; Abeles et al., 1992; Suttle and Hulstranstrand, 1991). Ethylene stimulates the production of hydrolytic enzymes in the abscission zone that initiate cell separation in the abscission layer (Abeles, 1968; Abeles, 1969; Horton and Osborne, 1967; Moore, 1968). Abscission zones can be defined during the early development of organ systems as a band of cells that fail to enlarge and vacuolate along with surrounding tissues (Bleeker and Patterson, 1997). The ability of the hormone to initiate abscission depends on the sensitivity of the separation layer cells to the gas (Abeles, 1968). Crocker and Zimmerman (1932), as well as Harvey (1913), found that exposure to 0.1 to 2 μg mL^{-1} ethylene produced epinasty without causing leaves to defoliate, but when applied with 2 to 10 μg mL^{-1} ethylene, the older leaves abscised. However, Morgan (1969) found that low concentrations of ethylene did not cause leaf abscission, but rather caused young flowers and fruit to abscise in cotton.

Stress Induced Ethylene

Ethylene can be elicited by almost all biotic and abiotic stress conditions (Bleeker and Kende, 2000). Pathogen (Hoffman et al., 1999), nutritional (Guinn, 1976), temperature (Cooper et al., 1969), water (Ben-Yehoshua and Aloni, 1974; El-Beltagy and Hall, 1974; McMichael et al., 1972; Wright, 1977), and light (Craker et al., 1973; Lin et al., 2008; Rikin et al., 1984; Vandenbussche et al., 2003) stresses can increase ethylene production. Apelbaum and Yang (1981) found that wheat (*Triticum aestivum* L. cv. Anza) subjected to water stress increased ethylene production more than 30-fold within four hours. It is also known that light directly affects the conversion of ACC into ethylene (Rikin et al., 1984). In cotton, research demonstrates increased ethylene evolution and young boll abscission during low light conditions (Guinn, 1975; Rikin et al., 1984; Vandenbussche et al., 2003).

Effects of Lower Light (Shade)

Previous studies have shown that lower PPFD (photosynthetic photon flux density) represented by cloud cover and extreme vegetative growth can reduce cotton lint yield and is a major limiting factor in cotton lint yield (Baker, 1966). Zhao and Oosterhuis (2000) demonstrated that shade at 63% reduction in PPFD for 8-days decreased leaf weight, dry matter accumulation, lint yield, and fiber micronaire and strength during the latter stages of development in cotton. Decreasing light intensity has also been shown to increase the shedding of

squares and bolls in cotton (Eaton and Ergle, 1954), and after a period of 3 days of shading (low PPFD), drastically reduced the number of mature cotton bolls by 75% (Dunlap, 1943).

1-Methylcyclopropene

1-methylcyclopropene (1-MCP) is an ethylene inhibitor (Blankenship and Dole, 2002; Sisler and Serek, 1997) that has proved to be widely successful in the horticulture industry. It is a stable, non-toxic gas (Binder and Bleeker, 2003) with a formula of C_4H_6, and is active at very low concentrations (Blankenship and Dole, 2002). It is thought that 1-MCP may interact with ethylene receptors when applied at very low concentrations (Blankenship and Dole, 2002) which would prevent ethylene-dependent responses (Sisler and Serek, 1997; Sisler et al., 1996). Recent studies have proposed various mechanisms for the action of 1-MCP. Binder and Bleeker (2003) suggested that 1-MCP may bind with the copper cofactor of the ethylene receptor, rendering action by only affecting a subset of the total receptor pool. Though an exact mode of action is not evident, 1-MCP has proven to be an effective ethylene inhibitor.

Effects of 1-Methylcyclopropene

In the horticulture industry, 1-MCP has shown to have an array of physiological effects, such as: decreased or inhibited ethylene production (Abdi et al., 1998; Jiang et al., 2001), postharvest quality of flowers (Serek et al., 1994), increased longevity of flowers (Serek et al., 1995), prevention of increased

mRNAs abundance with ripening (Nakatsuka et al., 1997), negated membrane electrolyte leakage (Mao et al., 2004), reduced rate of abscission (Michaeli et al., 1999), and extended periods of fruit firmness (Tatsuki and Endo, 2006). In agronomic crops, 1-MCP has also shown to have positive effects. Mishra et al. (2008b) demonstrated decreased break strength in the abscission zone of cotton (*Gossypium hirsutum* var RST-39) when pretreated with 1-MCP. Mishra et al. (2008a) also documented that 1-MCP treated cotton resulted in significant inhibition of enzyme activities and transcript accumulation associated with abscission layer formation. 1-MCP research has also displayed higher stomatal resistance in water-stressed cotton, suggesting protection against water loss from evapotranspiration during drought (Kawakami et al., 2010). Kawakami et al. (2010) found that cotton plants had a higher activity of antioxidant enzymes and better maintenance of membrane integrity after application.

Cotton Fiber Development and Quality

Cotton yield is dependent on factors such as boll size, number of bolls, amount of seeds per boll, the amount of fibers per seed and seed size. Cotton fibers are derived from the outer ovule epidermal cells and when mature, can be over 25 mm long and 20 μm in diameter. The primary cell walls of fibers elongate for approximately 15 to 27 days post anthesis (DPA) (Benedict, 1984), and secondary cell walls elongate overlapping primary cell wall formation at about 17 to 53 dpa (Schubert et al., 1973). Differences in fiber quality are

dependent on fiber elongation rate and period (Ruan et al., 2001), and time of onset of secondary wall thickening (Schubert, 1975). Fiber formation is dependent on species, cultivar, and environmental conditions (Benedict et al., 1999). Limiting environmental factors during fiber development can affect fiber cell wall thickness. Fiber cell wall thickness is correlated with fiber maturity, an important parameter of fiber quality. The quality of fibers can be determined by HVI (High Volume Instrument) and AFIS (Advanced Fiber Information System) test instruments (Hequet et al., 2006).

Objectives

Previous studies have shown that lower PPFD reduces cotton lint yield, boll size, and fiber quality (Baker, 1966; Zhao and Oosterhuis, 2000). A reduction in PPFD by 63% for a period of 8-days proved to reduce lint yield by up to 52% during the latter stages of development (Zhao and Oosterhuis, 2000). Furthermore, lower light has shown to increase ethylene synthesis (Vandenbussche et al., 2003). Recent studies have shown that 1-MCP is an effective ethylene inhibitor, and may have the potential to counter the effect of stresses that induce ethylene synthesis at lower light levels. The purpose of this study was to evaluate methods to alleviate induced ethylene stress during cotton growth. The objectives of this study were to specifically evaluate: the impact of 8 days of shading (63% reduction in PPFD) on cotton yield during four developmental growth stages, and the impact of 1-MCP applied as a foliar spray

(AF-600) at the rate of 25 g ha^{-1} under shaded and non-shaded conditions at the same four developmental growth stages.

CHAPTER III

MATERIALS AND METHODS

In 2008 and 2009, a two-year field study was conducted at the Texas A&M AgriLife Research Farm in Burleson County, Texas. Field plots were located in the Brazos River Bottom on a Weswood silt loam (fine-silty, mixed superactive, thermic, Udifluventic Haplustepts), having a pH of 8.2.

Prior to planting, urea ammonium nitrate (32-0-0) was applied by injection at the rate of 135 kg ha^{-1}. Stoneville 4554 B2RF was planted both years at the rate of 129,727 seeds ha^{-1} with a John Deere 1700 four-row MaxEmerge vacuum planter. Plots were irrigated by row-water as needed. Herbicide and pesticide applications were compliant with Texas Cooperative Extension recommendations for Burleson County.

The study was conducted as a randomized complete block design with thirteen treatments replicated four times (Table 1). Plots consisted of six 1-m rows that were 9.8-m in length that were hand thinned to a uniform population of 13 plants m^{-1}. 1-MCP was applied at the specified rate of 25 g ha^{-1} using a compressed air small plot sprayer equipped with Tee Jet® (Spraying Systems Inc.) AI 11002 VS air-induction flat spray tips. Application of 1-MCP was applied during four developmental growth stages: PHS (pinhead-square), FF

Table 1. List of treatments, rates, and growth stage of application for 2008 and 2009.

Treatment†	Rate‡	Time€	Growth Stage¥	Abbreviation¶
Shade	N/A	8d	PHS	SPHS
Shade	N/A	8d	FF	SFF
Shade	N/A	8d	PF	SPF
Shade	N/A	8d	BD	SBD
1-MCP	25 g ha^{-1}	N/A	PHS	MPHS
1-MCP	25 g ha^{-1}	N/A	FF	MFF
1-MCP	25 g ha^{-1}	N/A	PF	MPF
1-MCP	25 g ha^{-1}	N/A	BD	MBD
1-MCP & Shade	25 g ha^{-1}	8d	PHS	SMPHS
1-MCP & Shade	25 g ha^{-1}	8d	FF	SMFF
1-MCP & Shade	25 g ha^{-1}	8d	PF	SMPF
1-MCP & Shade	25 g ha^{-1}	8d	BD	SMBD
UTC	N/A	N/A	N/A	UTC

† Chemical and/or Shade treatment: Shade, 8 days at 63% reduction in light; 1-MCP, 1-methylcyclopropene; UTC, untreated control

‡ Chemical rate: N/A, none.

€ Time of Shading: N/A none.

¥ Developmental growth stage: PHS, pinhead-square; FF, first flower; PF, peak flower; BD, boll development.

¶ Abbreviations to be referred to in graphic figures at the results section.

