2004

Effect of cotton aphids, Aphis gossypii (Glover), on cotton plant development and yield components

Robert Hankins Jones
Louisiana State University and Agricultural and Mechanical College

EFFECT OF COTTON APHIDS, *APHIS GOSSYPII* (GLOVER), ON COTTON PLANT DEVELOPMENT AND YIELD COMPONENTS

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The Department of Entomology

by
Robert Hankins Jones
B.S. Louisiana Tech University, 1999
August 2004

ACKNOWLEDGMENTS

I would like to extend my gratitude to my major professor and mentor, Dr. Roger Leonard. His direction, encouragement, and friendship throughout my graduate studies forever will be appreciated. He has related to me a wealth of knowledge of not only entomology, but of agriculture and other related disciplines. I wish to thank the other members of my graduate committee, Mr. Eugene Burris, and Drs. Boyd Padgett and Richard Story. Their counsel and guidance has been beneficial in all aspects of my graduate studies. Appreciation is also expressed to Mr. Stanley Jacobs for awarding me a Louisiana State University Board of Supervisor's Scholarship. I would also like to thank my fellow graduate students Don Cook, Jeff Gore, Melissa Willrich, and Rhett Gable for their friendship and assistance during my education and field studies. I also appreciate Dr. Jerry Graves for his fellowship. He sets a wonderful example for all of us.

In addition, I would also like to thank Drs. Richard Costello and Donnie Miller for their assistance in the field studies at St. Joseph. I also thank Mrs. Karla Emfinger, Mr. Ralph Sheppard, and the numerous student workers for their friendship and support. Appreciation is also expressed to Cotton Incorporated and the Louisiana Cotton Producers Association for their funding of this project. Foremost, I would like to thank God, my parents, and my wife for their support and patience during this time of my life. I dedicate this work to everyone aforementioned and anyone else involved in my education at Louisiana State University.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The effect of cotton aphids, *Aphis gossypii* (Glover), on cotton plant development and yield was studied during 2000 and 2001. Tests were conducted at the Macon Ridge Station (Winnsboro, Louisiana) in 2000 and 2001, and at the Northeast Research Station (St. Joseph, Louisiana) in 2001. Tests were performed in irrigated and non-irrigated regimes using individual plant comparisons, micro-plots, and whole plots. In both years and at both locations, cotton aphid densities induced chlorosis, and a downward cupping of leaves during the infestation period. The insecticides, pymetrozine and thiamethoxam, were applied to control natural infestations of cotton aphids. Although pymetrozine and thiamethoxam significantly reduced cotton aphid densities ($P < 0.05$), the aphicides did not provide 100 percent control. In both years, the entomopathogenic fungus, *Neozygites fresenii,* established epizootics in late June or early July and rapidly reduced cotton aphid densities to near zero. Cotton aphids did not influence plant height, vegetative branch number, sympodial fruiting node number, vegetative boll number, sympodial bolls, sympodial fruiting positions, and plant maturity measured at the time of harvest. Also, cotton aphid feeding did not influence seedcotton yields from whole plots, micro-plots, and individual paired plants. No significant differences were observed between aphicide treated and non-treated plots for percent retention of first, second, and third fruiting position bolls, and seedcotton weights from first, second, and third fruiting position bolls. Cotton aphids caused transient injury symptoms during the period of infestation, but did not influence final crop maturity, total seedcotton weights, or yield distribution on plants.

INTRODUCTION

The cotton aphid, *Aphis gossypii* Glover, is an important secondary pest of cotton, *Gossypium hirsutum* L., in the United States. During the 2000 growing season, cotton aphids infested approximately 78% of the cotton acreage in the United States resulting in an estimated loss of 130,000 bales of cotton (Williams 2001). Cotton aphids injure cotton by continuously feeding on fluids in plant phloem systems (Rohfritsch 1990). This feeding can result in fewer fruiting positions, lower fruit retention, and reduced cotton lint weight (Bagwell et al. 1991, Fuchs and Minzenmayer 1995). Cotton yield losses associated with cotton aphids have been documented in several states (Andrews and Kitten 1989, Harris et al. 1992, Layton et al. 1996). In Arkansas, Bagwell et al. (1991), reported cotton plants heavily infested with cotton aphids were shorter, and had fewer main stem nodes and bolls than plants with low densities. Boll retention at first and second fruiting positions on the lowest five sympodial branches was reduced. Yield reductions were attributed to fruit abscission rather than reduced boll weight. In a related study in California, cotton aphid infestations on pre-flowering stage plants impacted the plant architecture compared to that on non-infested plants (Rosenheim et al. 1997). Cotton aphids reduced leaf area by 58% and shoot biomass by 45%. Cotton plants infested with cotton aphids were shorter and produced fewer vegetative branches than non-infested plants. However, cotton plants compensated for the physiological alterations and no seedcotton yield losses were observed.

Cotton aphid population dynamics can be influenced by agronomic and pest management practices. High densities commonly occur as resurgent populations following applications of selected insecticides for other insect pests (Isley 1946, Slosser et al. 1989, Torrey et al. 2000). Cotton aphid management has become more difficult in recent years with the implementation of the boll weevil eradication program throughout the Southeastern and Mid-Southern United States. The insecticide, malathion, used in boll weevil eradication programs, provides minimal control of cotton aphids. However, natural enemies in the Coccinellidae family (lady beetles), and the parasitic wasp, *Lysiphlebus testaceipes*, are often reduced after malathion applications, and cotton aphid densities can increase significantly compared to that in non-treated fields (Abney 2000). Also, chemical control is often ineffective due to cotton aphid resistance to many insecticides. With conditions optimal for cotton aphid outbreaks in Louisiana and limited recommended insecticides, additional data concerning the influence of cotton aphids on cotton yields are needed. The focus of this thesis is to collect data to refine action levels and management practices for this pest.

Objective. To determine the effect of early season (squaring) and mid-season (weeks 1-2 of flowering) cotton aphid infestations on cotton yields in irrigated or non-irrigated regimes.

REVIEW OF LITERATURE

Cotton Aphid Biology. The cotton aphid is in the Aphididae family and the order Homoptera (Borror et al. 1989). Cotton aphid adults are soft-bodied insects approximately 0.26 cm long (Isley 1946) and vary from light yellow to dark green in color (Blackman and Eastop 1984, Slosser et al. 1989, Ebert and Cartwright 1997). Cotton aphids have both pterous (winged) and apterous (wingless) forms. Environmental conditions initiating production of pterous or alate forms are usually associated with decreasing photoperiod and decreasing temperature (Drees 1993). Pterous forms also occur in response to the deterioration of host plants, or overcrowding (Fry 1982, Drees 1993). Pterous aphids emigrate from deteriorating winter host plants and infest new host plants in the spring (Fry 1982, Carter and Godfrey 1999). Successive generations on the same host species during the spring and summer are usually apterous, until an environmental stimulus causes aphids to initiate wing development.

Diagnostic structures found on aphids are siphunculi (cornicles). Siphunculi are tube-like structures on the posterior of the abdomen. When muscles of the siphunculi contract, a waxy liquid is expelled. This exudate solidifies in air and inhibits the mouth parts of predators from functioning, thus reducing their ability to prey on aphids (Miyazaki 1987). Aphids can also excrete alarm pheremones from siphunculi to warn other aphids of natural enemies (Borror et al. 1989).

A fundatrix, or stem mother, is usually the first stage to colonize new plants or plant parts. She produces genetic clones (Miyazaki 1987). Male aphids and eggs do not exist during parthenogenic generations. Under optimal conditions, cotton aphid generations can be completed in four days and a female can produce in excess of 80 offspring (Slosser et al. 1989). A cotton aphid can complete as many as 51 generations per year (Metcalf et al. 1962). Studies using cotton seedlings in Arizona reported that the optimal temperature for development was 27.5° C and a generation was completed in five days (Akey and Butler 1989). In a more recent study in Arizona, Henneberry et al. (2000) found under laboratory conditions at 26.7° C, cotton aphids produced an average of 1.7 nymphs per day that developed to adults in 4.1 days. Adult longevity was 16.1 days.

Host alternation is another biological characteristic of aphids (Dixon 1990). This process involves a primary host used for sexual reproduction, and a secondary host is utilized for asexual reproduction (Blackman and Eastop 1984). The cotton aphid colonizes over 60 plant species including cucurbits, citrus, vegetables and ornamental plants (Slosser et al. 1989). In addition, cotton aphids have been collected from numerous alternate, non-agronomic hosts throughout the year (O'Brien et al. 1993). Cotton aphids are capable of over-wintering in Louisiana as winged adults on non-crop hosts such as *Oenothera spp.* (evening primrose), *Lamium amplexicaule* L. (henbit), and *Rumex spp.* (dock) (O'Brien et al. 1993).

Cotton Plant Injury. Cotton aphids ingest plant fluids by piercing sieve tubes in phloem systems with their mouthparts (Rohfritsch 1990). Cotton aphids usually feed on the abaxial leaf surface, and on plant stems or petioles. Leaves in the plant terminal may become distorted and discolored when cotton aphid infestations are high (Isley 1946, Rosenheim et al. 1997). Cotton aphid injury is typically characterized by the downward cupping of leaves caused by the loss of cellular fluid and the growth response of larger, undamaged adjacent cells (Slosser et al. 1989). The removal of cellular contents from cells as a result of cotton aphid feeding may be compensated by adjacent cells after aphid infestations decrease (Slosser et al. 1989). Prolonged aphid infestations can cause premature leaf abscission and induce defoliation (Isley 1946, Rosenheim et al. 1997). Injury can also result in shorter plants, loss of leaf surface area, reduced shoot biomass, fewer mainstem nodes, and reduced photosynthesis (Bagwell et al. 1991, Johnson 1991, Layton et al. 1996, Rosenheim et al. 1997).

Seedcotton losses associated with cotton aphids have been documented in several states (Isley 1946, Andrews and Kitten 1989, Bagwell et al. 1991 Harris et al. 1992, Fuchs and Mizenmayer 1995, Layton et al. 1996). Yield losses attributed to cotton aphids result from fewer fruiting positions, reduced fruit retention, and smaller bolls (Bagwell et al. 1991, Fuchs and Minzenmayer 1995). Andrews and Kitten (1989) reported high aphid densities during flowering were correlated with yield losses. Fuchs and Minzenmayer (1995) found plants with low aphid densities (<50 aphids per leaf) yielded 103 pounds (16%) more lint than plants with high populations (>50 aphids per leaf for three weeks or >100 aphids per leaf for two weeks). Harris and Furr (1994) showed aphicide applications to cotton cultivars, DES 119 and DPL 51, increased yields over non-treated cotton by 116 and 138 pounds, respectively. Isley (1946) dusted cotton with calcium arsenate for boll weevil control and increased seed cotton yields by 128 pounds compared non-dusted cotton. The addition of nicotine to calcium aresenate, for aphid control, increased seed cotton yields by 393 pounds. In the Texas Rolling Plains, lint reductions of 120 pounds per acre were reported when populations exceeded 93 aphids per leaf (Price et al. 1983).

Andrews and Kitten (1989) found cotton plants infested for 50 and 312 “aphid days” suffered a yield loss of 188 pounds of lint per acre. “Aphid days” refers to the sum of the mean number of aphids per cotton plant terminal per day over a defined period (Andrews and Kitten 1989). This concept was used to correlate cotton yield loss with cotton aphid densities as well as the duration of the infestation. For example, ten cotton aphids occurring in a plant terminal for ten days equals 100 aphid days, or 100 cotton aphids occurring in a plant terminal for one day equals 100 aphid days.

