EVALUATION OF PGR PROPERTIES OF TRIMAX IN COTTON

A Thesis

by

CY CHRISTOPHER MCGUIRE

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 2005

Major Subject: Molecular and Environmental Plant Sciences

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Approved by:

Chair of Committee,	J. Tom Cothren
Committee Members,	Robert G. Lemon
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ABSTRACT

Evaluation of PGR Properties of Trimax in Cotton. (August 2005)

Cy Christopher McGuire, B.S. Texas A&M University

Chair of Advisory Committee: Dr. J. Tom Cothren

Pesticides comprise a large portion of production inputs in cotton. Reducing or enhancing their efficacy presents an avenue to increase profit. Pesticides containing both insecticidal and growth enhancing properties may be a viable option to increased profitability. In cotton (*Gossypium hirsutum* L.), early season applications of some insecticides have shown effects similar to those of plant growth regulators (PGRs). TRIMAX™ (imidacloprid) is one of these purported PGR insecticides. TRIMAX™ and Centric® 40WG (thiamethoxam), both nitroguanidine insecticides, have properties that may exhibit PGR activity.

A two-year field study was conducted at the Texas A&M Agricultural Experiment Station in Burleson County, Texas to assess the physiological effects of Centric® 40WG and TRIMAX™ on cotton. The statistical design consisted of a randomized complete block with four replications. Treatments consisted of each insecticide being applied one, two, and three times at the 5-leaf stage, 5-leaf stage plus 10 days after initial treatment (DAIT), and 5-leaf stage plus 10 DAIT plus 20 DAIT. Rates consisted of TRIMAX™ and Centric® 40WG being applied at 0.020 and 0.017 L/ha, respectively. Data was collected for plant height, total number of nodes, biomass

partitioning, photosynthetic rate, midseason plant mapping, end of season box-mapping, yield, and fiber quality analysis.

No significant differences in lint yield were observed among any of the insecticide PGR treatments. There was a general trend for numeric decreases in lint yield with each additional insecticide application for both chemistries, with the exception of TRIMAX™ at three applications in 2004. No significant differences were detected in any of the growth parameters that were measured (height, total nodes, biomass partitioning, and leaf area). Numerical differences resulted in trends, but rate responses did not follow any logical pattern. Numerous trends and rate responses were also observed in the Absolute and Relative Growth Rates, and photosynthetic rates, but no significant differences were evident. In general, as more insecticide was applied, the photosynthetic rates decreased along with lint yield.

Based on the parameters investigated during the course of this two-year study, there is no conclusive evidence that supports TRIMAX™ or Centric® 40WG as being growth and or yield enhancers in cotton.

DEDICATION

This thesis is dedicated to my family, because without their love and support I would never have made it this far. I would like to specifically dedicate this work to memories I have of Wanda Bell (Mamma) and Karen Janay (Aunt Nay) Morrison. Mamma and Aunt Nay influenced my life more than they will ever be able to know. Because God loved them so much, He just couldn't wait to take them home to be with Him.

ACKNOWLEDGMENTS

I would like to sincerely thank the following individuals who have made my graduate research possible: Dr. J.T. Cothren who always offered his insight, guidance, and sense of humor to every situation that arose; Dr. Robert G. Lemon and Dr. Marla Binzel for serving on my committee and for offering their guidance and expertise.

I would like to thank the MEPS faculty and Bayer CropSciences for providing the financial support for me to pursue my graduate degree.

I would also like to thank my fellow graduate peers and student workers for all of their assistance in the preparation and completion of the field studies. Josh Bynum, Shane Halfmann, Brett Niccum, Ellen Batchelder, Anthony Gola, Elliott Rounds, Quentin Shieldknight, Jamie Creel, Steve Hoffman, Dr. Ernest Clawson, Danny Fromme, and Leah Hundley each played critical roles in the planning and achievement of my research goals. Special thanks go to Josh Bynum for everything he has contributed towards the completion of this thesis and to my growth as a person. His leadership and statistical expertise were always available and he managed to become a life long friend along the way.