(first flower), PF (peak flower), and BD (boll development). The PHS treatments were established when 60% of the plants were in pinhead square. FF was defined as the time when 60% of the plants had the first white flower. PF and BD stages were at 12 and 24 days after first flower, respectively. Light was decreased with a syntheticshade cloth (Harps Tarps; Tucker, GA) one day following the application of 1-MCP and continued for a period of eight days covering an area of 5 m^2 $plot^{-1}$. Light intensity under the shaded area (63% reduction in light) was confirmed with a Li-250 light meter (Li-Cor Inc. St. Lincoln, NE). Each shade cloth area was marked with flags for identification of the exact area that was shaded.

Data collected for the study consisted of plant height, total node count, stomatal conductance and resistance readings, leaf membrane electrolyte leakage, box-mapping, lint yield, fiber quality, and number of fibers per seed.

Plant height and total number of node measurements were taken during each developmental growth stage and prior to harvest. Ten randomly selected cotton plants were chosen from the fifth row in each plot on the day of each application of 1-MCP, and at 7 and 14 days after 1-MCP application for the measurement. Plant height was measured from the cotyledonary node to the terminal bud or apex. Plant nodes were counted beginning at the first node above the cotyledonary nodes to the upper most fully expanded leaf (true leaf) having a diameter of at least 2.5 cm. Stomatal conductance and resistance

readings were taken from all plots at three or five days after application of 1-MCP during the FF, PF, and BD developmental growth stages from two randomly selected plants out of the fifth row of each plot. Stomatal conductance and resistance readings were taken using a SC-1 steady state diffusion leaf porometer (Decagon Devices, Inc., Pullman, WA). The leaf porometer is a device used to measure the function of the density, size, and degree of opening of stomata, reported in mmol m^{-2} s^{-1} conductance.

Just prior to harvest, a variation of box-mapping described by Jenkins and McCarty (1995) was conducted for the study during 2008 and 2009. Box-mapping consisted of the collection of final plant heights and nodes, total number of green and open bolls, and weights of open boll lint that were obtained from ten randomly selected plants from the second row of each plot.

During the BD growth stage and prior to defoliation for both years, leaf membrane electrolyte leakage data was taken from each plot. Five leaves from five randomly selected plants in each plot were collected from the third leaf down from the apical bud or apex, then immediately transported to the laboratory for analysis. Leaves were rinsed with deionized water. Five leaf disks (2 cm^2 in diameter) were then taken from the leaves, and placed in 10 ml of de-ionized water and incubated at 25^{o} C (room temperature) for 1 hour. After incubation, electrical conductivity of the solution was measured using a conductivity meter (Oakton Instruments, Vernon Hills, Illinois, USA). The

samples were then incubated again for 24 hours at 25° C in the same 10 mL of deionized water. After 24 hours samples were placed in a constant temperature bath (Magni Whirl®) for one hour at 95° C. After another 24 hours, conductivity of the leaf disk solution was measured again at 25° C. Electrolyte leakage was determined as the percent of total electrolytes following incubation at 1 hour 25°C.

Harvest aids (Appendix A) were applied during 2008 and 2009 when the plants were at 60% open boll. Plots were trimmed to the areas that were shaded (5 m^2), then the third and fourth rows were harvested mechanically by a John Deere two-row plot spindle picker. Cotton lint yield from each row was weighed and averaged over the two rows for determination of seed cotton yield. A 150-g sub-sample was taken from each plot and ginned using a ten-saw, hand fed, portable gin to determine ginout percentage. A 50-g sample of ginned lint from each plot was then sent to the International Textile Center in Lubbock, for HVI (High Volume Instrument) analysis.

Seed cotton from bolls collected during box mapping was weighed and recorded. A 25-g sample of seed cotton was ginned using a single boll roller gin. Ginned lint was then weighed and sent to the International Textile Center in Lubbock, Texas for AFIS (Advanced Fiber Instrument System) analysis. Seeds collected from the 25 g sample were acid delinted, weighed, and counted. Scanning of mean seed surface area was done by a WinSEEDLE™ seed image

analysis system (Courtesy of Dr. Eric Hequet, Lubbock, TX). The amount of fibers seed^{-1} was calculated by using the mean fiber length by number [L(n) km^{-1}] and linear density (mTex) of the lint samples analyzed by the AFIS. Mean surface area of seeds from the WinSEEDLE™ scanning was used to determine the amount of fibers seed^{-1} mm^{-2}.

All data collected were analyzed using SAS 9.2 statistical software (SAS Institute Inc., Cary, NC). Data for 2008 and 2009 were combined over years in the absence of year x treatment interaction. Pairwise comparisons of the means for data taken during individual growth stages (e.g. PHS, FF, PF, and BD) were analyzed using the Proc General Linear Model (GLM), and separated using Fisher's Protected Least Significant Difference (LSD) at the 5% significance level. LSMEANS contrast was used for pairwise comparisons of means for data collected at the end of both seasons from all thirteen treatments.

CHAPTER IV

RESULTS AND DISCUSSION

Plant Height and Total Nodes

Plant height and number of nodes were measured throughout the growing season during each developmental growth stage (Tables 2-a– 2-d and 3-a–3-d). Plant height and node measurements were taken three times for each growth stage, starting at the time of application of 1-MCP (0 DAT), seven days after application (7 DAT), and fourteen days after application (14 DAT). Plant height and node measurements at 0 DAT were taken as an initial measurement to insure uniformity across the study. Final plant height and total node measurements were taken during end-of-season box-mapping. Due to variation between years, an interaction of year x treatment was observed. Results are therefore reported on a by year basis.

In 2008 and 2009, PHS, FF, PF, and BD treatments at 0 DAT showed no significant differences in plant height and total nodes (Tables 2-a– 2-d and 3-a–3-d). These measurements insured uniformity of initial plant measurements. In 2008, treatments SPHS, MPHS, SMPHS at 7 DAT showed significantly greater plant heights and total nodes than the UTC (Table 2-a). For the same treatments and timings, in 2009, plant data showed no significant differences; however, the

Table 2-a. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during PHS, 2008.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SPHS	18.8a‡	7.4a	27.7a	9.3b	34.0a	11.6a
MPHS	20.7a	7.9a	29.4a	10.3a	35.7a	12.0a
SMPHS	20.1a	7.8a	28.6a	9.5b	35.8a	11.7a
UTC	18.6a	7.1a	21.5b	8.5c	30.2a	11.5a
Pr > F§	*0.0528*	*0.0150*	*0.0085*	*0.0031*	*0.0978*	*0.1656*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 2-b. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during FF, 2008.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SFF	44.6a‡	12.7a	56.5a	14.5a	62.7a	16.1a
MFF	45.3a	13.6a	54.4a	15.3a	62.7a	16.1a
SMFF	44.5a	12.8a	59.0a	15.3a	67.8a	16.5a
UTC	42.8a	13.0a	52.4a	14.7a	61.3a	16.1a
Pr >F§	*0.6183*	*0.3701*	*0.4230*	*0.3714*	*0.5958*	*0.5827*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; FF, treatment initiated at first flower; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 2-c. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during PF, 2008.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SPF	64.0a‡	16.0a	65.8a	16.8a	67.5a	17.4a
MPF	62.6a	15.8a	63.7a	16.7a	65.1a	16.9a
SMPF	59.9a	15.9a	62.9a	16.7a	63.5a	16.8a
UTC	61.3a	15.7a	61.8a	16.2a	65.4a	16.7a
Pr >F§	*0.0082*	*0.1683*	*0.0014*	*0.5180*	*0.0034*	*0.0220*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PF, treatment initiated at peak flower; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 2-d. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during BD, 2008.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SBD	59.4a‡	15.4a	57.1a	16.7a	58.8a	17.3a
MBD	66.9a	16.7a	62.4a	16.6a	65.6a	17.3a
SMBD	63.4a	16.6a	62.0a	16.5a	63.9a	17.8a
UTC	65.5a	16.7a	62.1a	16.9a	64.8a	17.9a
Pr >F§	*0.3287*	*0.4423*	*0.4920*	*0.9455*	*0.3806*	*0.7489*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 3-a. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during PHS, 2009.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SPHS	15.2a‡	6.9a	33.4a	7.6a	43.1a	9.3a
MPHS	14.8a	6.8a	31.0a	7.3a	40.7a	9.2a
SMPHS	15.6a	6.7a	34.9a	7.5a	42.5a	9.2a
UTC	16.2a	6.8a	30.1a	7.2a	39.5a	9.1a
Pr >F§	*0.6318*	*0.7089*	*0.3200*	*0.3580*	*0.6303*	*0.8556*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 3-b. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during FF, 2009.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SFF	52.7a‡	10.9a	53.5a	11.4a	57.0a	12.5a
MFF	50.5a	11.0a	58.0a	11.0a	57.4a	12.4a
SMFF	50.0a	10.8a	51.7a	11.2a	57.0a	12.5a
UTC	48.7a	11.0a	51.3a	11.3a	56.6a	12.3a
Pr >F§	*0.7820*	*0.9778*	*0.3750*	*0.7788*	*0.9915*	*0.9145*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; FF, treatment initiated at first flower; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 3-c. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during PF, 2009.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SPF	55.7a‡	12.5a	57.9a	16.0a	60.6a	17.0a
MPF	52.9a	11.9a	57.9a	15.9a	60.6a	17.7a
SMPF	53.1a	12.1a	58.5a	16.0a	61.1a	17.3a
UTC	54.6a	12.3a	59.9a	16.0a	61.3a	17.4a
Pr >F§	*0.0798*	*0.1281*	*0.0075*	*0.1555*	*0.0003*	*0.0007*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PF, treatment initiated at peak flower; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

Table 3-d. Effect of 1-methylcyclopropene (1-MCP) and shade on plant height and total number of nodes during BD, 2009.