Another problem associated with cotton aphids is "honeydew", resulting in the contamination of cotton lint (Carter 1992). "Honeydew" contains plant sugars mixed with the insect hemolymph sugars, trehalose and melezitose (Brushwood and Han 2000). The deposit of "honeydew" on cotton lint can negatively impact quality quality. These sugars accumulate on harvesting and processing machinery, thus inhibiting speed and efficiency of harvesting and processing (Brushwood and Han 2000). The accumulation of "honeydew" on leaf surfaces may reduce photosynthesis and lead to premature senescence (Dorschner 1990). "Honeydew" also produces a food base for the growth of saprophytic fungi (*Capnodium* spp., *Cladosporium* spp. and *Fumago* spp.) on leaves, fruiting structures, and open bolls in humid conditions (Hillocks and Bretell 1992). These fungi may be a factor in causing plants to abort flower buds (squares) and small bolls (Isley 1946). Cotton bollworm, *Helicoverpa zea* (Boddie), adults; ants, *Solenopsis* spp.; and predatory insects are attracted to "honeydew" as a food source (Isley 1946, Slosser 1989, Torrey et al. 2000).

Agronomic Practices and Cotton Aphid Populations. Numerous agronomic practices used in cotton production affect aphid populations. In Louisiana, higher densities of cotton aphids were observed in no-tillage or reduced tillage systems compared to conventional tillage systems (Torrey et al. 2000, Jones et al. 2001). Ruberson et al. (1995) observed higher cotton aphid populations in cotton planted into no-till plots following crimson clover, *Trifolium incarnatum* L., as a winter cover crop compared to that in conventional-tillage plots with no winter cover crop. Planting date and plant density affected cotton aphid populations in Texas (Slosser et al. 1992). Cotton aphid densities were higher on cotton planted in late June compared to cotton planted in late April or May. Plots with low plant densities supported higher aphid numbers on individual plants because of higher plant moisture concentrations. Slosser et al. (2001) found higher cotton aphid densities in plots irrigated in September (late season) compared to those in plots that were not irrigated. The smooth-leaf isoline of DES 119 offered substantial resistance to the cotton aphid compared to hairy-leaf varieties (Weathersbee et al. 1995). Increasing nitrogen fertilizer rates resulted in an increase in cotton aphid densities on cotton plants in Texas and California (Slosser 1997, Godfrey and Keillor 1999), however, Andrews et al. (2000) and Jones et al. (2001) found cotton aphid populations were not affected by nitrogen fertilization rates.

Biological Control. Biological control of cotton aphids from predators, parasitoids, and pathogens has been extensively studied. Weathersbee and Hardee (1994) surveyed Mississippi cotton fields and identified several mirids including *Deraeocoris nebulosus* (Uhler); the big-eyed bug, *Geocoris punctipes* (Say); the minute pirate bug, *Orius insidiosus* (Say); along with several coccinellids, chrysopids/hemerobids; and nabids as important cotton aphid predators. In Texas, *Hippodamia* spp. (coccinellids) and *Chrysopa* spp. (chrysopids) are primary predators that regulate cotton aphid populations (Rummel and Kidd 1994). In Alabama, the previously mentioned species and spiders (Araneida) are important predators (Kerns and Gaylor 1993). In addition, a parasitic Braconid, *Lysiphlebus testaceipes* (Cresson), has been documented as an important control agent of cotton aphids (Kerns and Gaylor 1993, Hardee et al. 1994, Weathersbee and Hardee 1994).

The most important natural enemy of mid-season cotton aphids in the Mid-South region of the United States is the entomopathogenic fungus, *Neozygites fresenii* (Steinkraus and Lorenz 1997). This fungus, which is disseminated by wind, kills cotton aphids within three days after infection (Steinkraus and Boys 1998). Epizootics in cotton aphid populations normally develop from late June to early August. Populations are commonly reduced from peak densities to low numbers within five to ten days after the initial infection (Steinkraus et al. 1995). This fungus is an important integrated pest management (IPM) tool that eliminates the need for insecticide applications (Hollingsworth et al. 1995). When $\geq$ 15% of the cotton aphids in a field become infected with *N. fresenii,* a decline in the cotton aphid population usually occurs within seven days (Steinkraus and Lorenz 1997). The fungicide treatments, carboxin, chlorothalonil, etridiazole, and metalaxyl, used at-planting to manage cotton seedling diseases inhibit the prevalence of the aphid pathogenic fungus *N. frensenii* Batko. (Smith and Hardee 1996, Wells et al. 2000).

Chemical Control. The first reports of problems with cotton aphids occurred in the 1930's as a result of insecticide applications used for other pests. Outbreaks of the cotton aphid followed calcium arsenate applications for boll weevil, *Anthonomus grandis grandis* Boheman (Gains 1945, Isley 1946). Gains (1945), in Texas, reported the addition of 2% nicotine to calcium arsenate was effective in controlling boll weevil and prevented outbreaks of the cotton aphid. The cotton aphid emerged as an important cotton pest in the late 1980's when most recommended insecticides failed to provide satisfactory control (Hardee and Ainsworth 1993). Laboratory studies revealed high levels of tolerance to several organophosphates including oxydemeton-methyl, chlorpyrifos, and dicrotophos (Grafton-Cardwell 1991). Indiscriminate use of these insecticides and other organophosphates selects for cotton aphids with a high reproductive potential (O'Brien and Graves 1992). Cotton aphid resistance to insecticides also has been documented to the pyrethroids, bifenthrin and cypermethrin (Grafton-Cardwell 1999, Kerns and Gaylor 1992). In California, repeated pyrethroid applications to control the lygus bug, *Lygus hersperus* (Knight), caused cotton aphid populations to increase compared to that in non-treated fields (Godfrey and Keillor 1999). Cotton aphid resistance to insecticides has forced IPM managers to develop new chemical control strategies. Current insecticides recommended to manage cotton aphid populations in Louisiana include acetamiprid, dicrotophos, imidacloprid, and thiamethoxam (Bagwell et al. 2002). The experimental insecticide, pymetrozine (Fulfill®), is also efficacious against cotton aphids (Earnest et al. 2000, Koeing et al. 2000). During the 1998 through 2002 growing seasons, Louisiana and other cotton producing states were awarded emergency clearance approval (EPA, FIFRA Section 18's) for carbofuran to control cotton aphids.

Action Levels to Initiate Chemical Control Strategies. Cotton aphid action thresholds in selected cotton producing states are listed in Table 1. Mid-Season treatments are made to prevent potential yield loss in flowering stage and "honeydew" contamination during the boll maturity stages of plant development. The variation among threshold levels is probably attributed to the lack of research concerning cotton aphids and their effect on cotton yields. Most threshold levels are not precise and are based upon the level of aesthetic damage or percentage of infested plants. The exception is in Texas where seedcotton yield losses are consistently observed when cotton aphids exceed 50 insects per cotton leaf (Drees 1993).

Table 1. Action thresholds for cotton aphids in selected cotton producing states.

State	Action Threshold
Arkansas	Treat when aphid populations are building and aphids are present on 50% of the plants
California	Early Season: Treat when 50-75 aphids are present of 5th main stem node leaf for 7-10 days. Open Boll: Treat when mean density of aphids present on 5th main stem node is 10-15 for yellow aphids and 5 for black aphids
Georgia	Treat when aphids are abundant, seedling leaves are severely cupped or when honeydew is present on older cotton
Louisiana	Treat when honeydew and leaf crinkling are uniform
Mississippi	Treat when 11-25 aphids per terminal leaf or 50-100 aphids per plant leaf
Missouri	Treat when aphids are numerous, honeydew present
North Carolina	No treatment
Texas	Treat when >50 aphids per leaf (early bloom to first open boll)

MATERIALS AND METHODS

Insecticide Treatments and Application. In 2000, the insecticide used for control of cotton aphids was pymetrozine (Fulfill ® 50% Wettable Powder [WP], Syngenta Crop Protection, Greensboro, NC) at 0.29 g AI/hectare with a non-ionic surfactant (Kinetic 0.25% v/v, Helena Chemical Company, Memphis, TN). Pymetrozine was utilized because of its low toxicity to mammals and cotton aphid's natural enemies. In 2001, the insecticide treatment included thiamethoxam (Centric 40% WP, Syngenta Crop Protection, Greensboro, NC) at 0.116 g AI/hectare. Thiamethoxam is more efficacious than pymetrozine against cotton aphids and was used in 2001 to achieve a higher level of cotton aphid control. Insecticide applications were made with a John Deere® 6000 high clearance sprayer calibrated to deliver 94.6 liters/ha at 40 psi through TeeJet 8002 flat fan nozzles (two/row).

Sampling Procedures and Data Collection. Cotton aphid densities were quantified weekly from seedling emergence to mid-July. Thirty plant terminals (all apical growth including first fully expanded leaf) were randomly collected from whole plots and washed onto 300-mesh wire sieves, backwashed onto ruled filter paper (7 cm), and counted using a binocular dissecting scope (Burris et al. 1990). Weekly samples of cotton aphids from non-treated plots were preserved in vials of ethyl alcohol (70%) during both years and sent to the University of Arkansas's cotton aphid fungus identification laboratory (University of Arkansas, Fayetteville, AR). Cotton aphid samples were assayed for the presence of the entomopathogenic fungus, *N. fresenii* (Steinkraus et al. 1995). In all plots, the number of main stem nodes above the uppermost first position white flower (NAWF) was recorded from five plants per plot during July to compare plant maturity among insecticide treatments (Kerby et al. 1996).

Within each whole plot, two sections of row (one meter) were designated as micro-plots. Flags were placed at the origin and endpoint of a meter section in rows two and three of each whole plot on 16 May 2000 and 6 Jun in 2001. All plants were rated in each micro-plot to determine the percentage of cotton aphid infested plants. Cotton plant terminal ratings consisted of visually estimating cotton aphid populations on all apical growth including the first fully expanded leaf. Cotton plant terminals with $\geq$ 10 aphids per plant terminal were considered infested.

Seedcotton yields were collected during both years. In 2000, plant height, node number, vegetative and sympodial boll numbers, fruiting position boll weight (first, second, and third), and percent boll retention were recorded. In 2001, plant height, vegetative boll number, vegetative branch seedcotton yield, and sympodial branch seedcotton yield were recorded.

Cotton Aphid Effects on Irrigated and Non-Irrigated Cotton Plants-Macon Ridge. In 2000, cottonseed, (cv. NuCOTN 33B, Delta and Pine Land Co., Scott, MS) were planted 28 Apr at the LSU AgCenter's Macon Ridge Research Station (Franklin Parish) near Winnsboro, LA, using conservation tillage production practices. The soil at the site is a Gigger-Gilbert silt loam. A wheat, *Triticum aestivum* L., cover crop was planted the previous October to enhance the probability of aphid infestations. The whole plot size was four rows (101.6 cm row spacing) x 15.24 m. Micro-plot areas within whole-plots were selected 16 May. Plots were fertilized prior to planting with 100.8 kg of nitrogen (32% liquid) per hectare. Treatment combinations were arranged in a split-plot arrangement within a randomized complete block design with six replications. The main plot factor was irrigation regime, and included irrigated plots and non-irrigated plots. Plots were irrigated with an overhead sprinkler system calibrated to deliver 1.9 cm of water per hectare per application. Irrigation was applied 3, 7, 11, 13, 17, 24, Jul and 2, 8, 14, 13 Aug. The sub-plot factor consisted of pymetrozine-treated plots and non-treated plots. Pymetrozine treatments were applied on 2, 12, 16, 22, 30 Jun and 11, 20 Jul.

Cotton aphids were quantified in whole plots and rated in micro-plots 17, 24, 30 May; 8, 16, 21, 28, Jun; and 5 Jul. NAWF data was collected on 12, 20 Jul by counting NAWF on five randomly selected cotton plants with a first position white flower from each plot. Seedcotton was harvested 29 Sep from rows two and three of each plot using a mechanical harvester. Cotton plants within each micro-plot were hand-harvested 21 Sep to determine seedcotton yield. Plant density, plant height, and boll number were also recorded within each micro-plot at this time. Seedcotton yield per plant was determined by dividing the seedcotton yield from each section by the total number of plants from that section.

A third level of examination was also used to quantify the effects of cotton aphids on plants. Within each whole plot and separate from each micro-plot, approximately ten plants were marked with yellow snap-on tags (A. M. Leonard, Piqua, OH) on 1 Jun. These plants were selected prior to the first insecticide treatment application to control cotton aphids. Cotton plants infested with cotton aphids only were selected in the non-treated plots. As a comparison to infested plants, non-infested plants were marked in the pymetrozine-treated plots.