I would like to again thank my family for their love and support during this chapter of my life. There were many times during the last couple of years that would have been absolutely unbearable if my mother had not been there praying for me.

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INTRODUCTION

Maintaining profitability is key in any cropping system; therefore producers are constantly striving to fine-tune management strategies that minimize inputs while optimizing yield. Pesticides constitute a large portion of production inputs for cotton. Therefore, reducing or enhancing pesticide efficacy presents an avenue to increase profit. Pesticides that contain both insecticidal and growth enhancing properties may be a viable option to increase profitability. Chlordimeform, an ovicide that increased lint yields above those expected from any pesticidal properties of the chemical, was shown to have cytokinin-like properties (Bauer and Cothren, 1990). The systemic insecticide aldicarb has also shown enhanced cotton growth rates and promotion of root growth (Reddy et al., 1997). Pesticide chemistries that potentially offer this dual function could further increase profitability to the producer.

TRIMAX™ and Centric® 40WG, both nitroguanidines, have proven beneficial in controlling the major piercing/sucking insects in cotton (Moore et al., 2003). The active ingredient in TRIMAX™, imidacloprid, is similar in structure to compounds such as nicotinamide and chloronicotinic acid that enable plants to tolerate stress elicited by drought, disease and insect infestation (Berglund, 1994). Since multiple applications of both chemicals can be made throughout the growing season, the possibility for extending the window for sustained activity exists.

This thesis follows the style and format of Crop Science.

LITERATURE REVIEW

PGRs and Cotton

Previous research has shown that the use of plant growth regulators (PGRs) in cotton (*Gossypium hirsutum*) can increase plant health, maintain manageability, and increase lint yields (Fernandez, 1997; Norton and Silvertooth, 2000; Kumar et al., 2001). The indeterminate nature of cotton can lead to excessive vegetative growth that causes the crop to become rank and unmanageable. PGRs, such as PIX (*N*,*N*-dimethylpiperidinium chloride) are utilized to maintain the manageability of the crop by reducing internode length of new growth. This allows more photoassimilates to be partitioned towards the fruiting structures and less towards vegetative growth. Fernandez (1997) found that PIX applications increased seedcotton yield per plant by 13% to 14% over untreated plants, which was partly explained by a 7% increase in boll weight and an increase in fruit retention of 5.3% to 7.0%.

Under water stressed conditions, applications of abscisic acid (ABA) increased water use efficiency (WUE) (Kumar et al., 2001). This increase in WUE could be the result of reduced stomatal conductance and transpirational rate, both of which improve the overall water status of the plant and plant health.

Kumar et al. (2001) found that certain PGRs, specifically indoleacetic acid (IAA), gibberellic acid (GA_3), and benzylaminopurine (BAP) increased net photosynthesis when foliarly applied to plants at various water stress levels.

Insecticides as PGRs

Although insecticides are used specifically for pest control without consideration of their impact on the physiology of the crop in which they are used, some insecticides have shown benefits beyond those of simply controlling insects. Previous studies have shown that some insecticides exhibit PGR properties which may increase their efficacy. For example, the systemic insecticide aldicarb [2-methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl)oxime] has enhanced the growth rate of cotton through the promotion of root growth (Reddy et al., 1997). Likewise, aldicarb effectively controls early season insects in cotton (Parrott et al., 1985; Slosser, 1993), but even in the absence of insects, there is a direct response for enhanced growth and increased yields (Scott et al. 1985; Cooke et al. 1992; Reddy et al. 1997). Reddy et al. (1997) found that cotton treated with aldicarb resulted in enhanced early season vegetative growth and early square formation. The most significant benefit of aldicarb was promotion of root growth (Parrott et al. 1985; Scott et al.1985; Reddy et al. 1997). Root growth from 0 to 60 cm was not significantly increased; however, the treated plants did produce a significantly higher root length density from 61 to 80 cm (Reddy et al. 1997). The ovicide chlordimeform, [*N*'-(4-chloro-O-tolyl)-*N*,*N*-dimethylformamidine] also increased lint yields above those expected from the insecticidal properties of the compound (Lincoln and Dean, 1976; Phillips et al., 1977; Bauer and Cothren, 1990). The physiological responses to chlordimeform mimic those of cytokinins. Bauer and Cothren (1990) utilized zeatin, a naturally occurring cytokinin, to compare its physiological activity to that of chlordimeform. They found that the fresh weight of chlordimeform-treated radish cotyledons was significantly greater than the untreated plants.