	0 DAT		7 DAT		14 DAT	
	Plant height	Total nodes	Plant height	Total nodes	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—	—cm—	—nodes plant^{-1}—
SBD	62.4a‡	17.3a	58.6a	16.3b	60.7b	17.9a
MBD	64.2a	17.7a	65.0a	18.2a	65.7a	18.7a
SMBD	64.8a	17.3a	62.6a	17.1a	64.6ab	17.7a
UTC	63.3a	17.3a	61.7a	17.4ab	63.3ab	19.9a
Pr >F§	*0.0667*	*0.2305*	*0.2305*	*0.0033*	*0.0139*	*0.1980*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.

§ Probability of the ANOVA.

shaded treatments were still numerically higher in height and total nodes than the UTC (Table 3-a). At 14 DAT in 2008 no statistical differences were observed among treatments, but higher numerical values still existed for plant heights and total nodes when compared to the UTC (Table 2-a). In 2009, 14 DAT measurements showed no significant differences in plant height and nodes; however, slightly higher numerical values still existed for the same treatments when compared to the UTC (Table 3-a).

For measurements taken during all other growth stages, data failed to show significant differences in heights and nodes at 0 DAT, 7 DAT, and 14 DAT for all treatments when compared to the UTC (Tables 2-a– 2-d and 3-a–3-d). The results indicate that heights and nodes of shaded, and 1-MCP-treated plants were higher than the UTC during the early growth season.

Final plant heights were taken during end-of-season box-mapping (Tables 4-a–4-c and 5-a–5-c). Plant heights in 2008 and 2009, ranged from 66 to 79.8cm and 56.9 to 64.9cm, respectively. Total nodes measured from 20.5 to 22.2 and 20.4 to 22.4, respectively, in 2008 and 2009. For 2008 and 2009, plant heights and total nodes were not significantly different than the UTC across all treatments.

Table 4-a. Effect of shade on plant heights, and total nodes prior to harvest, 2008.

	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—
SPHS	79.8a‡	22.2a
SFF	72.3a	20.5b
SPF	76.6a	21.3ab
SBD	78.6a	21.5ab
UTC	73.3a	21.4ab

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 4-b. Effect of 1-methylcyclopropene (1-MCP) on plant heights, and total nodes prior to harvest, 2008.

	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—
MPHS	71.3a‡	20.8a
MFF	74.5a	21.0a
MPF	74.6a	21.1a
MBD	76.5a	21.2a
UTC	73.3a	21.4a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 4-c. Effect of 1-methylcyclopropene (1-MCP) and shade on plant heights, and total nodes prior to harvest, 2008.

	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—
SMPHS	76.7a§	22.2a
SPHS	79.8a	22.2a
SMFF	70.2a	20.5a
SFF	72.3a	20.5a
SMPF	66.0a	21.3a
SPF	76.6a	21.3a
SMBD	78.8a	21.5a
SBD	78.6a	21.5a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 5-a. Effect of shade on plant heights, and total nodes prior to harvest, 2009.

	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—
SPHS	58.5a‡	20.9ab
SFF	64.5a	20.6b
SPF	62.6a	21.8ab
SBD	61.3a	22.2a
UTC	60.0a	21.2ab

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 5-b. Effect of 1-methylcyclopropene (1-MCP) on plant heights, and total nodes prior to harvest, 2009.

	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—
MPHS	61.3a‡	21.2ab
MFF	61.9a	21.6ab
MPF	56.9a	20.4b
MBD	63.4a	22.4a
UTC	60.0a	21.2ab

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 5-c. Effect of 1-methylcyclopropene (1-MCP) and shade on plant heights, and total nodes prior to harvest, 2009.

	Plant height	Total nodes
Treatment†	—cm—	—nodes plant^{-1}—
SMPHS	64.9a§	22.3a
SPHS	58.5a	20.9a
SMFF	61.7a	20.8a
SFF	64.52a	20.6a
SMPF	61.2a	22.0a
SPF	62.6a	21.8a
SMBD	62.0a	21.3a
SBD	61.3a	22.2a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Electrolyte Leakage

Research indicates that increased rates of ethylene can stimulate higher membrane electrolyte leakage (Guthrie and Cothren, 1989). On the other hand, 1-MCP can inhibit ethylene, suggesting an ability to maintain the integrity of membranes. In 2008 and 2009, a variation of the technique described by Wang, et al. (2009) was used to determine treatment effects on electrolyte leakage. Samples were taken at two timings; during the BD growth stage and a few days prior to defoliation. The results for these measurements are expressed as the percent of total electrolytes leaked into the solution after 1-hour incubation at 25^{o} C. Due to variability over years, a significant treatment x year interaction existed; therefore, results are reported by year.

In 2008 and 2009, percent total electrolytes leaked ranged from 6.8 to 7.8%, and 9.8 to 10.9%, respectively. For both years, percent total electrolytes leaked into the solution after 1-hour showed no significant differences among treatments when compared to the UTC for all treatments sampled during the boll development (BD) stage (Table 6). Percent total electrolytes leaked for measurements taken prior to defoliation ranged from 9.1 to 16.9%, and 8.3 to 10.5%, respectively, for 2008 and 2009. For both years of the study, all

Table 6. Effect of 1-methycyclopropene (1-MCP) and shade on electrolytic leakage during boll development (BD), 2008 and 2009.

	2008 percent total electrolytes†	2009 percent total electrolytes‡
Treatment§	—%—	—%—
SBD	7.8a¶	10.2a
MBD	7.6a	10.9a
SMBD	6.8a	10.5a
UTC	7.1a	9.8a
Pr >F#	*0.5750*	*0.5144*

† Percent total electrolytes leaked after 1 hour at 25°C during 2008.
‡ Percent total electrolytes leaked after 1 hour at 25°C during 2009.
§ Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; BD, treatment initiated at boll development; UTC, untreated control.
¶ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
# Probability of the ANOVA.

treatments failed to show significant differences when compared to their respective controls (Tables 7-a–7-c).

Stomatal Conductance

Previous research has shown that 1-MCP treated cotton can display a higher stomatal resistance under stress (Kawakami et al., 2010). Inversely, a lower stomatal conductance would suggest a protection against water loss from evapotranspiration. For this study, adaxial and abaxial stomatal conductance was measured for treatments during the FF, PF, and BD developmental stages. A final measurement was taken from all treatments prior to defoliation. Due to a significant treatment x year interaction, results are reported by year.

Adaxial and abaxial measurements taken during the FF stage in 2008 ranged from 719 to 1038 mmol m^{-2} s^{-2} and 483 to 851 mmol m^{-2} s^{-2}, respectively, and were not significantly different (Table 8). Results for 2009 for the FF stage ranged from 106 to 177 mmol m^{-2} s^{-2} and 48 to 105 mmol m^{-2} s^{-2}, respectively, for adaxial and abaxial leaves. These conductance measurements also failed to show any significant differences (Table 9). Adaxial measurements taken during the PF growth stage ranged from 485 to 661 and 268 to 362 mmol m^{-2} s^{-2}, respectively, in 2008 and 2009. Abaxial measurements ranged from 462 to 627 and 263 to 357 mmol m^{-2} s^{-2} in 2008 and 2009, respectively. Measurements for

Table 7-a. Effect of shade on electrolytic leakage prior to defoliation, 2008 and 2009.

	2008 percent total electrolytes†	2009 percent total electrolytes‡
Treatment§	—%—	—%—
SPHS	13.6a¶	10.3a
SFF	13.9a	10.4a
SPF	11.0a	10.0a
SBD	15.8a	10.0a
UTC	12.0a	10.5a

† Percent total electrolytes leaked after 1 hour at 25°C during 2008.
‡ Percent total electrolytes leaked after 1 hour at 25°C during 2009
§ Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
¶ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 7-b. Effect of 1-methylcyclopropene (1-MCP) on electrolytic leakage at prior to defoliation, 2008 and 2009.

	2008 percent total electrolytes†	2009 percent total electrolytes‡
Treatment§	—%—	—%—
MPHS	10.1a¶	10.2a
MFF	12.0a	10.1a
MPF	9.1a	10.2a
MBD	11.4a	9.6a
UTC	12.0a	10.5a

† Percent total electrolytes leaked after 1 hour at 25°C during 2008
‡ Percent total electrolytes leaked after 1 hour at 25°C during 2009
§ Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
¶ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 7-c. Effect of 1-methylcyclopropene (1-MCP) and shade on electrolytic leakage prior to defoliation, 2008 and 2009.

	2008 percent total electrolytes†	2009 percent total electrolytes‡
Treatment§	—%—	—%—
SMPHS	12.0a¶	10.2a
SPHS	13.6a	10.3a
SMFF	10.3a	9.9a
SFF	13.9a	10.4a
SMPF	10.0a	8.3a
SPF	11.0a	10.0a
SMBD	16.9a	10.1a
SBD	15.8a	10.0a

† Percent total electrolytes leaked after 1 hour at 25°C during 2008
‡ Percent total electrolytes leaked after 1 hour at 25°C during 2009
§ Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
¶ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 8. Stomatal conductance taken during first flower (FF), 2008.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² ·s)—	—mmol/(m² ·s)—	—°C—	—°C—
SFF	719a‡	483a	35a	35a
MFF	1038a	851a	35a	35a
SMFF	723a	591a	35a	35a
UTC	922a	508a	36a	36a
Pr > F§	*0.1599*	*0.1206*	*0.0066*	*0.0113*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; FF, treatment initiated at first flower; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.
§ Probability of the ANOVA.