The pairs of infested and non-infested plants were mapped for individual boll location and boll weight prior to mechanical harvest. Plant height, sympodial internode length, number of vegetative branches, total sympodial branch nodes, total bolls, and total fruiting positions were recorded. Internode length was determined by using mid-point of nodes as an endpoint. Percent boll retention was determined by dividing total boll number by total fruiting positions. The distribution of seedcotton yield on vegetative and sympodial branches was determined by hand-harvesting bolls.

In 2001, cottonseed, (cv. NuCOTN 33B, Delta and Pine Land Co., Scott, MS) were planted 30 April, at the same location as the 2000 experiment. This experiment followed the same methods as the previous experiment with the exception of the sub-plot factors consisting of thiamethoxam at 0.116 g AI/hectare or no insecticide (non-treated) treatments. Acephate (Orthene 90SP, Valent U.S.A. Corporation, Walnut Creek, CA) at 280 g AI/ha was applied 15 May to minimize thrips damage. Thiamethoxam was applied to treated plots 13, 18, 26 Jun; and 2, 15, 25, 31 Jul. Micro-plot areas within whole-plots were selected 6 Jun. Cotton aphids were quantified 23, 28 May; 5, 13, 21, 25, 27, Jun; and 2, 9, 25, Jul. Cotton aphid populations were reduced by *N. fresenii* early in July and sampling was terminated during late Jul because of low population densities. Micro-plots were rated for percentage of cotton aphid infested plants 7, 13, 18, 22, 26 Jun; and 2, 25, 31 Jul. NAWF data was collected 12, 17, 25, 31 Jul. Seedcotton was harvested 19 Oct from rows two and three of each plot using a mechanical harvester. Cotton plants within each micro-plot were tagged at main stem node 13 with a yellow snap-on tag. This tag corresponded with the growing stage that *N. fresenii* eliminated cotton aphid populations. The distribution of bolls above and below main stem node 13 and on vegetative branches in each micro-plot were recorded and hand-harvested from 3 Oct to 20 Oct. The percentage of total yield contributed from each of the three respective sections was quantified by dividing the separate yields from each section by the total combined yield.

Cotton Aphid Effects on Non-Irrigated Cotton Plants-Macon Ridge. In 2000, cottonseed, (cv. NuCOTN 33B, Delta and Pine Land Co., Scott, MS) were planted 28 Apr, in a conservation tillage system similar to that used in the irrigated tests. Plots were eight rows (203.2 cm/row) x 15.24 m. Treatments were placed in a randomized complete block design with four replications. Treatments consisted of pymetrozine at 0.21 g AI/hectare plus a non-ionic surfactant (Kinetic 0.25% v/v, Helena Chemical Company, Memphis, TN) or no insecticide (non-treated). Pymetrozine was applied on 2, 12, 16, 22, 30 Jun; and 11, 20 Jul. Micro-plot areas within each whole plot were designated 16 May. Cotton aphids were quantified in whole plots and rated in micro-plots 17, 24, 30 May; 8, 16, 21, 28 Jun; and 5 Jul. NAWF data was collected 12 and 20 Jul. Seedcotton was harvested 18 Sep from the middle four rows of each plot using a mechanical harvester. Cotton plants within each micro-plot were hand-harvested 19 Sep to determine seedcotton yield after plant density, plant height, and boll number were recorded.

In 2001, cottonseed, (cv. NuCOTN 33B, Delta and Pine Land Co., Scott, MS) were planted 30 Apr, in a conservation tillage-system similar to that previously discussed. Plot size was eight rows (8.1m/row) x 15.24 m. Treatments were placed in a randomized complete block design with four replications. In 2001, insecticide treatments included thiamethoxam at 0.116 g AI/ha and no insecticide (non-treated). Acephate 280g AI/ha was applied 15 May to minimize thrips damage. Thiamethoxam was applied 13, 18, 26 Jun; and 2, 15, 25, 31 Jul. Micro-plot areas within each whole-plot were designated 6 Jun. Cotton aphids were quantified 23, 28 May; 5, 13, 21, 25, 27 Jun; and 2, 9, 25, Jul. Micro-plots were rated 7, 13, 18, 22, 26 Jun; and 2, 25, 31 Jul. NAWF data was collected 12, 17, 25, 31 Jul. Seedcotton was harvested 10 Oct from the middle four rows of each plot using a mechanical harvester.

Cotton Aphid Effects on Non-Irrigated Cotton Plants-Northeast. In 2001, cottonseed (cv. Suregrow 501 Bollgard-Roundup Ready, Delta and Pine Land Co., Scott, MS) were planted 28 Apr into a Sharkey Clay soil and were maintained as a stale seedbed cotton production system. Plots were located at the LSU AgCenter's Northeast Research Station (Tensas Parish) near St. Joseph, LA. Plots were eight rows (8.13m/row) x 10.67 m. Acephate 280g AI/ha was applied 18 May to minimize thrips damage across the test area. Insecticide treatments were arranged in a randomized complete block design with 4 replications. Treatments consisted of thiamethoxam at 0.116g AI/ha, and no insecticide. One application of thiamethoxam was applied 25 Jun to selected plots to control cotton aphids. Micro-plot areas within each whole-plot were designated 16 May and sampled 16, 21, 28 May; 11, 18, 25 Jun; and 2, 9, 25 Jul to determine the percentage of plant terminals infested with cotton aphids. Seedcotton was harvested 4 Oct from the middle two rows of each plot using a mechanical harvester.

Data Analysis. Cotton aphid densities were compared among treatments to determine significant differences on each sampling date in both years. Cotton aphid densities, seedcotton yields, and cotton plant growth characteristics were determined in the irrigated and non-irrigated tests using the SAS MIXED procedure, with means being separated using Tukey's studentized range test (SAS Institute 1989). Paired t-tests were used to compare insect densities, cotton plant growth components, and seedcotton yields in the non-irrigated tests at the Macon Ridge and Northeast Research Stations (Proc TTEST, SAS Institute 1989).

RESULTS

Cotton Aphid Effects on Irrigated and Non-Irrigated Cotton Plants-Macon Ridge. In 2000, cotton aphid densities in non-treated plots ranged from zero at seedling emergence to 90 per plant terminal on 20 Jun (Figure 1). Cotton aphid infested plants ranged from 1.3% to 58.8% in the irrigated regime and from 1.1% to 85.8% in the non-irrigated plots (Table 2). No significant irrigation by insecticide interaction was observed. There was a significant irrigation effect observed on 16 Jun [F(1,39) = 29.67, P <0.0001] and 20 Jun [F(1,39) = 9.15, P = 0.0292). On these dates, there were significantly more infested plants in non-irrigated plots than irrigated plots. There were no significant insecticide or irrigation effects at any other rating date. The entomopathogenic fungus, *N. fresenii*, reduced cotton aphid densities by the last week of Jun and populations remained low for the remainder of the growing season. There also were significant differences in the percentage of cotton aphid infested plants among insecticide treatments on 7 Jun [F(1,39) = 23.00, P <0.0049] and 16 Jun [F(1,39) = 37.98, P <0.0016]. Plots treated with

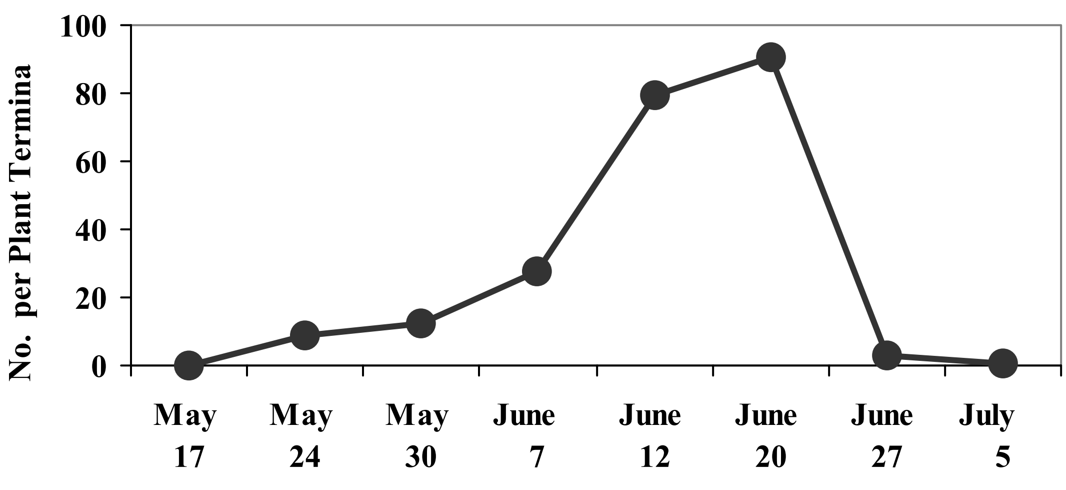

Figure 1. Cotton aphid density in non-treated plots-Macon Ridge, 2000.

pymetrozine had significantly fewer infested plants than non-treated plants. Cotton aphid infested plants ranged from 40.2% in the pymetrozine treated plots and 85.3% in the non-irrigated regime on 16 Jun.

In 2001, cotton aphid densities ranged from zero at emergence to 120 per plant terminal on 26 Jun (Figure 2). There was no significant irrigation by insecticide interaction observed for each rating date. There was no significant irrigation effect observed at any rating date. The percentage of infested plants ranged from 0.7% to 61.8% in the irrigated plots and from 1.9% to 56.8% in the non-irrigated plots (Table 3). There were significant differences in the percentage of cotton aphid infested plants among insecticide treatments on 18 Jun [$F(1,3) = 10.08$, $P = 0.0572$], 26 Jun [$F(1,3) = 42.60$, $P = 0.0073$], 25 Jul [$F(1,3) = 11.45$, $P = 0.0430$], and 31 Jul [$F(1,3) = 18.37$, $P = 0.0233$]. Thiamethoxam-treated plots contained significantly fewer cotton aphids than non-treated plots in both irrigated and non-irrigated plots. *N. fresenii* reduced cotton aphid populations during the first week of July.

Table 2. Percent cotton aphid infested cotton plants in pymetrozine treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2000.

			Percent Cotton Aphid Infested Plants					
			Irrigated			Non-Irrigated		
Date of Sample	Days Post Treatment	Insecticide P>F	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
7 June	5 DAT1[2]	0.0049	18.0	47.8	32.9	26.5	54.8	40.7
16 June	4 DAT2	0.0016	13.1	44.6	28.9	40.2	85.3	62.8
20 June	4 DAT3	0.0728	40.3	58.8	49.6	55.8	78.8	67.3
27 June	5 DAT4	0.1845	2.3	4.6	6.9	3.1	8.8	5.9
5 July	6 DAT5	0.2297	1.3	2.2	1.8	1.1	3.2	2.2

[1] Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21g AI/ha.
[2] DAT = days after treatment.

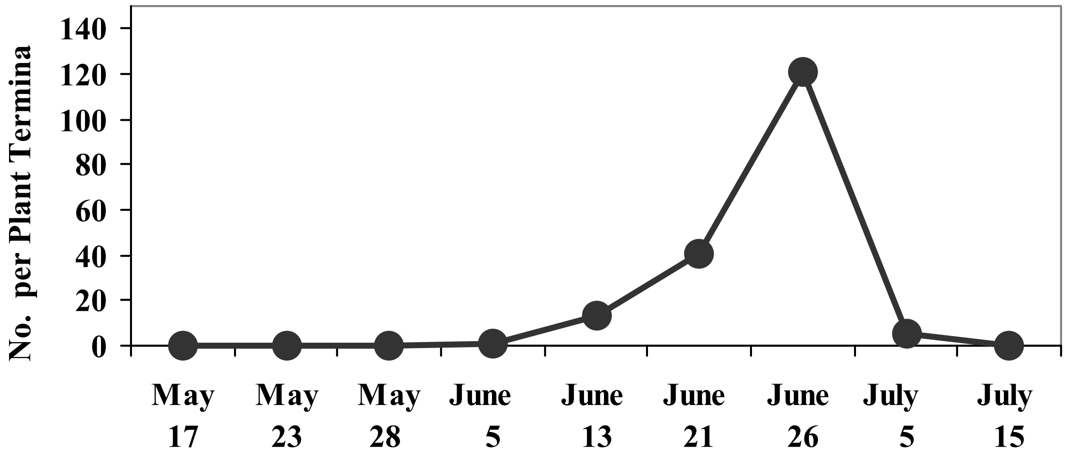

Figure 2. Cotton aphid density in non-treated plots-Macon Ridge, 2001.