Photosynthesis

Photosynthesis is the primary metabolic process that determines yield potential (Kasemsap et al., 1999). Crop management techniques that alter photosynthesis can potentially increase fruiting positions and retention, which lead to increased yield (Wells, 2001). Nitrogen fertilization is an example of a management technique that can potentially increase photosynthesis. Reddy et al. (1997) reported that leaf-level photosynthesis was related to the nitrogen status of the plant. Because photosynthetic pigments such as chlorophyll are composed of high amounts of nitrogen, increasing nitrogen availability should theoretically lead to greater leaf area production and better light interception. Nitrogen, a readily translocatable nutrient in the plant, is moved from older leaves into newly developing leaves at the apical meristem. A consequence of this translocation is that photosynthetic capacity declines with leaf age in cotton (Chapin et al., 1987). However, the greater availability of nitrogen ensures that the leaves that intercept the highest photosynthetic photon flux density, PPFD, will have the ability to convert that light into chemical energy. Other factors which may impact photosynthesis include temperature, leaf age, leaf angle, light, and plant water status. Whether consequences of the exposure of the crop to these factors can be reduced by PGR treatments is unknown. Peng and Krieg (1991) found that the photosynthetic rates of single leaves decreased by 38% as the leaf aged from 70 to 115 days after planting (DAP). In addition to being affected by age, most crops respond best within a thermal kinetic window (TKW). Burke et al. (1988) defined TKW as the range of plant temperatures at which the apparent Michaelis constant, K_m, is at or below 200% of the minimum observed value. For cotton, the TKW is within the temperature range between 23.5 and 32 ^oC (Burke et al., 1988). This TKW represents a fairly wide range of temperatures, which as defined corresponds to the activity of glyoxylate reductase in the leaves. Perry et al. (1983) described a narrower range of slightly greater temperatures, between 32 and 34 ^oC, as the optimum for photosynthesis for cotton. These temperature differences could be the result of other unknown regional environmental parameters. Another equally important parameter for photosynthetic activity is light. The photosynthetic machinery of cotton becomes light saturated around 1200 µmols m^{-2} s^{-1} (Perry et al., 1983). The major objective to optimize use of solar radiation is to manage for effective light interception. Increasing PPFD beyond the saturation point does not result in increased photosynthesis because another photosynthetic parameter becomes limiting.

Photosynthetic rate can be measured as the rate at which CO_2 is exchanged between a leaf and the atmosphere. Numerous studies have been conducted on photosynthesis in cotton (Mauney et al., 1978; Perry et al., 1983; Peng and Krieg, 1991; Wells, 2001). Many of these studies have been conducted on individual leaves rather than on canopy. Single leaf photosynthetic rates have traditionally been assessed for the uppermost unfurled leaf, which is usually the third leaf below the apex (Kumar et al., 2001). Measurements taken from this leaf provide a good indication of the overall health of the plant.

A mathematical simulation model for cotton estimated that a 50% increase in photosynthetic rate would result in a 71% increase in yield (Baker et al., 1973). Elevated CO_2 concentrations have been utilized to mimic the response of a higher photosynthetic rate. In studies performed by Mauney et al. (1978), high CO_2 concentrations (630 ppm) resulted in an increase in lint yield. From these studies it is evident that the carbohydrate supply is the limiting factor for growth, fruit set, and fiber development in cotton (Mauney et al, 1978). Marginal increases in photosynthetic rates could therefore result in greater lint yield and ultimately economic gains.