Table 9. Stomatal conductance taken during first flower (FF), 2009.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² ·s)—	—mmol/(m² ·s)—	—°C—	—°C—
SFF	151a‡	105a	38a	38a
MFF	113a	48a	41a	41a
SMFF	177a	62a	41a	41a
UTC	106a	67a	41a	41a
Pr > F§	*0.2968*	*0.1654*	*0.0034*	*0.0051*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; FF, treatment initiated at first flower; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.
§ Probability of the ANOVA.

treatments taken during the PF growth stage were not significantly different for both years (Tables 10 and 11). The BD growth stage treatments in 2008 ranged from 354 to 455 and 393 to 484 mmol m^{-2} s^{-2} for adaxial and abaxial measurements, respectively. In 2009, during the BD stage of development, measurements ranged from 66 to 149 mmol m^{-2} s^{-2} and 127 to 156 mmol m^{-2} s^{-2}, respectively, for adaxial and abaxial leaves. The treatments for both separate years in the BD growth stage were not significantly different from the UTC (Tables 12 and 13).

Final measurements were also taken during 2008 and 2009 at the end of the season (Tables 14-a-14-c and 15-a-15-c). Final measurements in 2008, showed a numerically higher conductance for the SBD and SPHS treatments when compared to the UTC (Table 14-a) for the adaxial leaves, but were not significantly different. In 2009, adaxial leaf results showed the inverse of the SBD treatment in 2008, however, the SPHS treatment was consistent numerically with 2008 results. Results from 2009 adaxial leaves also indicated a statistically higher conductance measurement for the SPF treatment when compared to the UTC. Abaxial leaves in 2009 also showed a much higher value of conductance for the SPF treatment aswell as the SPHS treatment that resulted in being significantly different than the UTC (Table 15-a). The abaxial results in 2009 for shaded treatments were not the same as statistical or numerical differences in

Table 10. Stomatal conductance taken during peak flower (PF), 2008.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² ·s)—	—mmol/(m² ·s)—	—ºC—	—ºC—
SPF	595a‡	462a	31a	31a
MPF	485a	553a	30a	31a
SMPF	508a	496a	31a	31a
UTC	661a	627a	31a	31a
Pr > F§	*0.1011*	*0.7312*	*0.0006*	*0.0007*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PF, treatment initiated at peak flower; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.
§ Probability of the ANOVA.

Table 11. Stomatal conductance taken during peak flower (PF), 2009.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² ·s)—	—mmol/(m² ·s)—	—ºC—	—ºC—
SPF	268a‡	357a	37a	37a
MPF	293a	327a	38a	38a
SMPF	362a	263a	37a	37a
UTC	340a	282a	37a	37a
Pr > F§	*0.6810*	*0.3740*	*0.0108*	*0.0576*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PF, treatment initiated at peak flower, UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.
§ Probability of the ANOVA.

Table 12. Stomatal conductance taken during boll development (BD), 2008.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² ·s)—	—mmol/(m² ·s)—	—ºC—	—ºC—
SBD	409a‡	473a	34a	34a
SMBD	407a	466a	34a	34a
MBD	354a	393a	35a	35a
UTC	455a	484a	35a	35a
Pr > F§	*0.6466*	*0.8042*	*0.0030*	*0.0017*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; BD, treatment initiated at boll development, UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.
§ Probability of the ANOVA.

Table 13. Stomatal conductance taken during boll development (BD), 2009.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² ·s)—	—mmol/(m² ·s)—	—°C—	—°C—
SBD	145a‡	156a	28a	28a
SMBD	66a	151a	27a	27a
MBD	149a	127a	28a	28a
UTC	136a	151a	28a	28a
Pr > F§	*0.0508*	*0.7213*	*0.1564*	*0.2173*

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fisher's protected LSD.
§ Probability of the ANOVA.

Table 14-a. Effect of shade on stomatal conductance prior to defoliation, 2008.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² s)—	—mmol/(m² s)—	—°C—	—°C—
SPHS	592a‡	383a	32a	31a
SFF	366b	295a	31a	31a
SPF	370b	316a	32a	32a
SBD	528a	323a	31a	31a
UTC	509ab	332a	32a	32a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 14-b. Effect of 1-methylcyclopropene (1-MCP) on stomatal conductance prior to defoliation, 2008.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² s)—	—mmol/(m² s)—	—°C—	—°C—
MPHS	423a‡	338a	32a	32a
MFF	504a	380a	32a	32a
MPF	442a	291a	32a	32a
MBD	377a	305a	32a	32a
UTC	509a	332a	32a	32a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 14-c. Effect of 1-methylcyclopropene (1-MCP) and shade on stomatal conductance prior to defoliation, 2008.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² s)—	—mmol/(m² s)—	—°C—	—°C—
SMPHS	593a§	368a	32a	32a
SPHS	592a	383a	32a	31a
SMFF	269a	216a	32a	32a
SFF	366a	295a	31a	31a
SMPF	420a	302a	32a	32a
SPF	370a	316a	32a	32a
SMBD	558a	237a	31a	31a
SBD	528a	323a	31a	31a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 15-a. Effect of shade on stomatal conductance prior to defoliation, 2009.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² s)—	—mmol/(m² s)—	—°C—	—°C—
SPHS	77.27b‡	109.83a	39.0a	39.0a
SFF	77.43b	56.10b	38.6a	38.7a
SPF	155.87a	116.03a	39.3a	39.3a
SBD	38.87b	39.17b	39.3a	39.4a
UTC	49.70b	58.30b	39.7a	39.4a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 15-b. Effect of 1-methylcyclopropene (1-MCP) on stomatal conductance prior to defoliation, 2009.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² s)—	—mmol/(m² s)—	—°C—	—°C—
MPHS	83.67bc‡	79.33a	39.2a	39.3a
MFF	74.63c	58.40a	39.4a	39.4a
MPF	137.43a	80.57a	39.5a	39.5a
MBD	133.07ab	69.27a	38.8a	38.9a
UTC	49.70c	58.30a	39.7a	39.4a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 15-c. Effect of 1-methylcyclopropene (1-MCP) and shade on stomatal conductance prior to defoliation, 2009.

	Adaxial	Abaxial	Adaxial Temperature	Abaxial Temperature
Treatment†	—mmol/(m² s)—	—mmol/(m² s)—	—°C—	—°C—
SMPHS	45.00a§	91.50a	38.8a	38.9a
SPHS	77.27a	109.83a	39.0a	39.0a
SMFF	84.38a	57.67a	39.4a	39.6a
SFF	77.43a	56.10a	38.6a	38.7a
SMPF	123.90a	140.07a	39.4a	39.3a
SPF	155.87a	116.03a	39.3a	39.3a
SMBD	100.50a	46.03a	38.3a	38.5a
SBD	38.87b	39.17a	39.3a	39.4a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

2008. When looking at 1-MCP treated cotton, adaxial leaves or the MPF and MBD treatments were significantly higher than the UTC (15-b) in 2009. For adaxial leaves in 2008, the MPF and MBD treatments were numerically lower than the UTC and failed to show statistical differences (Table 14-b).

Yield and Fiber Quality

Though yield, percent gin turnout, and fiber quality parameters displayed different results for 2008 and 2009 (Tables 16-a–16-c and 17-a–17-c), no year x treatment interaction existed for seed cotton yield, lint yield, percent gin turnout, and fiber quality parameters.

The SBD treatment was significantly lower in seed cotton and lint yield than the UTC (Table 18-a). Seed cotton and lint yield for the SBD treatment was 522 and 207 kg ha^{-1} less than the UTC, respectively. Seed cotton and lint yield for all treatments ranged from 1746 to 2451, and 752 to 1076 kg ha^{-1}, respectively. 1-MCP treatments alone showed no statistical differences when compared to the UTC (Table 18-b). Additionally, for all shaded treatments, seed cotton and lint yield were numerically lower than the UTC. When considering the shaded 1-MCP treatments, although not significantly different, all 1-MCP treatments, except for one, were higher than their shaded UTC. The exception was for the SMPF and SPF treatments which ranged from 1807 to 2026 kg ha^{-1}, respectively for seedcotton, and 765 to 862 kg ha^{-1}, respectively, for lint (Table 18-c). The

Table 16-a. Effect of shade on seed cotton yield, gin turnout, and lint yield, 2008.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
SPHS	2100ab‡	40.75a	873b
SFF	2288ab	42.00a	954ab
SPF	2600a	42.00a	1089a
SBD	1856b	43.75a	815b
UTC	2378b	42.25a	996ab

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 16-b. Effect of 1-methylcyclopropene (1-MCP) on seed cotton yield, gin turnout, and lint yield, 2008.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
MPHS	2322a‡	43.25a	1003a
MFF	2500a	45.00a	1123a
MPF	2278a	45.25a	1031a
MBD	2623a	45.25a	1193a
UTC	2378a	42.25a	996a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 16-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed cotton yield, gin turnout, and lint yield, 2008.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
SMPHS	2100a§	43.50a	920a
SPHS	2100a	40.75a	873a
SMFF	2389a	42.50a	1016a
SFF	2288a	42.00a	954a
SMPF	2378a	41.50a	987a
SPF	2600a	42.00a	1089a
SMBD	1889a	46.50a	873a
SBD	1856a	43.75a	815a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 17-a. Effect of shade on seed cotton yield, gin turnout, and lint yield, 2009.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
SPHS	2065ab‡	40.75a	859a
SFF	1887bc	42.00a	824a
SPF	1454c	42.00a	635b
SBD	1637c	43.75a	691b
UTC	2159a	42.25a	923a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 17-b. Effect of 1-methylcyclopropene (1-MCP) on seed cotton yield, gin turnout, and lint yield, 2009.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
MPHS	2198a‡	43.25a	947a
MFF	2259a	45.00a	992a
MPF	2270a	45.25a	969a
MBD	2281a	45.25a	958a
UTC	2159a	42.25a	923a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 17-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed cotton yield, gin turnout, and lint yield, 2009.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
SMPHS	2219a§	43.50a	967a
SPHS	2065a	40.75a	859a
SMFF	1798a	42.50a	778a
SFF	1887a	42.00a	824a
SMPF	1238a	41.50a	544a
SPF	1454a	42.00a	635a
SMBD	1909a	46.50a	827a
SBD	1637b	43.75a	691b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 18-a. Effect of shade on seed cotton yield, gin turnout, and lint yield, 2008 and 2009.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
SPHS	2082ab‡	41.30a	857ab
SFF	2087ab	42.72a	888ab
SPF	2026ab	42.81a	862ab
SBD	1746b	43.04a	752b
UTC	2268a	42.47a	959a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 18-b. Effect of 1-methylcyclopropene (1-MCP) on seed cotton yield, gin turnout, and lint yield, 2008 and 2009.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
MPHS	2259a‡	43.19a	974a
MFF	2379a	44.37a	1056a
MPF	2273a	44.00a	999a
MBD	2451a	43.77a	1076a
UTC	2268a	42.47a	959a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 18-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed cotton yield, gin turnout, and lint yield, 2008 and 2009.