Table 3. Percent cotton aphid infested cotton plants in thiamethoxam treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2001.

			Percent Cotton Aphid Infested Plants					
			Irrigated			Non-Irrigated		
Date of Sample	Post Treatment	Insecticide P>F	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
7 June	6 DBT1[2]	0.2016	13.2	0.7	6.9	5.5	6.3	5.9
13 June	0 DAT1[3]	0.7789	38.8	35.0	36.9	32.5	41.9	37.2
18 June	5 DAT1	0.0503	14.5	38.8	26.7	10.0	37.5	23.8
26 June	8 DAT2	0.0073	19.4	61.8	40.6	15.4	56.8	36.1
2 July	6 DAT3	0.0572	10.7	39.9	25.3	12.5	53.4	32.9
25 July	10 DAT5	0.0430	0.7	38.5	19.6	2.7	34.9	18.8
31 July	6 DAT6	0.0233	1.9	14.4	8.2	1.9	13.8	7.9

[1]Thiamethoxam applied 13, 18, 26 Jun; and 2, 15, 25, 31 Jul at 0.116 g AI/ha.
[2] DBT = days before treatment.
[3] DAT = days after treatment.

In 2000, no significant irrigation and insecticide treatment interaction was observed for plant height [F (1,433) = 0.15, P = 0.06953]. However, there was a significant irrigation effect on plant height [F (1,5) = 34.46, P = 0.0020]. Cotton plants in irrigated plots (87.6 cm) were significantly taller than plants in non-irrigated plots (69.5 cm). There was no insecticide treatment effect on plant height [F (1,5) = 0.52, P = 0.5046] (Table 4).

No significant irrigation and insecticide treatment interaction occurred for the number of main stem fruiting nodes [F(1,433) = 1.32, P = 0.2507]. There was a significant irrigation effect [F(1,5) = 12.6, P = 0.0245]. Plants in irrigated plots had significantly more fruiting nodes than non-irrigated plants. There was no significant insecticide treatment effect [F(1,5) = 1.83,P = 0.2338] (Table 4) on the number of main stem fruiting nodes.

There was no irrigation and insecticide treatment interaction observed for the number of total fruiting positions per plant [F(1,433) = 0.39, P = 0.5312]. There was a significant irrigation effect [F(1,5) = 10.97, P = 0.0212]. Irrigated plants produced significantly more total fruiting positions than non-irrigated plants. The number of total fruiting positions was 33.4 in the irrigated regime and 24.6 in the non-irrigated regime. There was no significant insecticide treatment effect [F(1,5) = 0.31, P = 0.6008] (Table 4).

No significant irrigation and insecticide treatment interaction was observed for the number of sympodial bolls [F(1,433) = 0.02, P = 0.8793]. However, there was a significant irrigation treatment effect [F(1,5) = 7.52, P = 0.0407]. Irrigated plants had significantly more bolls than plants within non-irrigated plots. Sympodial bolls ranged from 8.7 to 12.9 bolls per plant across irrigation regimes. There was no significant insecticide treatment effect observed [F(1,5) = 0.08, P = 0.7836] (Table 4).

Table 4. Cotton aphid effects on cotton plant growth parameters in irrigated and non-irrigated micro-plots-Macon Ridge, 2000.

		Irrigated			Non-Irrigated		
Plant Characteristic	Insecticide (P>F)	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
Height (cm)	0.5046	86.8	88.4	87.6	69.5	70.3	69.9
Vegetative Branches	0.8322	2.0	2.1	2.1	2.1	2.1	2.1
Main Stem Fruiting Nodes	0.2338	12.4	12.9	12.7	10.9	11.0	10.9
Total Main Stem Fruiting Positions	0.6008	32.9	33.9	33.4	24.6	24.6	24.6
Sympodial Bolls	0.7836	12.9	13.0	12.9	8.8	8.6	8.7
Vegetative Bolls	0.7284	4.2	5.0	4.6	2.6	2.2	2.4

[1]Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21 g AI/ha.

In 2000, no significant irrigation and insecticide treatment interaction was observed for bolls on vegetative branches [F(1,433) = 2.14, P = 0.1441]. There also was no irrigation effect [F(1,5) = 4.72, P = 0.0891] and no insecticide treatment effect [F(1,5) = 0.13, P = 0.7284] (Table 4).

In 2001, there was no significant irrigation and insecticide treatment interaction for cotton plant height [F (1, 518) = 0.01, P = 0.9384]. There was also no irrigation effect [F (1, 3) = 0.21, P = 0.6792] and no insecticide treatment effect [F (1, 3) = 1.25, P = 0.3445] (Table 5). Plant height averaged 92.1 cm/plant in irrigated plots and 91.5 cm/plant non-irrigated plots.

In 2001, there was no significant irrigation and insecticide treatment interaction observed for the number of bolls on vegetative branches [F (1, 518) = 0.24, P = 0.6238]. There was also no significant irrigation [F (1, 3) = 3.45, P = 0.1602] or insecticide treatment effect [F (1, 3 = 1.31, P = 0.3359] (Table 5).

Table 5. Cotton aphid effects on cotton plant growth parameters in irrigated and non-irrigated micro-plots-Macon Ridge, 2001.

		Irrigated			Non-Irrigated		
Plant Characteristic	Insecticide (P>F)	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
Height (cm)	0.3445	92.9	91.2	92.1	91.9	90.2	91.5
Vegetative Bolls/Plant	0.3559	0.58	0.84	0.71	0.36	0.46	0.41

[1]Thiamethoxam applied 13, 18, 26 Jun, and 2, 15, 25, 31 Jul at 0.116 g AI/ha.

In 2000, there was no significant irrigation by insecticide treatment interaction observed for plant maturity as measured by the days to reach NAWF < four [F(1,29) = 0.38, P = 0.5424]. There was also no insecticide effect [F(1,5) = 0.03, P = 0.8731] (Table 6). However, there was a significant irrigation effect [F(1,5) = 25.92, P = 0.0038]. Plants in irrigated plots required more time to reach NAWF ≤ four than those in non-irrigated plots. Days to reach NAWF ≤ four ranged from 75.6 to 81.1 across irrigation regimes.

Table 6. Days after planting to nodes above uppermost first position white flower four in aphicide treated and non-treated plots in irrigated and non-irrigated regimes-Macon Ridge, 2000 and 2001.

		Irrigated			Non-Irrigated		
	Treatment (P>F)	Treated	Non-Treated	Mean	Treated	Non-Treated	Mean
2000[1]	0.8731	80.8	81.4	81.1	75.4	75.8	75.6
2001[2]	0.2594	82.6	83.2	82.9	78.8	80.1	79.5

[1] Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21g AI/ha.
[2] Thiamethoxam applied 13, 18, 26 Jun; and 2, 15, 25, 31 Jul at 0.116 g AI/ha.

In 2001, no significant irrigation and insecticide interaction occurred for plant maturity as measured by the days to reach NAWF $<$ four [F(1,29) = 1.21, P = 0.2794]. However, there was a significant irrigation effect [F(1,5) = 17.90, P = 0.0082]. Plants in irrigated plots required more time to reach NAWF ≤ four compared to in non-irrigated plots. The number of days to reach NAWF ≤ four was 79.5 in the non-irrigated plots and 82.9 days in irrigated plots. There was no insecticide treatment effect [F(1,5) = 1.62 , P = 0.2594] (Table 6).

For yields in the mechanically harvested whole plots, no significant irrigation and insecticide interaction was observed for yields [F(1,28.3) = 0.19, P = 0.6684] in 2000. However, irrigation significantly increased seedcotton yield [F(1,8.73) = 19.50, P = 0.0018]. In 2000, Seedcotton yields averaged 611.2 kg/ha and 364.5 kg/ha in irrigated and non-irrigated regimes, respectively. There also was no insecticide treatment effect observed [F(1, 6.7) = 0.10, P = 0.9819] on yields (Table 7).

In 2001, no significant irrigation and insecticide treatment interaction was observed for seedcotton yield [F(1,19) = 2.35; P = 0.1419]. However, irrigation significantly increased seedcotton yield [F(1,3) = 29.79, P = 0.0121]. Seedcotton yields averaged 596.3 kg/ha in the irrigated plots and 376.8 kg/ha in the non-irrigated plots. Insecticide treatment did not affect seedcotton yield [F(1,3) = 1.27, P = 0.3418] (Table 7).

In the micro-plots during 2000, there was no significant irrigation by insecticide treatment interaction for seedcotton yield [F(1,22) = 0.21, P = 0.6521]. However, there was a significant irrigation effect [F(1,22) = 6.76, P = 0.0164] on seedcotton yield. Seedcotton yields in the irrigated plots were significantly higher than yields in the non-irrigated regime. Seedcotton yields ranged from 440.8 g/micro-plot in the non-irrigated regime to 630.9 g/micro-plot in the irrigated regime.

There was no insecticide treatment effect [F(1,3) = 0.02, P = 0.9026] on seedcotton yields (Table 8).

Table 7. Cotton aphid effects on whole plot seedcotton yields in aphicide treated and non-treated plots in irrigated and non-irrigated regimes-Macon Ridge, 2000 and 2001.

		Seedcotton Yield (kg/ha)					
		Irrigated			Non-Irrigated		
Year	Treatment (P>F)	Treated	Non-Treated	Mean	Treated	Non-Treated	Mean
2000[1]	0.9819	605.2	617.1	611.2	367.1	361.9	364.5
2001[2]	0.3418	575.5	617.1	596.3	379.7	373.8	376.8

[1] Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21 g AI/ha.
[2] Thiamethoxam applied 13, 18, 26 Jun; and 2, 15, 25, 31 Jul at 0.116 g AI/ha.

Table 8. Cotton aphid effects on micro-plot seedcotton yield in aphicide treated and non-treated plots in irrigated and non-irrigated regimes-Macon Ridge, 2000.

		Seedcotton Yield g/micro-plot					
		Irrigated			Non-Irrigated		
	Treatment (P>F)	Treated	Non-Treated	Mean	Treated	Non-Treated	Mean
Total	0.9026	619.2	642.7	630.9	462.5	419.1	440.8

[1]Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21 g AI/ha.

In 2001, no significant irrigation by insecticide interaction was observed for total yield [F(1,22) = 0.88, P = 0.3591] in the micro-plots. Irrigation significantly influenced micro-plot yield [F(1,22) = 58.02, P = 0.0001]. Seedcotton yield was significantly higher in irrigated plots than in non-irrigated plots. Seedcotton yield ranged from 681.4 g/micro-plot in the irrigated plots to 359.2 g/micro-plot in the non-irrigated plots. Insecticide treatment did not influence yield [F(1,3) = 0.34, P = 0.5984] (Table 9).

There was no significant irrigation and insecticide treatment interaction for seedcotton harvested on vegetative branches [F (1,28) = 0.22, P = 0.6450]. No irrigation [F(1,28) = 1.36, P

= 0.2530] or insecticide treatment [F(1,28) = 0.61, P = 0.4408] effect on yields was observed (Table 9). Seedcotton yield from vegetative branches was 78.8 g/micro-plot in the irrigated plots and 60.1 g/micro-plot in the non-irrigated plots.

There was no irrigation and insecticide interaction observed for the seedcotton yield in cotton aphid infested plant zone (node 1 to node 13) [F(1,25) = 1.95, P = 0.1753]. However, irrigation significantly increased seedcotton yields [F(1,25) = 57.32, P = 0.0001]. Seedcotton

Table 9. Distribution of seedcotton yield on plants from aphicide treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2001.