TrimaxÔ and CentricÓ 40WG

Trimax™ [1-[6-chloro-3-pyridinyl)methyl]-*N*-nitro-2-imidazolidinimine], (TRI), is an imidacloprid insecticide marketed by Bayer CropScience for control of major piercing/sucking insects. Recent studies have suggested that TRI may possess PGR properties that promote plant health, stress recovery, and yield increases (Oosterhuis and Brown, 2003). Hopkins et al. (2003) described the active ingredient, imidacloprid, as the only insecticide in the nitroguanidine subclass of chloronicotinyl insecticides with a chloropyridine side chain. This unique side chain is related to nicotinamide and chloronicotinic acid which appear to reduce the environmental stresses from drought, diseases, and insect attack (Hopkins et al., 2003). Centric© 40WG [4H-1,3,5-oxadiazin-4-imine,3-[(2-chloro-5-thiazolyl) methyl]tetrahydro-5-methyl-N-nitro-], (CEN), is a thiamethoxam insecticide marketed by Syngenta that has a similar mode of action to TRI and also controls a range of insects similar to that of TRI. Both chemicals are in the neonicotinoid class of insecticides and therefore may exhibit similar physiological responses.

OBJECTIVE

The objective of this study was to evaluate the physiological responses of TRIMAX™ and Centric® 40WG through various parameters including plant growth, photosynthetic rate, yield, and fiber quality of cotton.

MATERIALS AND METHODS

A two-year field study was conducted at the Texas A&M Agricultural Experiment Station in Burleson County, Texas. Cotton, cv. Delta and PineLand 20B in 2003 and Delta and PineLand 444 BGR in 2004, was seeded at 130,000 plants/ha with a John Deere Max-Emerge planter. The initial study was planted on May 7, 2003 and the second year on April 8, 2004. Plots consisted of 4 rows x 9.75 meters in length on raised beds spread 1.01 meters apart. Statistical design was a randomized complete block, consisting of seven treatments with four replications. Plots were managed using furrow and linear irrigation and pest management practices common to the region. Two insecticides, Trimax™, 1-[6-chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine, (TRI), and Centric® 40WG, 4H-1,3,5-oxadiazin-4-imine,3-[(2-chloro-5-thiazolyl) methyl]tetrahydro-5-methyl-N-nitro-, (CEN), were applied to evaluate growth regulator properties and the rate responses of the crop to different treatments. One, two, and three applications of Trimax™, an imidacloprid, were applied at a rate of 0.020 L/ha. Timings of these applications occurred at the 5-leaf stage, 5-leaf stage plus 10 days after treatment (DAIT), and 5-leaf stage plus 10 DAIT plus 20 DAIT. Also one, two, and three applications of Centric® 40WG, a thiamethoxam, were applied at a rate of 0.017 L/ha. Timings of these applications occurred at the 5-leaf stage, 5-leaf stage plus 10 DAIT, and 5-leaf stage plus 10 DAIT plus 20 DAIT. All possible combinations including the untreated control were applied for a total of seven treatments (Table 1).

Table 1. Foliarly applied insecticidal treatments.

Treatments§	Rate	Timing
UTC	NA	NA
Centric 1	0.017 L/ha	5th Leaf
Centric 2	0.017 L/ha	5th Leaf + 10 DAIT
Centric 3	0.017 L/ha	5th Leaf + 10 DAIT + 20 DAIT
Trimax 1	0.020 L/ha	5th Leaf
Trimax 2	0.020 L/ha	5th Leaf + 10 DAIT
Trimax 3	0.020 L/ha	5th Leaf + 10 DAIT + 20 DAIT

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.; DAIT = days after initial treatment

To ensure that any differences between treatments were the result of PGR properties and not a result of the insecticidal properties of the two chemicals, blanket applications of Bidrin® 8, dimethyl phosphate of 3-hydroxy-*N,N*-dimethyl-*cis*-crotonamide, were applied across all treatments. These Bidrin® 8 applications were applied weekly during the period of PGR treatment at a rate of 0.29 L/ha to prevent infestation or to control insects that were potentially present. Plots were scouted for early season insect pressure to determine if additional applications were necessary.

Initial data for determining uniformity across plots was collected at 37 and 42 days after planting (5-leaf stage) for 2003 and for 2004, respectively. These data included height, total number of nodes, and biomass. Six representative plants were tagged in each plot for collection of height and node data throughout the season.