Treatment†	Seed cotton	Lint	Lint
	—kg ha^{-1}—	—%—	—kg ha^{-1}—
SMPHS	2159a§	43.62a	943a
SPHS	2082a	41.30b	857a
SMFF	2093a	42.93a	896a
SFF	2087a	42.72a	888a
SMPF	1807a	42.79a	765a
SPF	2026a	42.81a	862a
SMBD	1898a	44.83a	850a
SBD	1746a	43.04a	752a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

SMPF and SPF treatments were not significantly different at the 0.05 level. All of the 1-MCP treatments alone showed numerically higher yield when compared to the UTC.

When considering 1-MCP in the different developmental growth stages, the MBD treatment had the greatest impact on yield, resulting in 183 and 117 kg ha^{-1} more seed cotton and lint yield, respectively than the UTC (Table 18-b). However, these results were not statistically different.

For gin turnout, all 1-MCP treatments were numerically higher than the UTC (Table 18-b), but not significantly different. A significant difference for percent gin turnout was observed for the comparison of the SMPHS and SPHS treatments (Tables 18-c). Percent gin turnout for the SPHS was 41.30% while the SMPHS treatment was 43.62%. For the cotton variety ST 4554 B2RF, gin turnout is estimated to be approximately 41%.

High volume instrument testing (HVI) was used to determine fiber quality attributes: micronaire, length, uniformity, strength, elongation, reflectance (Rd), and the degree of yellowness (+b) (Tables 19-a–19-c, 20-a–20-c, and 21-a–21-c). For the SBD treatment, micronaire was significantly lower than the UTC (Table 21-a). Micronaire values were 5.0 and 5.4 for the SBD and UTC treatments, respectively. However, even though the SBD treatment exhibited lower micronaire, this value is still considered to be in the premium range.

Table 19-a. Effect of shade on lint quality parameters, 2008.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
SPHS	5.32a‡	1.10ab	83.00a	31.48a	9.95a	62.43a	9.25a
SFF	5.38a	1.09ab	82.18a	31.83a	10.50a	61.65a	9.40a
SPF	5.32a	1.14a	83.33a	31.85a	9.93a	61.28a	9.10a
SBD	5.22a	1.08b	81.85a	30.65a	9.98a	61.93a	9.18a
UTC	5.42a	1.08b	83.15a	30.70a	10.38a	62.10a	9.33a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 19-b. Effect of 1-methylcyclopropene (1-MCP) on lint quality parameters, 2008.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
MPHS	5.37a‡	1.11a	82.70a	31.43a	9.97a	61.97a	9.03a
MFF	5.47a	1.11ab	82.75a	31.73a	9.88a	61.15a	9.08a
MPF	5.49a	1.05c	82.28a	29.23b	10.30a	61.33a	9.03a
MBD	5.43a	1.09abc	81.98a	30.55a	10.00a	61.20a	8.98a
UTC	5.42a	1.08bc	83.15a	30.70ab	10.38a	62.10a	9.33a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 19-c. Effect of 1-methylcyclopropene (1-MCP) and shade on lint quality parameters, 2008.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
SMPHS	5.36a§	1.11a	82.40a	31.28a	10.15a	62.58a	9.15a
SPHS	5.32a	1.10a	83.00a	31.48a	9.95a	62.43a	9.25a
SMFF	5.37a	1.08a	81.80a	31.37a	10.33a	63.40a	9.37a
SFF	5.38a	1.09a	82.18a	31.83a	10.50a	61.65a	9.40a
SMPF	5.24a	1.13a	82.98a	31.00a	9.93a	63.70a	9.03a
SPF	5.32a	1.14a	83.33a	31.85a	9.93a	61.28a	9.10a
SMBD	5.29a	1.08a	81.55a	30.05a	10.20a	61.95a	9.20a
SBD	5.22a	1.08a	81.85a	30.65a	9.98a	61.93a	9.18a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 20-a. Effect of shade on lint quality parameters, 2009.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
SPHS	5.4a‡	1.11ab	83.6ab	30.6bc	5.7a	60.7a	8.5a
SFF	5.2ab	1.12a	84.9a	32.1a	6.2a	62.5a	7.9b
SPF	5.0ab	1.09b	83.3b	30.3c	6.1a	63.0a	8.3ab
SBD	4.8b	1.11ab	83.6ab	30.7abc	6.1a	62.3a	8.1b
UTC	5.3a	1.12ab	84.0ab	31.8ab	6.0a	62.9a	8.0b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 20-b. Effect of 1-methylcyclopropene (1-MCP) on lint quality parameters, 2009.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
MPHS	5.3a‡	1.11a	83.4a	31.3a	5.9a	61.6a	7.9a
MFF	5.2a	1.10a	83.6a	30.4a	6.2a	62.0a	7.9a
MPF	5.4a	1.11a	83.9a	31.5a	5.9a	64.2a	8.1a
MBD	5.4a	1.10a	83.6a	30.2a	6.0a	61.0a	7.8a
UTC	5.3a	1.12a	84.0a	31.8a	6.0a	62.9a	8.0a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 20-c. Effect of 1-methylcyclopropene (1-MCP) and shade on lint quality parameters, 2009.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
SMPHS	5.2a§	1.10a	83.5a	30.6a	6.2a	63.9a	8.3a
SPHS	5.4a	1.11a	83.6a	30.6a	5.7b	60.7a	8.5a
SMFF	5.0a	1.13a	83.8b	31.6a	6.0a	63.4a	7.9a
SFF	5.2a	1.12a	84.9a	32.1a	6.2a	62.5a	7.9a
SMPF	5.2a	1.09a	83.8a	29.6a	6.1a	62.7a	8.0a
SPF	5.0a	1.09a	83.3a	30.3a	6.1a	63.0a	8.3a
SMBD	4.8a	1.11a	84.2a	31.9a	6.1a	61.9a	8.1a
SBD	4.8a	1.11a	83.6a	30.7a	6.1a	62.3a	8.1a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 21-a. Effect of shade on lint quality parameters, 2008 and 2009.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
SPHS	5.4a‡	1.10a	83.3a	31.0a	7.8a	61.6a	8.8a
SFF	5.3a	1.10a	83.5a	31.4a	8.3a	62.1a	8.6a
SPF	5.2ab	1.11a	83.3a	30.5a	8.0a	62.1a	8.7a
SBD	5.0b	1.10a	82.7a	30.6a	8.0a	62.1a	8.6a
UTC	5.4a	1.10a	83.6a	31.2a	8.2a	62.5a	8.6a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 21-b. Effect of 1-methylcyclopropene (1-MCP) on lint quality parameters, 2008 and 2009.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
MPHS	5.4a‡	1.11a	83.1a	31.4a	7.6a	61.7a	8.4a
MFF	5.3a	1.11a	83.2a	31.0a	8.0a	61.5a	8.5a
MPF	5.5a	1.08a	83.1a	30.3a	8.1a	62.7a	8.6a
MBD	5.4a	1.10a	82.8a	30.4a	8.0a	61.1a	8.4a
UTC	5.4a	1.10a	83.6a	31.2a	8.2a	62.5a	8.6a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 21-c. Effect of 1-methylcyclopropene (1-MCP) and shade on lint quality parameters, 2008 and 2009.

	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Treatment†		—cm—		—g tex^{-1}—			
SMPHS	5.3a§	1.10a	82.9a	30.9a	8.2a	63.2a	8.7a
SPHS	5.4a	1.10a	83.3a	31.0a	7.8a	61.6a	8.8a
SMFF	5.2a	1.10a	82.9a	31.5a	7.8a	63.4a	8.5a
SFF	5.3a	1.10a	83.5a	31.4a	8.3a	62.1a	8.6a
SMPF	5.2a	1.11a	83.4a	30.3a	8.0a	63.2a	8.5a
SPF	5.2a	1.11a	83.3a	30.5a	8.0a	62.1a	8.7a
SMBD	5.0a	1.10a	82.8a	30.9a	8.1a	61.9a	8.6a
SBD	5.0a	1.10a	82.7a	30.6a	8.0a	62.1a	8.6a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Box-mapping

Prior to harvest, end of season box-mapping was conducted to explain possible yield differences. In 2008 and 2009, ten plants were randomly selected from each plot. Open bolls were collected by node and fruiting position to determine yield distribution throughout the plant using a variation described by Jenkins and McCarty (1995). Due to a significant year x treatment interaction, data could not be pooled over years.