		Seedcotton Yield (g/6 m micro-plot)					
		Irrigated			Non-Irrigated		
Plant Zone	Treatment (P>F)	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
Total	0.5984	648.9	713.8	681.4	366.4	351.9	359.2
Vegetative	0.4408	81.2	76.3	78.8	70.3	50.8	60.1
Infested[2]	0.0601	419.7	508.5	464.1	256.9	272.0	264.5
Non-Infested[3]	0.4412	147.9	128.9	138.4	39.2	29.1	34.2

[1]Thiamethoxam applied 13, 18, 26 Jun; and 2, 15, 25, 31 Jul at 0.116 g AI/ha.
[2] Yield on sympodial branches 1-13.
[3] Yield on sympodial branches $\geq$14.

yield in the infested zone averaged 464.1 g/micro-plot in the irrigated plots and 264.5 g/micro-plot in the non-irrigated plots. No insecticide treatment effect occurred [F(1,25) = 3.88, P = 0.0601] (Table 9).

No significant irrigation and insecticide interaction was observed for seedcotton yield harvested from non-infested zones (nodes > 13) [F(1,25) =31.58, P =0.06]. However, irrigation significantly increased seedcotton yield [F (1,25) = 31.58, P = 0.0001] above that in the non-irrigated zone. Seedcotton yield averaged 138.4 g/micro-plot in the irrigated plots and 34.2

g/micro-plot in the non-irrigated plots. Insecticides did not influence cotton yield [F(1,25) = 0.61, P = 0.4412] in this zone (Table 9).

There was no significant irrigation and insecticide treatment interaction for percent retention of first position bolls [F (1, 518) = 0.01, P = 0.9856]. However, irrigation did influence retention [F (1, 3) = 84.85, P = 0.0027]. The percentage of first position bolls retained was significantly higher in irrigated (42.8) plots compared to non-irrigated plots (30.1). Insecticide treatment did not influence first position boll retention [F (1, 3) = 0.01, P = 0.9442] (Table 10). No significant irrigation and insecticide treatment interaction occurred for second position boll retention [F (1, 518) = 0.06, P = 0.8022]. However, irrigation significantly influenced retention [F (1, 3) = 91.88, P = 0.0024]. Boll retention was significantly higher in irrigated (29.7) plots compared to non-irrigated (11.3) plots. Insecticide treatment did not influence second position boll retention [F (1, 3) = 0.95, P = 0.4014]. No significant irrigation and insecticide interaction occurred for third position boll retention [F (1, 518) = 0.04, P = 0.8474]. Irrigation did influence retention [F (1, 3) = 29.29, P = 0.0124]. Plants in the irrigated plots retained significantly more third position bolls (7.4) than plants in the non-irrigated regime (1.9). Insecticide treatment did not influence third position boll retention [F (1, 3) = 0.53, P = 0.5206].

In 2000, on aphid-infested and non-infested paired plants, no significant irrigation and insecticide treatment interaction was observed for seedcotton yield on vegetative branches [F(1,25) = 1.30, P = 0.2655]. A significant irrigation effect was observed [F(1,25) = 5.60, P = 0.0260]. Seedcotton yields harvested from vegetative branches in the irrigated regime were significantly higher compared to the non-irrigated regime. Seedcotton yields from vegetative branches were 156.2 g/10 plants in irrigated plots and 89.0 g/10 plants in the non-irrigated plots. No significant insecticide treatment effect was observed for seedcotton yields from vegetative

Table 10. Cotton aphid effects on cotton boll retention at first, second, and third fruiting positions in aphicide treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2001.

		Percent Boll Retention					
		Irrigated			Non-Irrigated		
Boll Position	Treatment (P>F)	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
First	0.9442	42.7	42.8	42.8	30.9	31.0	30.1
Second	0.4014	29.1	30.2	29.7	10.4	12.2	11.3
Third	0.5206	7.9	6.9	7.4	2.2	1.7	1.9

[1]Thiamethoxam applied 13, 18, 26 Jun; and 2, 13, 25, 31 Jul at 0.116 g AI/ha.

branches [F(1,25) = 0.02, P = 0.8760] (Table 11). No significant irrigation and insecticide treatment interaction occurred for seedcotton yield in the cotton aphid infested plant zone [F(1,22) = 0.05, P = 0.8311]. Yields were significantly higher in irrigated plots [F(1,22) = 4.51, P = 0.0453] compared to the non-irrigated regime. Seedcotton yields harvested from cotton aphid infested branches averaged 351.7 g/10 plants in the irrigated regime and 278.3 g/10 plants in the non-irrigated regime. No significant insecticide treatment effect was observed for seedcotton yields harvested from cotton aphid infested branches [F(1,3) = 0.37, P = 0.5882]. No significant irrigation and insecticide treatment interaction occurred for seedcotton yield in the non- infested plant zones [F(1,25) = 0.20, P = 0.6574]. Seedcotton yields were significantly higher [F(1,25) =12.41, P = 0.0017] in irrigated plots compared to the non-irrigated plots. Seedcotton yields were 123.1 g/10 plants in irrigated plots and 73.5 g/10 plants in the non-irrigated plots. There also was no significant insecticide treatment effect observed for seedcotton harvested from non-infested plant zones [F(1,25) =1.62, P = 0.2143]. yields harvested from cotton aphid infested branches [F(1,3) = 0.37, P = 0.5882].

Table 11. Distribution of seedcotton yield on plants from aphicide treated and non-treated plants in irrigated and non-irrigated regimes-Macon Ridge, 2000.

		Seedcotton Yield g/10 plants per plot					
		Irrigated			Non-Irrigated		
Plant Zone	Treatment (P>F)	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
Total	0.9026	619.2	642.7	630.9	462.5	419.1	440.8
Vegetative	0.8760	142.2	170.1	156.2	107.4	70.6	89.0
Infested[2]	0.5882	359.7	343.7	351.7	293.8	262.8	278.3
Non-Infested[3]	0.2143	117.2	128.9	123.1	61.4	85.6	73.5

[1]Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21 g AI/ha.
[2] Yield on sympodial branches 1-13.
[3] Yield on sympodial branches $\geq$ 14.

No significant irrigation and insecticide treatment interaction occurred for seedcotton yield in the non- infested plant zones [$F(1,25) = 0.20$, $P = 0.6574$]. Seedcotton yields were significantly higher [$F(1,25) = 12.41$, $P = 0.0017$] in irrigated plots compared to the non-irrigated plots. Seedcotton yields were 123.1 g/10 plants in irrigated plots and 73.5 g/10 plants in the non-irrigated plots. There also was no significant insecticide treatment effect observed for seedcotton harvested from non-infested plant zones [$F(1,25) = 1.62$, $P = 0.2143$].

There was no significant irrigation and insecticide interaction on the boll weights from the first fruiting position on fruiting nodes one through 15. First position boll weights ranged from 0.15 g/boll at the 14th fruiting node, (irrigated, treated), to 3.89 g/boll at the 2nd fruiting node (irrigated, treated) (Table 12). There was a significant irrigation effect on boll weight at the 5th fruiting node [$F(1,5) = 6.90$, $P = 0.0467$], 7th fruiting node [$F(1,5) = 16.84$, $P = 0.0093$], and 8th fruiting node [$F(1,5) = 17.88$, $P = 0.0083$]. Insecticide treatments did not affect first position boll seedcotton weight.

There was no significant irrigation by insecticide interaction for second fruiting position boll weight on fruiting nodes one through 13. First position boll weights ranged from 0.28 g/boll at the 13th fruiting node, (irrigated, non-treated), to 2.59 g/boll at the 1st fruiting node (irrigated, treated) (Table 13). There was a significant irrigation effect on boll weights at the 1st fruiting node [F(1,5) = 8.20, P = 0.0352], 2nd fruiting node [F(1,5) = 8.49, P = 0.0333], and 5th fruiting node [F(1,5) = 7.65, P = 0.0395]. Second position bolls at the 1^{st,}, 2^{nd,} and 5th fruiting nodes in irrigated plots weighed significantly more than second position bolls at the respective positionsin non-irrigated plots. Insecticide treatments did not affect second position boll seedcotton weights.

There was no significant irrigation by insecticide interaction for third fruiting position boll weight on fruiting nodes one through 12. Third position boll weights ranged from 0.05 g/boll at the 10th fruiting node (irrigated, non-treated) to 1.13 g/boll at the fruiting 5th node (non irrigated, non-treated) (Table 14). There was a significant irrigation effect on boll weights at the 1st fruiting node [F(1,5) = 6.79, P = 0.0479], and the 2nd fruiting node [F(1,5) =- 13.19, P = 0.0150]. Third position bolls in irrigated plots weighed more than those in non-irrigated plots. Insecticide treatments did not affect third position boll seedcotton weight.

Cotton Aphid Effects on Non-Irrigated Cotton Plants-Macon Ridge, 2000. Cotton aphid densities ranged from zero per plant terminal at emergence to 33.9 per plant terminal on 20 June (Figure 3). The percentage of cotton aphid infested plants ranged from zero at emergence to 52.6 in the non-pymetrozine treated plots on 20 Jun. There were no significant differences in the percentage of cotton aphid infested plants on 7 Jun [F (7,7) = 1.69, P = 0.5044], 20 Jun [F (7,7) = 2.98, P = 0.1728], 3 Jul [F (7,7) = 1.04, P = 0.9628] (Table 15). However, pymetrozine significantly reduced cotton aphid populations on 27 Jun [F (7,7) = 6.02, P = 0.0304] and 11 Jul [F (7,7) = 26.78, P = 0.0003]. There was no significant insecticide treatment effect for

Table 12. Cotton aphid effects on boll weights at first position sites on fruiting branches for aphicide treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2000.

		Yield/boll (g)					
		Irrigated			Non-Irrigated		
Fruiting Node	Treatment P>F	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
1	0.9635	3.41	3.56	3.47	3.38	3.21	3.30
2	0.3909	3.89	3.79	3.84	3.76	3.52	3.64
3	0.3154	3.52	3.36	3.44	3.41	3.11	3.26
4	0.8462	3.12	3.32	3.17	2.99	2.69	2.84
5	0.3655	2.72	3.22	2.97	1.98	1.89	1.94
6	0.2632	2.34	2.06	2.20	1.44	1.03	1.24
7	0.2304	1.71	2.24	1.98	0.82	0.95	0.89
8	0.9877	1.59	1.68	1.64	0.67	0.59	0.63
9	0.0766	0.82	1.14	0.98	0.56	1.21	0.89
10	0.8919	1.39	1.51	1.45	1.03	0.97	1.00
11	0.6630	1.18	1.61	1.40	0.77	0.63	0.70
12	0.3179	0.51	0.97	0.74	0.19	0.50	0.35
13	0.1284	0.31	0.70	0.51	0.20	0.48	0.34
14	0.2554	0.15	0.27	0.21	n/a[2]	0.37	n/a
15	0.5932	n/a	0.16	n/a	n/a	0.23	n/a

[1] Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 22 Jul at 0.21 g AI/ha.
[2] No bolls were present for harvest.

Table 13. Cotton aphids effects on boll weights at second position sites fruiting branches for aphicide treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2000.

		Yield/boll (g)					
		Irrigated			Non-Irrigated		
Fruiting Node	Treatment P>F	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
1	0.1293	2.59	2.00	2.30	1.75	1.59	1.67
2	0.4817	2.23	1.85	2.04	1.45	1.32	1.39
3	0.4959	1.42	1.86	1.64	1.08	0.91	0.99
4	0.6831	1.50	1.61	1.56	1.05	0.74	0.89
5	0.8306	1.42	1.52	1.47	0.70	0.68	0.69
6	0.4482	0.92	1.10	1.01	0.64	0.70	0.67
7	0.2600	1.03	1.09	1.06	0.53	0.93	0.73
8	0.5530	0.84	1.16	1.00	1.39	0.45	0.92
9	0.7996	1.09	1.76	1.43	0.80	0.89	0.85
10	0.7328	0.64	0.73	0.69	0.38	0.57	0.48
11	0.5715	0.55	0.39	0.47	n/a[2]	0.71	n/a
12	0.6049	n/a	0.53	n/a	n/a	n/a	n/a
13	0.9267	0.32	0.28	0.30	n/a	n/a	n/a

[1] Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 22 Jul at 0.21 g AI/ ha.
[2] No bolls were present for harvest.