Four one-meter sections were tagged in each plot for removal of plants after each foliar application for biomass partitioning. Heights, nodes, leaf weight, stem weight, and leaf area were recorded seven days after each PGR insecticidal application. These observations were again collected for midseason biomass partitioning and plant mapping 61 DAIT in 2003 and 2004.

Leaf Area Index (LAI), Absolute Growth Rate (AGR), Relative Growth Rate (RGR), and Specific Leaf Area (SLA) were determined for each treatment using the appropriate parameters.

Photosynthetic rate was measured using a portable LI-6400. The CO_2 exchange rate was determined for the third leaf below the apex. The rate of photosynthesis was recorded after each chemical application and prior to the subsequent application.

Readings were again taken 46 DAIT in 2003 to record the photosynthetic rate. Weather prevented additional photosynthetic measurements to be taken during the 2004 season.

Nodes above white flower (NAWF) (Bourland et al.,1992) was used to determine physiological cutout. Harvest aids were applied when the crop averaged 60% open bolls.

At harvest, five plants per plot were box-mapped for yield distribution. The heights and number of nodes were also noted for these plants. Yield was then taken from the middle two rows of the four-row plots by hand picking in 2003 and by machine harvest in 2004, and fiber characteristics were observed for both years. A 150-gram sample of seedcotton was ginned from each plot using a 10-saw table gin. From this sample, 50-g of lint was taken to send to the International Textile Center in Lubbock, Texas for fiber quality analysis using the High Volume Instrument (HVI).

All data was combined over years and was submitted to statistical analysis in SAS® (version 8.02) using PROC MIXED, and means were separated using Tukey Kramer's test at the $a = 0.05$ level of probability (SAS, 1999-2001). Data that showed a significant interaction between years was analyzed using PROC GLM, and means were separated using Fisher's LSD at the $a = 0.05$ level of probability. Unless otherwise indicated, all differences will be discussed at this level of significance.

RESULTS AND DISCUSSION

PLANT GROWTH PARAMETERS

Plant growth parameters consisting of plant height, total number of nodes, and first reproductive node were assessed during each growing season to determine the overall development of the plant.

Height

No significant differences were found in plant height at the designated times of measurement for any of the foliar insecticide applications for either 2003 or 2004. The data for height from 2003 and 2004 was analyzed together because there was no interaction between treatment and year. All PGR treatments resulted in numeric increases in plant height at the end of season over the UTC with the exception of CEN 3 and TRI 3 (Table 2). These numeric increases in plant height ranged from 0.20 cm to 5.36 cm per plant for TRI 1 and TRI 2, respectively. Zhao and Oosterhuis (1998) reported that certain PGRs can alter plant height. They found that the PGRs mepiquat chloride (MC) and CCC significantly reduced plant height, while Early Harvest (EH) numerically increased the plant height. Studies have also shown that the systemic insecticide aldicarb can significantly increase early season plant heights (Reddy et al., 1997).

Total Nodes

No significant differences were found in the total number of nodes per plant for any of the foliar insecticide applications for either 2003 or 2004. Application timings

Table 2. Insecticidal treatment effect on height and total number of nodes per plant after each foliar application.

	Plant Height (cm)					
Treatment§	**T-0 ¶**	**T-1**	**T-2**	**T-3**	**T-4**	**T-5**
UTC	14.13 a †	22.33 a	43.48 a	66.23 a	81.35 a	83.18 a
Centric 1	13.58 a	21.71 a	41.69 a	63.96 a	74.30 a	88.16 a
Centric 2	13.62 a	22.65 a	41.69 a	63.63 a	77.43 a	83.43 a
Centric 3	13.56 a	21.79 a	40.54 a	61.31 a	73.60 a	78.40 a
Trimax 1	13.95 a	22.54 a	41.48 a	63.63 a	78.13 a	83.38 a
Trimax 2	13.85 a	22.52 a	42.65 a	66.27 a	81.89 a	88.54 a
Trimax 3	12.63 a	20.50 a	41.17 a	60.94 a	77.28 a	83.18 a
P value	0.09	0.12	0.74	0.16	0.14	0.20