In 2008 and 2009, there were no significant differences in the number of total bolls or weights for bolls located on nodes 3 through 5 in the first, second, and third positions (Appendix B). A large number of bolls were located on nodes 6 through 10. In 2008 and 2009, the total number of bolls on nodes 6 through 10 in first position ranged from 2.2 to 3.25 and 1.3 to 2.7 per plant, respectively. These numbers correspond to the weight values of 6.94 to 14.12g and 5.65 to 10.48g, respectively for 2008 and 2009. No significant differences were found among treatments for the number and weight of bolls in 2008 that correlate with yield results (Tables 22-a–22-c). In 2009, the number of bolls for the SFF treatment was significantly less than the UTC (Table 23-a). This correlates with the decrease in seedcotton for this year (Table 17-a). All other treatment weights and number of bolls for these nodal and fruiting positions were not significant (Tables 23-b and 23-c). Bolls on nodes 6 though 10 second

Table 22-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	3.00a‡	11.88ab
SFF	2.23a	6.94b
SPF	2.45a	9.76ab
SBD	3.05a	13.68a
UTC	3.05a	12.90a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 22-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	3.05a‡	12.44a
MFF	3.25a	11.64a
MPF	3.23a	13.62a
MBD	3.15a	14.12a
UTC	3.05a	12.90a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 22-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	3.13a§	12.48a
SPHS	3.00a	11.88a
SMFF	2.20a	9.22a
SFF	2.23a	6.94a
SMPF	2.90a	9.27a
SPF	2.45a	9.76a
SMBD	3.08a	11.90a
SBD	3.05a	13.68a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 23-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	2.30a‡	7.28a
SFF	1.60b	7.11a
SPF	2.53a	9.52a
SBD	2.20ab	9.56a
UTC	2.33a	9.72a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 23-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	2.45a‡	8.93a
MFF	2.43a	10.37a
MPF	2.13a	8.08a
MBD	2.70a	10.48a
UTC	2.33a	9.72a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 23-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	2.50a§	9.48a
SPHS	2.30a	7.28a
SMFF	1.30a	5.65a
SFF	1.60a	7.11a
SMPF	2.30a	8.59a
SPF	2.53a	9.52a
SMBD	2.30a	9.53a
SBD	2.20a	9.56a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

position ranged from 0.50 to 1.73 and 0.45 to 0.80 per plant, respectively, in 2008 and 2009 (Tables 24-a-24-c and 25-a-25-c). Corresponding weights ranged from 1.81 to 5.81g and 0.71 to 2.55 g per boll. The SPF and SBD treatments showed a significantly lower amount of bolls than the UTC in 2008, (Table 24-a). In 2009, data failed to show any significant results for the same boll numbers and weights (Table 25-a). For 1-MCP alone treatments, MBD displayed a numerically higher number of bolls and boll weights for both 2008 and 2009, but were not significantly different (Tables 24-b and 25-b). Results for 2008 also showed that the SMPF and SMBD treatments had significantly higher boll numbers and boll weights than their respective shade comparisons, SPF and SBD (Table 24-c). In 2009, the SMPF and SMBD treatments showed the inverse of 2008 boll numbers and weights, but were not statistically different than their respective comparisons, SPF and SBD (Table 25-c). In 2008 and 2009, bolls located on nodes 6 through 10 in the third position showed no significant differences in number or weight (Tables 26-a–26-c and 27-a–27-c).

Seed cotton located on nodes 11 through 15 also contributed a large amount to yield. First position bolls located in this section ranged from 1.80 to 3.05 in 2008, and 0.53 to 1.45 in 2009 (Tables 28-a-28-c and 29-a-29-c). Respective weights ranged from 5.94 to 10.52 g and 1.02 to 4.90g. In 2008, the SFF treatment

Table 24-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	1.35a‡	4.12a
SFF	1.23ab	4.03a
SPF	0.50c	1.81a
SBD	0.65bc	1.91a
UTC	1.33a	3.77a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 24-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.98b‡	2.94b
MFF	1.13ab	4.78ab
MPF	1.15ab	4.02ab
MBD	1.73a	5.81a
UTC	1.33ab	3.77ab

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 24-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	1.33a§	4.62a
SPHS	1.35a	4.12a
SMFF	1.23a	4.44a
SFF	1.23a	4.03a
SMPF	0.75a	2.38a
SPF	0.50b	1.81b
SMBD	1.30a	3.78a
SBD	0.65b	1.91b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 25-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.55a‡	1.83a
SFF	0.68a	1.54a
SPF	0.58a	1.42a
SBD	0.78a	1.96a
UTC	0.75a	2.20a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 25-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.60a‡	1.71a
MFF	0.73a	2.45a
MPF	0.75a	2.19a
MBD	0.80a	2.55a
UTC	0.75a	2.20a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 25-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.53a§	1.84a
SPHS	0.55a	1.83a
SMFF	0.43a	1.43a
SFF	0.68a	1.54a
SMPF	0.45a	0.71a
SPF	0.58a	1.42a
SMBD	0.70a	1.85a
SBD	0.78a	1.96a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 26-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.05a	0.20a
SPF	0.10a	0.48a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 26-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.05a‡	0.16a
MFF	0.10a	0.38a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 26-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.15a§	0.50a
SPHS	0.00a	0.00a
SMFF	0.03a	0.09a
SFF	0.05a	0.20a
SMPF	0.15a	0.64a
SPF	0.23a	0.88a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 27-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.08a‡	0.16a
SFF	0.13a	0.29a
SPF	0.03a	0.03a
SBD	0.18a	0.47a
UTC	0.23a	0.66a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 27-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2009.

	Total bolls	Total weight boll^{-1}
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.15a‡	1.22a
MFF	0.33a	0.79a
MPF	0.13a	0.70a
MBD	0.25a	1.20a
UTC	0.23a	0.66a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 27-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 6 through 10 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.18a§	0.76a
SPHS	0.08a	0.16a
SMFF	0.33a	1.27a
SFF	0.13a	0.29a
SMPF	0.05a	0.18a
SPF	0.03a	0.03a
SMBD	0.05a	0.18a
SBD	0.18a	0.47a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 28-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	2.30ab‡	8.16a
SFF	3.05a	9.11a
SPF	2.53ab	10.82a
SBD	1.80b	6.79a
UTC	2.10b	8.12a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 28-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	1.88a‡	7.24a
MFF	1.95a	6.69a
MPF	1.80a	6.45a
MBD	2.48a	8.12a
UTC	2.10a	8.12a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 28-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	2.75a§	10.51a
SPHS	2.30a	8.16a
SMFF	2.68b	8.30a
SFF	3.05a	9.11a
SMPF	2.08a	8.09a
SPF	2.53a	10.82a
SMBD	2.08a	5.94a
SBD	1.80a	6.79a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 29-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.53b‡	1.67b
SFF	1.20a	3.95a
SPF	0.55b	1.02b
SBD	0.83ab	2.26ab
UTC	1.08a	3.92a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 29-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	1.05a‡	3.02a
MFF	1.35a	4.72a
MPF	0.85a	3.07a
MBD	1.38a	4.51a
UTC	1.08a	3.92a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 29-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.93a§	2.55a
SPHS	0.53a	1.67a
SMFF	1.45a	4.90a
SFF	1.20a	3.95a
SMPF	0.60a	1.59a
SPF	0.55a	1.02a
SMBD	1.35a	4.31a
SBD	0.83b	2.26a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

had a significantly larger number of bolls when compared to the UTC (Table 28-a). In 2009, the amount of bolls and corresponding weights for treatments SPF and SPHS were significantly lower than the UTC (Table 29-a). Though the SPHS treatment did not correspond with overall yield differences for this year, the SPF treatment did, suggesting that yield differences treated with shade during this time may have been due to boll number differences. Second position bolls on nodes 11 through 15 in 2008 and 2009 ranged from 0.05 to 1.30 and 0.03 to 0.48 (Tables 30-a-30-c and 31-a-31-c). Boll weights ranged from 0.16 to 4.94 g and 0.09 to 1.27 g, correspondingly, in 2008 and 2009. Total bolls from 2008 data showed that the SBD treatment was significantly lower than the UTC. Though no statistical differences were observed for the corresponding weights, the SBD treatment showed a numerically lower weight than the UTC (Table 30-a). In 2009, the SBD treatment displayed no significant differences, but numerical values lower than the UTC were observed, corresponding with the previous year (Table 31-a). Though other statistical differences were observed throughout sympodial branches, many did not correspond to overall yield differences. This data can be found in Appendix B.

Table 30-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.18bc‡	0.59c
SFF	0.50bc	3.20ab
SPF	1.30a	4.94a
SBD	0.05c	0.16c
UTC	0.63b	1.51bc

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 30-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.40a‡	1.45a
MFF	0.40a	1.40a
MPF	0.20a	0.63a
MBD	0.33a	1.27a
UTC	0.63a	1.51a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 30-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.70a§	3.01a
SPHS	0.18b	0.59b
SMFF	0.23a	0.65b
SFF	0.50a	3.20a
SMPF	0.68b	2.28b
SPF	1.30a	4.94a
SMBD	0.08a	0.24a
SBD	0.05a	0.16a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 31-a. Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.23ab‡	0.40a
SFF	0.40a	1.07a
SPF	0.05b	0.09a
SBD	0.08b	0.16a
UTC	0.30ab	0.92a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 31-b. Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.30a‡	1.20a
MFF	0.28a	0.61a
MPF	0.28a	1.11a
MBD	0.35a	0.77a
UTC	0.30a	0.92a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 31-c. Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.48a§	1.27a
SPHS	0.23a	0.40a
SMFF	0.30a	0.77a
SFF	0.40a	1.07a
SMPF	0.03a	0.10a
SPF	0.05a	0.09a
SMBD	0.20a	0.34a
SBD	0.08a	0.16a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

In both years of this study, box-mapping failed to substantiate or provide consistent information on yield differences between treatments. However, final box-mapping, is still a useful tool in assessing plant growth and yield parameters on a whole plant basis. Although boll number and boll size are major factors that contribute to yield, differences in yield can be explained by many parameters beyond these two parameters.