Table 14. Cotton aphid effects on boll weights at third position sites on fruiting branches for aphicide treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2000.

		Yield/boll (g)					
		Irrigated			Non-Irrigated		
Fruiting Node	Treatment P>F	Treated[1]	Non-Treated	Mean	Treated[1]	Non-Treated	Mean
1	0.6971	1.05	0.75	0.90	0.34	0.49	0.42
2	0.9840	0.99	0.90	0.95	0.31	0.40	0.36
3	0.6136	0.54	0.69	0.62	0.42	0.44	0.43
4	0.9635	0.90	0.70	0.80	0.34	0.52	0.43
5	0.1252	0.75	1.01	0.88	0.49	1.13	0.81
6	0.4402	1.01	0.84	0.93	0.96	0.80	0.88
7	0.9804	0.93	0.87	0.90	0.78	0.83	0.81
8	0.4856	0.33	0.53	0.43	n/a[2]	0.29	n/a
9	0.7274	0.36	0.06	0.21	n/a	n/a	n/a
10	0.4426	n/a	0.05	n/a	n/a	n/a	n/a
11	0.5371	n/a	0.33	n/a	n/a	n/a	n/a
12	0.7117	n/a	0.40	n/a	n/a	n/a	n/a

[1]Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 22 Jul at 0.21 g AI/ha.
[2] No bolls were present for harvest.

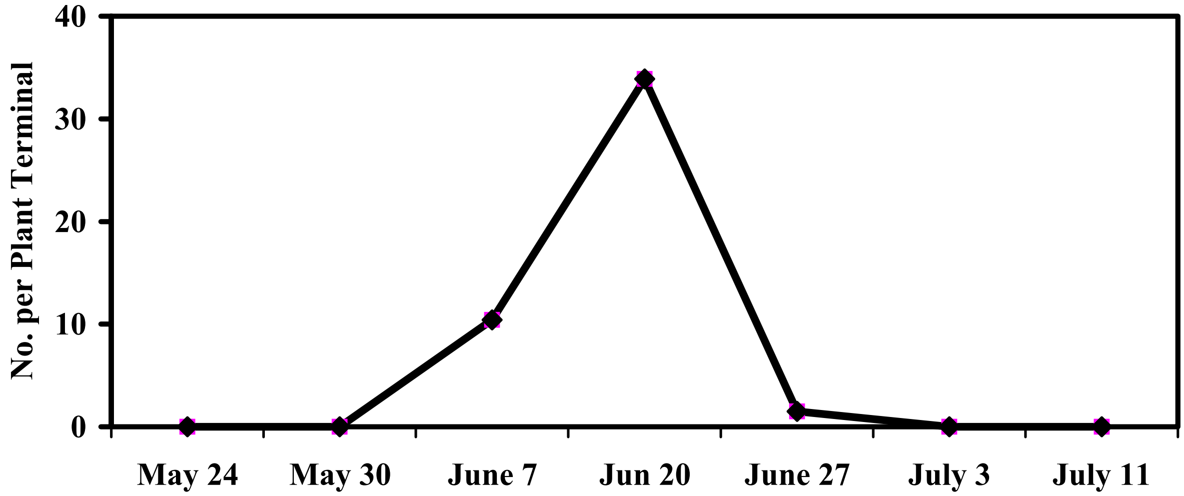

Figure 3. Cotton aphid density in non-irrigated, non-treated plots-Macon Ridge, 2000.

Table 15. Percent cotton aphid infested cotton plants for pymetrozine treated and non-treated micro-plots in irrigated and non-irrigated regimes-Macon Ridge, 2000.

			Percent Infested Plants		
Date of Sample	Post Treatment	Insecticide P>F	Treated[1]	Non-Treated	Mean
07 June	5 DAT1[2]	0.5044	6.6	6.8	6.7
20 June	4 DAT2	0.1728	38.6	52.6	45.6
27 June	5DAT3	0.0304	6.6	18.6	12.6
03 July	4 DAT 4	0.9628	2.6	1.7	2.2
11 July	11 DAT4	0.0003	0.8	10.3	5.6

[1] Pymetrozine applied 2, 16, 22, 30 Jun; and 11, 20 Jul at 0.21g AI/ha.
[2] DAT = days after treatment.

seedcotton yield [F(6,6) = 5.14, P = 0.0666]. Seedcotton yields averaged 1251.9 kg/ha in the non-pymetrozine treated plots and 1285.3 kg/ha in pymetrozine treated plots in micro-plots. No significant insecticide treatment effect was observed for plant height [F(6,6) = 1.05, P = 0.9534] (Table 16). The number of bolls per plant did not significantly differ between insecticide treatments [F (5,6) = 4.73, P = 0.0851]. There was no significant insecticide treatment effect observed on seedcotton yield per plant [F (6,6) = 5.71, P = 0.0522].

Table 16. Cotton aphid effects on plant growth parameters for aphicide treated and non-treated micro-plots in a non-irrigated regime-Macon Ridge, 2000.

Plant Character	Insecticide (P>F)	Treated[1]	Non-Treated
Plant Height (cm)/ plant	0.9534	75.0	75.1
Boll No./ Plant	0.0851	6.9	7.5
Seedcotton Yield/ plant (g)	0.0522	27.2	25.9

[1]Pymetrozine applied 2, 12, 16, 22, 30 Jun; and 11, 20 Jul at 0.21 g AI/ha.

Cotton Aphid Effects on Non-Irrigated Cotton Plants-Macon Ridge, 2001. Cotton aphid densities ranged from zero per terminal on 28 May to 60 per terminal on 27 Jun (Figure 4). There were no significant differences in the percentage of infested plants between insecticide treatments on 7 Jun [F (7,7) = 2.14, P = 0.3361], 13 Jun [F (7,7) = 1.34, P = 0.7114], 18 Jun [F(7,7) = 4.56, P = 0.0634] (Table 17). However, thiamethoxam significantly reduced cotton aphids on 26 Jun [F (7,7) = 9.44, P = 0.0084] and 2 Jul [F (7,7) =18.1, P = 0.0011]. Thiamethoxam did not influence seedcotton yields [F (7,7) = 2.25, P = 0.3063. Seedcotton yields were 2420.1kg/ha in treated plots and 2168.6 kg/ha in non-treated plots.

Cotton Aphid Effects on Non-Irrigated Cotton Plants-St. Joseph, 2001. Cotton aphid populations ranged from zero at 28 May to 60.7 aphids per plant terminal on 2 Jul (Figure 5). There were no significant differences in the percentage of infested plants on any sample date (Table 18). There was no significant insecticide effect on cotton yields [F (7,7) = 1.11, P = 0.8932]. Seedcotton yields were 1955.5 kg/ha in treated plots and 2363.8 kg/ha in non-treated plots.

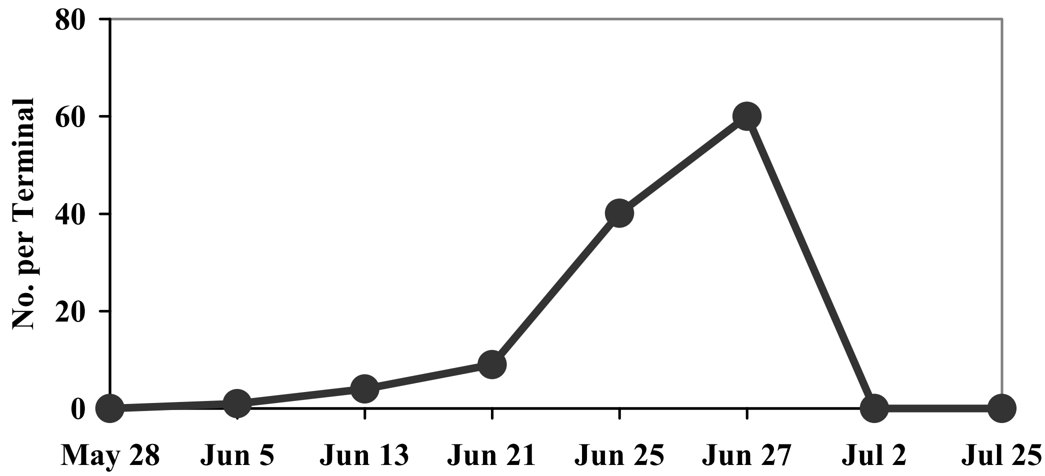

Figure 4. Cotton aphid density in non-irrigated, non-treated plots-Macon Ridge, 2001.

Table 17. Percent cotton aphid infested cotton plants for thiamethoxam treated and non-treated micro-plots in a non-irrigated regime-Macon Ridge, 2001.

Date	Days Post Treatment	Treatment (P>F)	Percent Infested Plants		
			Treated[1]	Non-Treated	Mean
7 June	Pre-Treat	0.3361	0.6	1.9	1.3
13 June	0 DAT1[2]	0.7114	31.9	32.5	32.2
18 June	5 DAT1	0.0634	10.0	32.5	21.3
26 June	8 DAT2	0.0084	47.3	69.8	58.6
2 July	6 DAT3	0.0011	18.8	53.9	36.4

[1] Thiamethoxam applied 13, 18, 26 Jun; 2, 15, 25, 31 Jul at 0.116 g AI/ha.
[2] DAT= days after treatment.

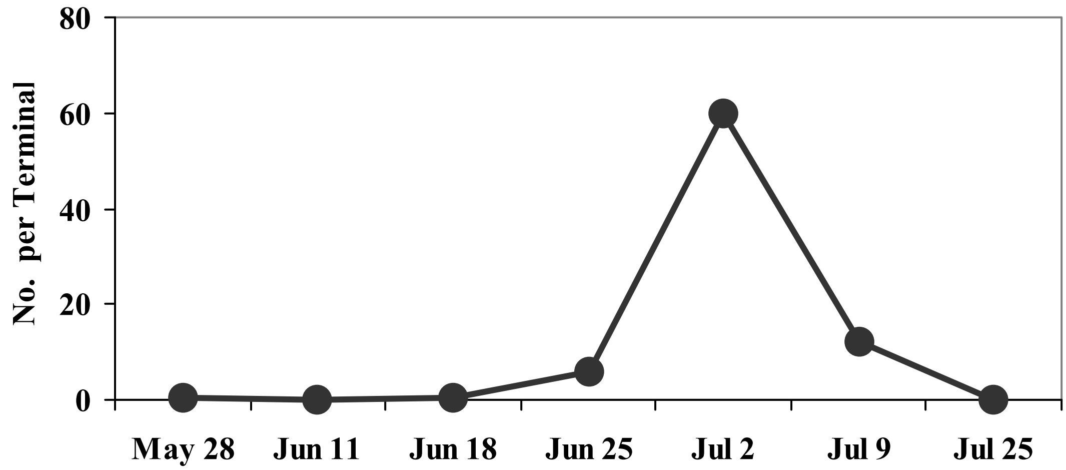

Figure 5. Cotton aphid density in non-treated plots-Northeast, 2001.

Table 18. Percent cotton aphid infested plants for thiamethoxam treated and non-treated micro-plots-Northeast, 2001.

			Percent Infested Plants		
Date of Sample	Days Post Treatment	Treatment (P>F)	Treated[1]	Non-Treated	Mean
8 June	Pre Treat	n/a	0.0	0.0	0.0
11 June	Pre Treat	0.3361	0.6	1.9	1.3
18 June	Pre Treat	0.6682	10.0	10.0	10.0
25 June	Pre Treat	0.9863	25.6	31.3	28.5
2 July	7 DAT1	0.1566	61.9	71.9	66.9
9 July	14 DAT1	0.4939	8.1	3.8	5.9

[1]Thiamethoxam applied 25 Jun at 0.116 g AI/ha.