	Total Number of Nodes per Plant						
	T-0	**T-1**	**T-2**	**T-3**	**T-4**		**T-5**
					2003 ‡	**2004 ‡**	
UTC	4.79 a	7.40 a	11.73 a	14.44 a	16.72 a	19.35 a	21.11 a
Centric 1	4.62 a	7.46 a	11.67 a	14.79 a	17.60 a	18.28 abc	20.60 a
Centric 2	4.81 a	7.62 a	11.32 a	14.56 a	17.40 a	17.70 bc	20.52 a
Centric 3	4.56 a	7.29 a	11.23 a	14.33 a	17.85 a	17.00 c	20.43 a
Trimax 1	4.73 a	7.52 a	11.42 a	14.62 a	16.95 a	18.45 ab	20.10 a
Trimax 2	4.73 a	7.63 a	11.54 a	14.69 a	17.28 a	18.95 ab	20.80 a
Trimax 3	4.46 a	7.04 a	11.56 a	14.17 a	17.00 a	18.40 ab	20.33 a
P value	0.25	0.06	0.62	0.39	0.71	0.04	0.81

† Means within a column followed by the same letter are not statistically different at P<0.05 according to the Tukey-Kramer procedure.

‡ These data showed significant interaction between treatment and year; therefore, the data is presented by year. Means within these columns followed by the same letter are not statistically different at P<0.05 according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 DAIT), T-5 = End of season were devoid of interaction with the exception being the midseason (T-4) total node count per plant. Because T-4 showed interaction between treatment and year, the data is separated by year. The 2004 midseason total node count indicated that CEN 2 and CEN 3 had significantly fewer nodes per plant than the UTC (Table 2). The UTC also had a numerically higher total number of nodes than all of the PGR treatments at this time. The numeric decreases in total nodes below that of the UTC ranged from 0.40 nodes for TRI 2 to 2.35 nodes for CEN 3. There was also a numeric increase in total number of nodes for the UTC over all of the PGR treatments for the end of season (T-5). The numeric decreases in total nodes for the insecticidal treatments below that of the UTC at T-5 ranged from 0.31 nodes for TRI 2 to 1.01 nodes for TRI 1. This difference in total number of nodes may reflect that the treated plants retained higher fruit loads which demanded more photosynthate relative to vegetative production and allowing greater reproductive growth of the plant. Also, the treated plants may have also started fruiting earlier which would cause a shift in their growth curve. Studies by Zhao and Oosterhuis (1998) indicated that PGR IV applied at pinhead square and first flower would significantly increase the number of main-stem nodes. Other PGRs, such as MC and CCC, reduced the number of total nodes, which follows more closely the results of this study.

BIOMASS PARTITIONING

Biomass partitioning was examined by individual biomass components (stem and leaf weights) as well as for total biomass (combined stem and leaf weights). Due to the inability to retrieve roots, root weight was not considered as a component of biomass.

Stem Weight

Stem weights did not differ for any of the foliar insecticide applications for 2003 or 2004. Following one application of insecticide, stem weight decreased numerically for all treatments below that of the UTC with the exception of CEN 3 and TRI 1 (Table 3). After the second insecticide application, all treatments that received two insecticide applications (CEN 2 and 3 and TRI 2 and 3) resulted in numeric increases over the UTC ranging from 0.29 g per plant for CEN 3 to 0.44 g per plant for CEN 2. All PGR treatments resulted in a numeric decrease below the UTC except for TRI 3 following 3 applications. These decreases ranged from 0.56 g per plant for CEN 1 to 1.8 g per plant for TRI 1. After the third application of TRI, the TRI treatments showed a positive relationship to the amount of insecticide applied.