Fibers and Seed

In an effort to further explain yield differences, data was collected from box-mapped samples to determine the amount of fibers per seed, and seed weights. Samples for both years were taken from sympodial branches 6 through 10 in the first and second positions. Due to a significant year x treatment interaction, data could not be pooled over years.

In 2008, seed weights ranged from 0.7 to 0.08 grams for sympodial branches 6 through 10 first position bolls (Table 32-a–32-c). Results show that the SBD treatment had a significantly less seed weight than the UTC. There were no significant differences in the amount of fibers per seed for the shade only treatments. The 1-MCP only treatments showed no significant differences in seed weight; however, the MBD treatment had a significantly higher number of fibers per seed and fibers per millimeter square than the UTC (Table 32-b).

Table 32-a. Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2008.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SPHS	0.08a‡	19486a	190.75a
SFF	0.08a	24050a	249.25a
SPF	0.08a	17107a	162.25a
SBD	0.07b	16988a	171.25a
UTC	0.08a	16860a	162.25a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 32-b. Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2008.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
MPHS	0.08a‡	17721b	169.75ab
MFF	0.08a	15092b	168.00b
MPF	0.08a	17566b	147.75ab
MBD	0.08a	28954a	279.00a
UTC	0.08a	16860b	162.25b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 32-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2008.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SMPHS	0.08a§	16158a	153.25a
SPHS	0.08a	19486a	190.75a
SMFF	0.08a	18696a	196.00a
SFF	0.08a	24050a	249.25a
SMPF	0.08a	18697a	175.75a
SPF	0.08a	17107a	162.25a
SMBD	0.08a	17184a	168.00a
SBD	0.07a	16988a	171.25a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

This correlates with the numerical differences in yield between the SBD and UTC treatments during 2008 and pooled years (Tables 16-b and 18-b). In 2009, the SBD treatment first position bolls showed no significant differences in seed weight and number of fibers per seed from the UTC; however, numerical differences in mean seed weight were observed (Table 33-a). First position bolls for the MPHS treatment showed a significantly higher mean seed weight, as well as a significantly higher amount of fibers per seed and fibers per millimeter square (Table 33-b). Data for 1-MCP and shade showed no statistical differences among all treatment comparisons (Table 33-c).

Fiber and seed data from second positions bolls located on branches 6 through 10 were also collected in 2008 and 2009 (Tables 34-a-34-c and 35-a-35-c). In 2008, mean seed weights for the SBD treatment bolls in the second position were significantly lower than the UTC (Table 34-a). Conversely, these differences were not observed in 2009. In 2008, a significantly lower amount of fibers per seed and millimeter square for the SFF treatment (Table 34-c) supported the numerical differences in yield for that year (Table 16-c) and pooled yield data (Table 18-c).

The second position bolls for the SMPF treatment demonstrated a significantly lower seed weight than the UTC in 2009 (Table 35-c). The results are a difference of two grams per seed. The SMBD treatment (Table 35-c), had a lower amount of fibers per seed than the UTC, suggesting that the higher yield

Table 33-a. Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2009.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SPHS	0.09a‡	14372a	134.95a
SFF	0.08a	14949a	139.21a
SPF	0.07a	12812a	122.46a
SBD	0.07a	13256a	130.44a
UTC	0.08a	14266a	135.53a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 33-b. Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2009.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
MPHS	0.18a‡	29999a	286.57a
MFF	0.09b	14144b	129.06b
MPF	0.08b	14630b	138.47b
MBD	0.08b	14041b	132.56b
UTC	0.08b	14266b	135.53b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 33-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in first position, 2009.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SMPHS	0.09a§	14196a	133.66a
SPHS	0.09a	14372a	134.95a
SMFF	0.07a	14843a	139.86a
SFF	0.08a	14949a	139.21a
SMPF	0.10a	19556a	190.52a
SPF	0.07a	12812a	122.46a
SMBD	0.08a	15020a	145.88a
SBD	0.07a	13256a	130.44a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 34-a. Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2008.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SPHS	0.08a‡	14287a	152.50a
SFF	0.08a	11842a	121.50a
SPF	0.08a	13919a	139.50a
SBD	0.06b	16541a	180.00a
UTC	0.08a	14794a	155.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 34-b. Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2008.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
MPHS	0.07a‡	13782a	153.50a
MFF	0.08a	14708a	148.00a
MPF	0.07a	15051a	161.25a
MBD	0.07a	13837a	147.50a
UTC	0.08a	14794a	155.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 34-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2008.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SMPHS	0.08a§	13317a	140.50a
SPHS	0.08a	14287a	152.50a
SMFF	0.08a	34937a	350.75a
SFF	0.08a	11842b	121.50b
SMPF	0.08a	14088a	142.50a
SPF	0.08a	13919a	139.50a
SMBD	0.06a	15618a	171.25a
SBD	0.06a	16541a	180.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 35-a. Effect of shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2009.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SPHS	0.08a‡	13219a	129.39a
SFF	0.07a	11144a	105.73a
SPF	0.06a	12857a	128.65a
SBD	0.07a	14943a	150.98a
UTC	0.06a	11649a	118.30a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 35-b. Effect of 1-methylcyclopropene (1-MCP) on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2009.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
MPHS	0.06b‡	10074a	94.76a
MFF	0.09a	13720a	130.75a
MPF	0.07ab	12669a	124.72a
MBD	0.07ab	12926a	126.25a
UTC	0.06ab	11649a	118.30a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Table 35-c. Effect of 1-methylcyclopropene (1-MCP) and shade on seed weight and number of fibers per seed for sympodial branches 6 through 10 in second position, 2009.

	Weight seed^{-1}	Fibers seed^{-1}	Fibers seed^{-1}
Treatment†	—g—		—mm^2—
SMPHS	0.08a§	13139a	121.95a
SPHS	0.08a	13219a	129.39a
SMFF	0.08a	11851a	111.17a
SFF	0.07a	11144a	105.73a
SMPF	0.04b	11217a	118.97a
SPF	0.06a	12857a	128.65a
SMBD	0.06a	12775b	132.18a
SBD	0.07a	14943a	150.98a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

for the seed cotton and lint yield numeric differences for SMBD (Table 18-a–18-c) were not determined by the amount of fibers per seed in this position.

CHAPTER V

CONCLUSIONS

Cotton is subject to many stresses that cause fruit abscission throughout the growing season. Since research has indicated that ethylene is the gaseous plant hormone that signals abscission and 1-methylcyclopropene (1-MCP) is an ethylene action inhibitor, it is conceivable that the chemical could counter the effects of stress induced by increased ethylene. Lower light, on the other hand, is one of the many stresses that contributes to cotton fruit abscission. According to the data in this two-year study, shade imposed for eight days during the boll development stage significantly reduced cotton yield. Though 1-MCP applied before an eight day period of shading did not significantly reduce the amount of yield loss, it did show higher numerical values during the boll development stage when compared to shaded cotton alone. The results for 1-MCP alone treated cotton, although not significant, also showed numerically higher values than the untreated control. Numerically higher values of percent ginout were also observed for 1-MCP treatments when compared to the untreated control. This could possibly mean that the chemical affected the amount of fibers per seed. Cotton fibers per seed and seed size did not show consistent correlations with the increase in cotton yield for 1-MCP treatments. Since the fibers were matured prior to 1-MCP application for the first and second position bolls located in the 6 through 10 sympodial branches, it is likely that cotton fibers

would have been affected during fiber development at a later time. Box-mapping, however, was unable to explain this possibility.

Research has also supported that higher ethylene concentrations can break down cell membranes, and 1-MCP can maintain cell membrane integrity. To investigate this, tests of electrolyte leakage were conducted. For both years, the percent total electrolytes leaked for shaded treatments failed to significant differences. In fact, it was anticipated that electrolytes would have been lost at a higher rate for shaded treatments. This however was not true in either year of this study. 1-MCP treatments under shaded and non-shaded conditions also failed to show statistical differences when compared to their controls.

Other researchers have shown that 1-MCP treated cotton can result in a lower stomatal conductance under stress. This study, however, showed only numerically lower conductance for 1-MCP alone treatments during the boll development stage, and a few days prior to defoliation. All other stages of growth were inconsistent in response to the compound.

Data from this study suggests that shade during the latter stage of growth, in this case the boll development stage, can significantly reduce cotton yield. The results of this study also suggest that1-MCP can possibly increase cotton yield when applied alone, and when applied prior to imposing a shade stress in the latter stages of growth. It is noted that these yield increases were not significant for 1-MCP treatments; however, the numerically higher yield

returns for the 1-MCP treatments are noteworthy. Although 1-MCP effects on other cotton growth yield parameters and components were few, the potential of this chemical in cotton production should not be ignored. New formulations of 1-MCP may improve delivery to the crop canopy and prolong its activity at the physiological level.

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APPENDIX A

CROP PRODUCTION PRODUCTS USED IN 2008 AND 2009 EXPERIMENT

The following products were used at the rates indicated for the designated weeds or pests.