DISCUSSION

Cotton aphids initially infested cotton plants in these tests during the third week of May in 2000 and the first week of June in 2001. At that time, plants had four to five main stem nodes. At peak cotton aphid densities, plants had 12 and 13 nodes in 2000 and 2001, respectively. These peaks occurred the third and fourth week of June in 2000 and 2001, respectively. Peak populations occurred prior to the first week of flowering during both years. At these densities, cotton plants were severely stunted and terminal leaves were distorted and chlorotic. The entomopathogen, *N. fresenii,* rapidly decreased cotton aphid populations and no significant resurgence of cotton aphids was noted in later rating periods during July and August of 2000. In 2001, *N. fresenii* effectively controlled cotton aphids, however, a minor resurgence was noted the final two weeks of July. These densities were low and consisted of fewer than five cotton aphids per terminal. A rainfall event on 28 July provided adequate conditions for an epizootic of *N. fresenii*, and cotton aphid densities were nearly eliminated across the test area. Thiamethoxam provided near 80% control of cotton aphid populations in 2001 while pymetrozine demonstrated only ca. 50% control of cotton aphids in 2000. Beneficial insects were present in both years across the test areas. Beneficial insects included: lady beetles *Hippodamia* spp., *Scymnus* spp., lacewing, (*Crysopa* spp.), and the parasitic wasp *Lysephlebis testacipes.* In both years, beneficial insects were present shortly after cotton aphids colonized plants. Also, red imported fire ants, *Solenopsis invicta,* were also present during these tests. These ants "tend" cotton aphid colonies by feeding on honeydew and by interfering with natural enemy populations. However, it did not appear that fire ants significantly reduced beneficial insect populations.

Cotton aphids did not significantly reduce seedcotton yields in these tests during 2000 and 2001. No significant differences were observed between insecticide treatments in any test for yield. No significant differences between insecticide treatments were observed for plant height, boll weight, boll retention, boll number, and node number in micro-plot and paired-plant comparisons. These findings are contrary to those of Andrews and Kitten (1989), Bagwell et al. (1991), Parker and Huffman (1991), Lesser et al. (1992), Harris et al. (1992), Rummel and Kidd (1994), Fuchs and Minzenmayer (1995), Layton et al. (1996). However, these researchers conducted tests in Mississippi, Texas, and Arkansas, where soil type, planting date, rainfall, temperature, humidity, and length of growing season may be different from those conditions found in Louisiana.

Our results are similar to those found by Rosenheim et al. 1997, and Slosser et al. 2001. Although cotton aphids caused reduced growth, leaf cupping and leaf discoloration during the period of infestation, cotton plants apparently compensated for any damage from early season cotton aphid infestations. There were no significant differences in seedcotton yield among the infested and non-infested plant zones. However, if cotton aphid densities remained higher than those levels observed in these tests and persisted for a longer duration, seedcotton yield losses may have occurred. Another explanation no differences in seedcotton yields between treatments occurred is the lack of complete control of cotton aphids with the aphicides used in these studies. There were no significant differences between aphicide treatment for percent boll retention at the first, second, and third fruiting positions. Slosser et al. (2001) demonstrated high leaf moisture levels reduced the aphicidal effects of pymetrozine and thiamethoxam. The reproductive potential of cotton aphids is directly related to leaf moisture content (Slosser et al. 1992), and when leaf moisture is high, cotton aphid reproduction can negate the effects of aphicides. In June and early July, when the aphicides were applied, cotton plants were not water stressed and may explain the lack of complete control provided by thiamethoxam and pymetrozine. If complete control of cotton aphids had been attained, a better comparison of cotton aphid infested versus non-infested plants could have been evaluated.

In these studies, cotton aphid populations occurred on pre-reproductive cotton. Cotton aphids were feeding on plants with squares, but before flowering was initiated. Weather conditions were also considered non-typical in both 2000 and 2001. In 2000, droughty conditions may have impacted cotton aphid populations by affecting cotton plant growth. Also, the high temperatures experienced during these years could have affected fruit retention in both irrigated and non-irrigated plots.

In other studies where seedcotton yields were reduced from cotton aphid infestations, cotton aphid densities were higher and persisted longer than that observed in Louisiana. In Mississippi, Layton et al. (1996) observed a yield loss of 243 kg/ha in cotton aphid infested plots compared to dicotophos treated plots. In this study, cotton aphid densities were recorded at 632 aphids per leaf at treatment and peaked three weeks later (800 aphids per leaf) before the occurrence of *N. fresenii.* In the present studies in Louisiana, cotton aphid densities were lower (ca. 90 and 120/terminal in 2000 and 2001, respectively) and persisted four to five weeks. In a Texas study, cotton aphid infestations lasted eight weeks and peaked at 1677 cotton aphids per leaf (Kidd and Rummel 1997). In Louisiana, durations and population densities may not attain the levels mentioned in the Mississippi and Texas study because of the early onset of *N. fresenii,* in late June or early July. In another study in Texas, Fuchs and Minzenmayer (1995) attributed seedcotton yield losses to reduced boll weight on plants infested with cotton aphids. In our study in 2000, cotton aphids were not present after flowering. In 2001, cotton aphid populations had diminished considerably prior to flowering, but relatively low populations (ca. five per terminal) persisted to the last week of July.

Cotton plants can compensate for early season fruit loss by producing more bolls on vegetative branches and in the upper canopy (Montez and Goodell 1994, Fife 2000). Rosenheim et al. (1997) found that cotton plants fully compensated for early season aphid infestations in the San Joaquin Valley in California. In that study, cotton aphid populations in pre-reproductive cotton suppressed the fruit production on vegetative branches and shifted cotton into a reproductive growth pattern earlier than non-infested plants (Rosenheim et al. 1997). These results are similar to those found by Slosser et al. (2001). In that Texas study, pymetrozine did not reduce cotton aphid densities relative to the non-treated control. However, thiamethoxam was utilized the following year and significantly reduced cotton aphid populations. However, there was no significant aphicide treatment effect on seedcotton yields in irrigated or non-irrigated plots, but yields from the irrigated plots were significantly higher than those in non-irrigated plots.

These data provide valuable information about pre-flowering cotton aphid populations and their effect on cotton yields. However, more research is needed to clearly define the impact of cotton aphid populations on cotton yields prior to making conclusions based on these data. These experiments were conducted under abnormal climatic conditions that may have altered our results. Also, we did not receive adequate control (>95%) from aphicides in both years in order to make complete comparisons between aphicide treated and non-treated plots. Research to show the effects of cotton aphid infestations on cotton planted at different planting dates also may be needed in order to further define the role of cotton aphids infestations on cotton yields. Additionally, research should examine other insect pests such as thrips and tarnished plant bugs whose presence coincides with cotton aphid infestations and may create a synergistic negative effect on cotton yields. The data generated in these studies will hopefully aid in structuring an appropriate treatment threshold for cotton aphids and should aid producers in making IPM decisions.

SUMMARY AND CONCLUSIONS

Several field studies were conducted in 2000 (Macon Ridge Research Station) and 2001 (Macon Ridge and Northeast Research Stations) to determine the effect of cotton aphids on cotton growth development and seedcotton yield in irrigated and non-irrigated regimes. The aphicides, pymetrozine and thiamethoxam, were applied in 2000 and 2001, respectively, to control cotton aphids in these tests. Cotton plant development was monitored using nodes above white flower growth stages, plant height, and vegetative and sympodial node numbers. Seedcotton yields were harvested from whole plots, one-meter micro-plots, and individual paired aphid-infested and non-infested plants. Paired (infested and non-infested) cotton plants (2000) and plants in micro-plots (2001) were partitioned into aphid infested, non-infested, and vegetative plant zones to determine if cotton plants could compensate for damage caused in the infested area by producing more seedcotton in non-infested and vegetative zones.

In 2000, initial cotton aphid infestations were observed in mid-May and peaked the third week of June (90 per plant terminal) at the Macon Ridge Research Station. In 2001, cotton aphids initially infested plants in early June and peaked the fourth week on June (120 per terminal) at the Macon Ridge Research Station. At the Northeast Research Station, cotton aphids began increasing during mid-May and peaked the first week of July (ca. 60 per plant terminal). In both years, the entomopathogenic fugus, *N. fresenii,* significantly lowered cotton aphid densities during the first week of July.

The percentage of cotton aphid infested plants was determined in aphicide-treated and non-treated plots. In the irrigated regime in 2000, cotton aphid populations peaked the third week of June with approximately 60% of the plants in non-treated micro-plots being infested at the Macon Ridge location. In the non-irrigated regime, cotton aphid populations peaked the second week of June with approximately 80% of the non-treated micro-plots being infested. In 2001 at the Macon Ridge Research Station, cotton aphid populations peaked in both irrigated and non-irrigated regimes the fourth week of June with approximately 60% of the plants in non-treated micro-plots being infested. At the Northeast Research Station, cotton aphid populations peaked the first week of July with 71.8 % of plants in non-treated micro-plots being infested.

Cotton aphids did not significantly affect plant height, total nodes, plant maturity and seedcotton yields in whole plots, micro-plots and on individual infested plants in all tests for both years ($P > 0.05$). Also, cotton aphids did not affect percent boll retention at first, second, and third fruiting positions ($P > 0.05$). There was no significant difference between aphicide treatments for first, second, and third position boll weights ($P > 0.05$). There were also no differences between aphicide treatments for seedcotton yield from cotton aphid infested zones, non- cotton aphid infested zones, and on vegetative branches ($P > 0.05$).

REFERENCES

Abney, M. R., J. R. Ruberson, G. A. Herzog, T. J. Kring, and D. C. Steinkraus. 2000. Natural enemies and population dynamics of the cotton aphid, *Aphis gossypii,* in Georgia, pp. 1246-1247. *In* Proceedings 2000 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Akey, D. H., and G. D. Butler, Jr. 1989. Developmental rates and fecundity of apterous *Aphis gossypii* on seedlings of *Gossypium hirsutum*. Southwest. Entomologist 14: 295-299.

Andrews, G. L., Cooke, F. Jr., and R. D. Meeks. 2000. The interaction of nitrogen fertilization and insect populations, pp. 993-996. *In* Proceedings 2000 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Andrews, G. L. and W. F. Kitten. 1989. How cotton yields are affected by aphid populations which occur during boll set, pp. 291-293. *In* Proceedings 1989 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Bagwell, R. D., N. P. Tugwell, and M. L. Wall. 1991. Cotton aphid: insecticide efficacy and an assessment of its damage to the cotton plant, pp. 693-695. *In* Proceedings 1991 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Bagwell, R. D., B. R. Leonard, G. Burris, and S. Micinski. 2002. Cotton Insect Control 2002. Louisiana Coop. Ext. Serv., LSU. Ag Center. Baton Rouge, LA. Publ. 1083.

Blackman, R. L., and V. F. Eastop. 1984. Aphids on the World's Crops: An Identification Guide. John Wiley and Sons. New York, NY.

Borror, D. J., C. A. Triplehorn, and N. F. Johnson. 1989. An Introduction to the Study of Insects, pp. 336-338. Harcourt Brace College Publishers, Orlando, FL.

Botrell, D. C, and P. L. Adkinson. 1977. Cotton insect pest management. Ann. Rev. Entomol. 22:451-481.

Brushwood, D. E. and Y. J. Han. 2000. Possible NIRS screening tool for entomological sugars on raw cotton. J. Cotton Sci. 4: 137-140.

Burris, E., A. M. Pavloff, B. R. Leonard, J. B. Graves, and G. Church. 1990. Evaluation of two procedures for monitoring populations of early season pests (Thysanoptera: Thripidae and Homoptera: Aphididae) in cotton under selected management strategies. J. Econ. Entomol. 83: 1064-1068.

Carter, F. L. 1992. The sticky cotton issue, p. 645. *In* Proceedings 1992 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Carter, L. M. and K. Godfrey. 1999. Evaluation of habitats for introduced parasites of the cotton aphid in the San Joaquin Valley, pp. 46-47. 1999 Agricultural Research Projects-Summary Reports. Cotton Incorporated. Cary, NC.