Leaf Weight

Leaf weight did not differ for any of the foliar insecticide applications for either 2003 or 2004, with the exception of the initial check for uniformity (T-0). Although leaf weight per plant for the CEN 1 plots was significantly greater at this time, this advantage in early leaf mass was not evident in subsequent measurements (Table 3). During the check for uniformity, the weights of the cotyledons were measured along with any leaves that were present. No interactions were detected for leaf weight between the application timings with the exception of that following the second application (T-2). Because T-2 showed interaction between treatment and year, the data is presented separately by year. The treatments receiving two applications (CEN 2 and 3 and TRI 2 and 3) resulted in numerically higher leaf weights than the UTC in 2004. These

Table 3. Insecticidal treatment effect on stem weight, leaf weight and total biomass (stem weight + leaf weight) after each application.

	Stem Weight (g plant^{-1})				
Treatment§	**T-0 ¶**	**T-1**	**T-2**		**T-3**
UTC	0.14 a †	0.68 a	2.83 a		9.06 a
Centric 1	0.16 a	0.63 a	2.87 a		8.50 a
Centric 2	0.12 a	0.65 a	3.27 a		8.02 a
Centric 3	0.13 a	0.68 a	3.12 a		8.00 a
Trimax 1	0.13 a	0.68 a	2.70 a		7.26 a
Trimax 2	0.14 a	0.61 a	3.18 a		8.40 a
Trimax 3	0.11 a	0.51 a	3.16 a		9.42 a
P value	0.43	0.15	0.74		0.22
	Leaf Weight (g plant^{-1})				
	T-0	**T-1**	**T-2**		**T-3**
			2003 ‡	**2004 ‡**	
UTC	0.27 b	1.37 a	3.84 a	4.44 a	8.82 a
Centric 1	0.41 a	1.30 a	3.50 a	4.72 a	7.97 a
Centric 2	0.25 b	1.32 a	3.86 a	4.96 a	8.00 a
Centric 3	0.28 b	1.40 a	4.11 a	4.64 a	8.08 a
Trimax 1	0.32 b	1.45 a	3.32 a	4.42 a	7.72 a
Trimax 2	0.30 b	1.26 a	3.53 a	5.97 a	9.25 a
Trimax 3	0.26 b	1.13 a	2.77 a	6.48 a	9.95 a
P value	0.02	0.23	0.38	0.12	0.31
	Total Biomass (g plant^{-1})				
	T-0	**T-1**	**T-2**		**T-3**
UTC	0.42 a	2.04 a	6.97 a		17.88 a
Centric 1	0.57 a	1.93 a	6.98 a		16.47 a
Centric 2	0.37 a	1.96 a	7.68 a		16.02 a
Centric 3	0.41 a	2.08 a	7.50 a		16.09 a
Trimax 1	0.44 a	2.14 a	6.56 a		14.98 a
Trimax 2	0.44 a	1.87 a	7.93 a		17.65 a
Trimax 3	0.37 a	1.64 a	7.78 a		19.37 a
P value	0.06	0.19	0.63		0.28

† Means within a column followed by the same letter are not statistically different at P<0.05 according to the Tukey-Kramer procedure.

‡ These data showed significant interaction between treatment and year; therefore, the data is presented by year. Means within these columns followed by the same letter are not statistically different at P<0.05 according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 Days after initial treatment) increases in leaf weight ranged from 0.2 g per plant for CEN 3 to 2.04 g per plant for TRI 3. After three insecticidal applications were made, there was a positive relationship between the amount of CEN and TRI applied and total leaf weight. Oosterhuis and Brown (2003) found that one application of TRI numerically increased leaf weight over that of the UTC.

Total Biomass

No significant differences were found in the total biomass (stem weight + leaf weight) per plant for any of the foliar insecticide applications for either 2003 or 2004. The CEN 1 plots were numerically higher than all other treatments at the initial check for uniformity (T-0). This was a result of the significantly higher leaf weights as described earlier. As with the leaf weights, the early advantages in total biomass were not evident in subsequent measurements (Table 3). Following two applications, all PGR treatments were numerically higher than the UTC except for TRI 1. However, after the third application, all treatments were numerically lower than the UTC except for TRI 3. The numerical decreases ranged from 0.23 g per plant (1.3 %) for TRI 2 to 2.90 g per plant (16.2 %) for TRI 1. The TRI-treated plants showed a positive relationship between the total biomass and the number of insecticide applications.