Preplanting	
Broadleaf weeds and annual grasses	Dual® II-metolachlor: 1.17 L ha^{-1} 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-Methoxy-1-methylethyl)acetamide
	Caporal® 4 L – prometryn: 2.34 L ha^{-1} 2,4-bis(isopropylamino)-6-methylthio)-*S*-triazine
Planting & Early Season	
Thrips (*Thrips tabaci*)	Temik® 15G-aldicarb: 5.61 kg ha^{-1} [2-methyl-2-(methylthio) propionaldehyde 0-(methylcarbomoy)]
Early & Mid-Season	
Annual grasses & Broad Leaves	Roundup Magnum® - glyphosate: 1.61 L ha^{-1} N-(phosphonomethyl)glycine
	Envoke™- trifolxysulfuron: 0.07 kg ha^{-1} 1-(4,6-dimethoxy-pyrimidin-2-yl)-3-[3-(2,2,2-trifuluroethoxy)-2-pyridylsulfonyl]urea(IUPAC)
Plant Growth Regulator	Pentia®- mepiquat pentaborate: 0.29 L ha^{-1} N,N-dimethylpiperidiniurn pentaborate

Harvest Aides	Ginstar® thidiazuron: 0.07 L ha^{-1} 5-Phenylcarbamoylamino-1,2,3-thiadiazole; diuron: 3-(3,4 Dichlorophenyl)-1,1-dimethylurea; *N*′-(3,4-dichlorophenyl)-*N*,*N*-dimethylurea Finish 6 Pro®-ethephon: 1.6 L ha^{-1} (2-chloroethyl) phosphonic acid; cyclanilide: 1-(2,4-dichlorophenylaminocarbonyl)-cyclopropane carboxylic acid Dropp® SC-thidiazuron: 0.15 L ha^{-1} (N-phenyl-N′-1,2,3-thiadiazol-5-ylurea)
Morning Glory (Ipomoea spp.)	Aim® EC: 0.07 kg ha^{-1} (Carfentrazone-ethyl)

APPENDIX B

BOX-MAPPING FOR 2008 AND 2009

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.03a	0.12a
SPF	0.02a	0.13a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 3 3 through 5 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.02a	0.02a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.03a	0.12a
SMPF	0.00a	0.00a
SPF	0.02a	0.13a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.08a‡	0.44a
SFF	0.08a	0.38a
SPF	0.03a	0.06a
SBD	0.10a	0.31a
UTC	0.13a	0.64a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.10a‡	0.25a
MFF	0.15a	0.40a
MPF	0.05a	0.16a
MBD	0.15a	0.43a
UTC	0.13a	0.64a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.05a§	0.32a
SPHS	0.08a	0.44a
SMFF	0.15a	0.50a
SFF	0.08a	0.38a
SMPF	0.23a	0.77a
SPF	0.03a	0.06a
SMBD	0.08a	0.08a
SBD	0.10a	0.31a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.01a	0.10a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.03a	0.11a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.01a	0.10a
SMPF	0.03a	0.04a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.03a	0.06a
UTC	0.05a	0.10a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.08a‡	0.21a
MFF	0.05a	0.21a
MPF	0.05a	0.06a
MBD	0.00a	0.00a
UTC	0.08a	0.18a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.03a	0.06a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.03a	0.08a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 3 through 5 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00b‡	0.00b
SFF	0.15b	0.23b
SPF	0.38a	1.27a
SBD	0.00b	0.00b
UTC	0.00b	0.00b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.03a‡	0.08a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.08a	0.24a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.13a§	0.50a
SPHS	0.00a	0.00a
SMFF	0.03a	0.06a
SFF	0.15a	0.23a
SMPF	0.18b	0.71a
SPF	0.38a	1.27a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.03a‡	0.06b
SFF	0.15a	1.58a
SPF	0.00a	0.00b
SBD	0.00a	0.00b
UTC	0.05a	0.11b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.05ab‡	0.14a
MFF	0.23a	0.47a
MPF	0.03b	0.70a
MBD	0.00b	0.00a
UTC	0.05b	0.11a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 11 through 15 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.20a§	0.41a
SPHS	0.03a	0.06a
SMFF	0.13a	0.36a
SFF	0.15a	1.58a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.03a	0.01a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.28b‡	0.95b
SFF	0.45b	1.12b
SPF	0.95a	3.12a
SBD	0.43b	0.36b
UTC	0.20b	0.55b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.38a‡	1.06a
MFF	0.48a	1.44a
MPF	0.13a	0.35a
MBD	0.23a	0.68a
UTC	0.20a	0.55a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in first position, 2008.

Treatment†	Total bolls	Total weight
	—boll plant^{-1}—	—g—
SMPHS	0.48a§	1.75a
SPHS	0.28a	0.95a
SMFF	0.43a	1.47a
SFF	0.45a	1.12a
SMPF	0.88a	2.29a
SPF	0.95a	3.12a
SMBD	0.15a	0.78a
SBD	0.43a	0.36a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00b‡	0.00b
SFF	0.48a	1.45a
SPF	0.00b	0.00b
SBD	0.03b	0.03b
UTC	0.15b	0.25b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.18a‡	0.34ab
MFF	0.25a	0.94a
MPF	0.03a	0.07b
MBD	0.18a	0.53ab
UTC	0.15a	0.25ab

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.48a§	1.67a
SPHS	0.00b	0.00b
SMFF	0.15b	0.27b
SFF	0.48a	1.45a
SMPF	0.08a	0.20a
SPF	0.00a	0.00a
SMBD	0.10a	0.14a
SBD	0.03a	0.03a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.03a	0.07a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.08a§	0.23a
SPHS	0.00b	0.00b
SMFF	0.03a	0.12a
SFF	0.03a	0.07a
SMPF	0.03a	0.07a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.05a‡	0.12a
SFF	0.10a	0.17a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.03a	0.01a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.03ab‡	0.03b
MFF	0.00b	0.00b
MPF	0.03ab	0.07ab
MBD	0.15a	0.41a
UTC	0.03ab	0.01b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.08a§	0.11a
SPHS	0.05a	0.12a
SMFF	0.03a	0.00a
SFF	0.10a	0.17a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00b‡	0.00b
MFF	0.03a	0.06a
MPF	0.00b	0.00b
MBD	0.00b	0.00b
UTC	0.00b	0.00b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 16 through 20 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in first position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in first position, 2009.

	Total bolls	Total weight boll^{-1}
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in first position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in second position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in second position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) number of bolls, and total boll weight per plant for sympodial branches 21through 25 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in third position, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.00a‡	0.00a
SFF	0.00a	0.00a
SPF	0.00a	0.00a
SBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.00a‡	0.00a
MFF	0.00a	0.00a
MPF	0.00a	0.00a
MBD	0.00a	0.00a
UTC	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for sympodial branches 21through 25 in third position, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.00a§	0.00a
SPHS	0.00a	0.00a
SMFF	0.00a	0.00a
SFF	0.00a	0.00a
SMPF	0.00a	0.00a
SPF	0.00a	0.00a
SMBD	0.00a	0.00a
SBD	0.00a	0.00a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for vegetative branches, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	1.05a‡	4.03a
SFF	1.23a	3.96a
SPF	2.18a	7.05a
SBD	1.10a	3.93a
UTC	1.78a	6.68a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for vegetative branches, 2008.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	1.33b‡	4.49b
MFF	2.73a	12.17a
MPF	1.38b	5.02b
MBD	1.70b	6.04b
UTC	1.78b	6.68b

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for vegetative branches, 2008.

Treatment†	Total bolls	Total weight
	—boll plant^{-1}—	—g—
SMPHS	2.55a§	10.11a
SPHS	1.05a	4.03b
SMFF	1.65a	5.42a
SFF	1.23a	3.96a
SMPF	1.98a	5.90a
SPF	2.18a	7.05a
SMBD	1.20a	4.21a
SBD	1.10a	3.93a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of shade on number of bolls, and total boll weight per plant for vegetative branches, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SPHS	0.17a‡	0.50a
SFF	0.67a	1.85a
SPF	0.10a	0.23a
SBD	0.27a	0.72a
UTC	0.62a	1.92a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) on number of bolls, and total boll weight per plant for vegetative branches, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
MPHS	0.52a‡	1.48a
MFF	0.92a	2.98a
MPF	0.67a	1.36a
MBD	0.57a	1.90a
UTC	0.62a	1.92a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development; UTC, untreated control.

‡ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

Effect of 1-methylcyclopropene (1-MCP) and shade on number of bolls, and total boll weight per plant for vegetative branches, 2009.

	Total bolls	Total weight
Treatment†	—boll plant^{-1}—	—g—
SMPHS	0.37a§	1.08a
SPHS	0.17a	0.50a
SMFF	0.67a	1.95a
SFF	0.67a	1.85a
SMPF	0.20a	0.39a
SPF	0.10a	0.23a
SMBD	0.32a	0.90a
SBD	0.27a	0.72a

† Abbreviations: S, shade imposed for 8d; M, 1-MCP applied at specified rate; PHS, treatment initiated at pinhead square, FF, treatment initiated at first flower; PF, treatment initiated at peak flower; BD, treatment initiated at boll development.
‡ Treatments are compared statistically only within developmental growth stages. Values within a column followed by the same letter are not significantly different at the 0.05 probability level using Fischer's protected LSD.
§ Values within a column followed by the same letter are not significantly different at the 0.05 probability level using LSMEANS contrast matrix.

VITA

Charles Warren Carden, son of Charles R. and Maria Carden, was born in Oklahoma. He graduated from Talihina High School in May 1999. Charles received a Bachelor of Science in agriculture science education from Texas A&M University in May 2008. Upon completion of his B.S. he entered the Master of Science program at Texas A&M University. He received his M.S. degree in August 2010. Charles intends to pursue a career in the agriculture research industry. His permanent address is 370 Olsen Blvd. 2474 TAMU College Station, TX 77843.