Dixon, A. F. G. 1990. Ecological interactions of aphids and their host plants, pp. 7-20. *In* Aphid-Plant Genotype Interactions. R. K. Campbell and R. D. Eikenbary, (Ed.) Elsevier Science Publishing Company Inc., New York, NY.

Dorschner, K.W. 1990. Aphid induced alteration of the availability and form of nitrogenous compounds in plants, pp. 225-235. *In* Aphid-Plant Genotype Interactions. R. K. Campbell and R. D. Eikenbary, (Ed.) Elsevier Science Publishing Company Inc., New York, NY.

Drees, B. A. 1993. Aphid management. Texas Agricultural Extension Service. http://entowww.tamu.edu/extension/bulletins/uc/uc-031.html.

Earnest, L., C. T. Allen, and M. S. Kharboutli. 2000. Comparison of insecticides for cotton aphid control, pp. 1348-1349. *In* Proceedings 2000 Beltwide Cotton Conf., National Cotton Council, Memphis TN.

Ebert, T. A. and B. Cartwright. 1997. Biology and ecology of *Aphis gossypii* Glover (Homoptera: Aphididae). Southwest. Entomologist 22: 116-153.

Fife, J. H. 2000. Determination of the last harvestable boll population and the effects of square abscission during flowering on cotton yield and maturity. M. S. Thesis, Louisiana State University, Baton Rouge, LA.

Fry, W. E. 1982. Principles of Plant Disease Management. Academic Press Inc., San Diego, CA.

Fuchs, T. W. and R. Minzenmayer. 1995. Effect of *Aphis gossypii* on cotton development and yield in West Texas. Southwest. Entomologist 20: 341-349.

Gains, J. C. 1945. Control of the cotton aphid with different forms of rotenone and nicotine. J. Econ. Entomol. 37:728-729.

Godfrey,L. D., and K. Keillor. 1999. Management of key cotton arthropod pests with insecticides and acaricides, pp. 34-35. 1999 Agricultural Research Projects-Summary Reports. Cotton Incorporated. Cary, NC.

Grafton-Cardwell, E. E. 1991. Geographical and temporal variation in response to insecticides in various life stages of *Aphis gossypii* (Homoptera: Aphididae) infesting cotton in California. J. Econ. Entomol. 84: 741-749.

Grafton-Cardwell, B. 1999. Monitoring for pesticide resistance in cotton pests in the San Joaquin valley of California, p. 181. 1999 Agricultural Research Projects-Summary Reports. Cotton Incorporated. Cary, NC.

Hardee, D. D., and J. M. Ainsworth. 1993. Cotton aphid (Homoptera: Aphididae): effect of in-furrow insecticides on pesticide resistance. J. Econ. Entomol. 86: 1026-1029.

Hardee, D. D., A. A. Weathersbee III, and M. T. Smith. 1994. Biological control of the cotton aphid, pp. 132-133. *In* Proceedings 1994 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Harris, F. A., G. L. Andrews, D. F. Caillavet, and R. E. Furr, Jr. 1992. Cotton aphid effect on yield, quality and economics of cotton, pp. 652-656. *In* Proceedings 1992 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Harris, F. A., and R. E. Furr, Jr. 1994. Stategies for chemical control of cotton aphid, pp.134-136. *In* Proceedings 1994 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Henneberry, T. J., Forlow Jech, T. de la Torre, and D. L. Hendrix. 2000. Cotton aphid (Homoptera: Aphidadae) biology, honeydew production, sugar quality and quantity, and relationships to sticky cotton. Southwest. Entomologist 25: 161-174.

Hillocks, R. J., and J. H. Brettell. 1992. The association between honeydew and growth of *Cladosporium herbarum* and other fungi on cotton lint. Tropical Sci. 33: 121-129.

Hollingsworth, R. G., D. C. Stienkraus, and R. W. McNew. 1995. Sampling to predict fungal epizootics in cotton aphids (Homoptera:Aphididae). Environ. Entomol. 24: 1414-1421.

Isley, D. 1946. The cotton aphid. Arkansas Agric. Exp. Sta. Bull. No. 462.

Jones, R. H., B. R. Leonard, D. J. Boquet, and K. D. Emfinger. 2001. Influence of agronomic practices on cotton aphid, *Aphis gossypii* Glover, densities in Louisiana cotton, pp. 1097-1098. *In* Proceedings 2001 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Johnson, D. R. 1991. Cotton aphid biology, management and control. Arkansas Coop. Ext. Serv.

Kerby, T. A. and K. D. Hake. 1996. Monitoring cotton's growth, pp. 335-355. Cotton Production Manual. S. J. Hake, T. A. Kerby, and K. D. Hake (Eds). University of California Division of Agriculture and Natural Resources.

Kerns, D. L. and M. J. Gaylor. 1992. Insecticide resistance in field populations of the cotton aphid (Homoptera: Aphididae). J. Econ. Entomol. 85: 1-8.

Kerns, D. L. and M. J. Gaylor. 1993. Biotic control of cotton aphids (Homoptera: Aphididae) in cotton influenced by two insecticides. J. Econ. Entomol. 86: 1824-1834.

Kidd , P. W. and D. R. Rummel. 1997. Effect of insect predators and a pyrethroid insecticide on cotton aphid, *Aphis gossypii,* Glover, population density. Southwest. Entomologist 22: 381-393.

Koeing, J. P., D. S. Lawson, N. Ngo, B. Minton, C. Ishida, K. Lovelace, and S. Moore. 2000. 1999 field trial results with pymetrozine (Fulfill®) and thiamethoxam (Centric®/Actara®) for control of cotton aphid (*Aphis gossyppi),* pp. 1335-1337. *In* Proceedings 2000 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Layton, M. B., H. R. Smith, and G. L. Andrews. 1996. Cotton aphid infestations in Mississippi: efficacy of selected insecticides and impact on yield, pp. 892-893. *In* Proceedings 1996 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Lesser, J. F., C. T. Allen, and T. W. Fuchs. 1992. Cotton aphid infestations in West Texas: a growing management problem, pp. 823-827. *In* Proceedings 1992 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Metcalf, C. L., W. P. Flint, and R. L. Metcalf. 1962. Destructive and Useful Insects, 4th ed. McGraw-Hill Book Co., New York, NY.

Miyazaki, M. 1987. Aphids: Their Biology, Natural Enemies and Control. Volume A. Elsevier Science Publishers, New York, NY.

Montez, G. M. and P. B. Goodell. 1994. Yield compensation in cotton with early season square loss, pp. 916-919. *In* Proceedings 1994 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

O'Brien, P. J. and J. B. Graves. 1992. Insecticide resistance and reproductive biology of *Aphis gossypii* Glover. Southwest. Entomologist 17: 115-122.

O'Brien, P. J., M. B. Stoetzel, R. C. Navasero, and J. B. Graves. 1993. Field biology studies of the cotton aphid, *Aphis gossypii* Glover. Southwest. Entomologist 18: 25-35.

Parker, R. D. and R. L. Huffman. 1991. Effects of early season aphid infestations on cotton yield and quality under dryland conditions in the Texas coastal bend, pp. 702-703. *In* Proceedings 1991 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Price, J. R., J. E. Slosser, and G. J. Puterka. 1983. Cotton aphid control. Chillicothe, TX, 1981. Insecticide and Acaricide Tests 8: 197-198.

Rohfritsch, O. 1990. Aphid stylet movement and host-plant reaction in the case of Adelgidae on spruce, pp. 101-116. *Aphid-Plant Genotype Interaction,* R. K. Campbell and R. D. Eikenbary, (Ed.) Elsevier Science Publishing Company Inc., New York, NY.

Rosenheim, J. A., L. R. Wilhiot, P. B. Goodell, E. E. Grafton-Cardwell, and T. F. Leigh. 1997. Plant compensation, natural biological control, and herbivory by *Aphis gossypii* on pre-reproductive cotton: the anatomy of a non-pest. Entomologia Experimentalis et. Applicata 85: 45-63.

Ruberson, J. R., W. J. Lewis, D. J. Waters, O. Stapel, and P. B. Haney. 1995. Dynamics of insect populations in a reduced-tillage, crimson clover/cotton system-part 1: pests and beneficials on plants, pp. 814-817. *In* 1995 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Rummel, D. R. and P. W. Kidd. 1994. Some factors influencing cotton aphid population development in the Texas high plains, pp. 1009-1012. *In* 1994 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

SAS Institute Inc. 1989. SAS/STAT® User's Guide, Version 6, Forth Ed., Vol. 1, Cary, NC: SAS Institute Inc. 1989. 943 pp.

Slosser, J. E., W. E. Pinchak, and D. R. Rummel. 1989. A review of known and potential factors affecting the population dynamics of the cotton aphid. Southwest. Entomologist 14: 302-313.

Slosser, J. E., W. E. Pinchak, and D. R. Rummel. 1992. Population development and regulation of the cotton aphid, pp. 649-651. *In* Proceedings 1992 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Slosser, J. E., R. Montandon, W. E. Pinchak, and D. R. Rummel. 1997. Cotton aphid response to nitrogen fertility in dryland cotton. Southwest. Entomologist 22: 1-10.

Slosser, J. E., M. N. Parajulee, G. B. Idol, and D. R. Rummel. 2001. Cotton aphid response to irrigation and crop chemicals. Southwest. Entomologist 26: 1-14.

Smith, M. T., and D. D. Hardee. 1996. Influence of fungicides on development of an entomopathogenic fungus (Zygomycetes: Neozygitaceae) in the cotton aphid (Homoptera: Aphididae). Environ. Entomol. 25: 677-687.

Steinkraus, D. C., R. G. Hollingsworth, and P.H. Slaymaker. 1995. Prevalence of *Neozygites frensenii* (Entomophthorales: Neozygitaceae) on cotton aphids (Homoptera: Aphididae) in Arkansas cotton. Environ. Entomol. 24: 465-474.

Steinkraus, D. C. and G. M. Lorenz III. 1997. Extension-based sampling service for cotton aphid fungus, pp.167-168. *In* Proceedings of the 1997 Cotton Research Meeting. D. M. Oosterhuis (ed.). Arkansas Agric. Exp. Sta. Special Report 183.

Steinkraus, D. C. and G. O. Boys. 1998. Aphid fungus sampling service: update, pp. 55-59. *In* Proceedings of the 1998 Cotton Research Meeting and 1998 Summaries of Cotton Research in Progress. Arkansas Agric. Exp. Sta.

Torrey, K., H. Fife, B. R. Leonard, and R. L. Hutchinson. 2000. Effects of conservation tillage systems on cotton aphid populations, pp. 1208-1209. *In* Proceedings 2000 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Weathersbee III, A. A. and D. D. Hardee. 1994. Abundance of cotton aphids (Homoptera: Aphididae) and associated biological control agents on six cotton cultivars. J. Econ. Entomol. 87: 258-265.

Weathersbee III, A. A., D. D. Hardee, and W. R. Meredith Jr. 1995. Differences in yield response to cotton aphids (Homoptera: Aphididae) between smooth-leaf and hairy-leaf isogenic cotton lines. J. Econ. Entomol. 88: 749-754.

Wells, M. L., R. M. McPherson, J. R. Ruberson, and G. A. Herzog. 2000. Effect of fungicide application on activity of *Neozygites fresenii* (Entomophthorales: Neozygitacaea) and cotton aphid (Homoptera: Aphididae) suppression. J. Econ. Enotomol. 93: 1118-1126.

Williams, M. R. 2001. Cotton insect losses 2000, pp. 774-776. *In* Proceedings 2001 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

VITA

Robert Hankins (Hank) Jones, the only child of Robert Henry and Martha Ann Hankins Jones, was born in Monroe, Louisiana, on September 23, 1978. He graduated from Ouachita Christian School in Monroe, Louisiana, in May, 1996. He obtained his Bachelor of Science degree in agronomy from Louisiana Tech University (Ruston, Louisiana) in November, 1999. In January 2000, Hank enrolled in the Department of Entomology (cotton pest management) under the direction of Dr. B. Rogers Leonard. Hank is currently a candidate for a Master of Science degree.