LEAF AREA

No significant differences were found in leaf area for any of the foliar insecticide applications for either 2003 or 2004. After one application, all treatments resulted in a numeric decrease below the UTC with the exception of CEN 3 and TRI 1 (Table 4). Two applications of insecticide caused numeric increases ranging from 33.67 cm^2 per

Table 4. Insecticidal treatment effect on Leaf Area and Leaf Area Index (LAI).

	Leaf Area (cm^2 $plant^{-1}$)				
Treatment§	**T-0 ¶**	**T-1**	**T-2**	**T-3**	**T-4**
UTC	76.68 a †	232.98 a	687.16 a	1719.83 a	2522.33 a
Centric 1	93.77 a	228.64 a	692.65 a	1578.47 a	2635.67 a
Centric 2	70.86 a	229.88 a	843.23 a	1587.14 a	2358.17 a
Centric 3	75.69 a	240.70 a	720.83 a	1487.54 a	2172.17 a
Trimax 1	77.59 a	245.47 a	652.76 a	1462.61 a	2393.33 a
Trimax 2	82.65 a	215.27 a	755.21 a	1687.83 a	2408.33 a
Trimax 3	69.32 a	197.13 a	589.32 a	1782.67 a	2571.67 a
P value	0.19	0.29	0.13	0.23	.63

	LAI				
	T-0	**T-1**	**T-2**	**T-3**	**T-4**
UTC	0.08 a	0.23 a	0.68 a	1.69 a	2.48 a
Centric 1	0.09 a	0.23 a	0.68 a	1.55 a	2.59 a
Centric 2	0.07 a	0.23 a	0.83 a	1.56 a	2.32 a
Centric 3	0.07 a	0.24 a	0.71 a	1.47 a	2.14 a
Trimax 1	0.08 a	0.24 a	0.64 a	1.44 a	2.35 a
Trimax 2	0.08 a	0.21 a	0.74 a	1.66 a	2.37 a
Trimax 3	0.07 a	0.20 a	0.58 a	1.75 a	2.53 a
P value	0.16	0.31	0.13	0.23	0.40

† Means within a column followed by the same letter are not statistically different at $P<0.05$ according to the Tukey-Kramer procedure.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 Days after initial treatment) plant for CEN 3 to 156.07 cm^2 per plant for CEN 2 over the UTC in all treatments except for TRI 3. TRI 3 had the lowest leaf area following the first and second applications; however, after the third application the leaf area of TRI 3 was the highest of all the treatments by 62.84 cm^2 per plant. TRI 3 was also the only treatment to have a numeric increase in leaf area compared to the UTC after three applications. The other treatments resulted in numeric deceases ranging from 32 cm^2 per plant for TRI 2 to 257.22 cm^2 per plant for TRI 1, but without any semblance to treatment effects. In other words, there was no order for decreases or increases relative to the UTC and number of insecticidal treatments. Measurements taken after all three applications were applied (T-3 and T-4) indicate that there was a positive relationship between the amount of TRI applied and total leaf area. Conversely, the CEN treatments resulted in an inverse relationship between the leaf area and the number of applications at T-4.

LEAF AREA INDEX (LAI)

LAI was not different for any of the foliar insecticide applications for either 2003 or 2004. Following all three insecticide applications (T-3), every treatment except TRI 3 had a numerically lower LAI than the UTC (Table 4). Again at the midseason (T-4) timing, every treatment was numerically lower for LAI than the UTC with the exception of CEN 1 and TRI 3. There appeared to be a positive relationship between the amount of TRI applied and the LAI after all three applications were made that continued through the midseason (T-4) measurements. The LAI ranged from 2.14 for CEN 3 to 2.59 for CEN 1 between all PGR treatments. Whereas LAI appeared to respond in a positive manner to TRI treatment, the opposite was observed for CEN. With each additional insecticidal treatment, LAI decreased numerically for CEN. Although there was a positive trend to the TRI applications, TRI 3 was the only TRI-treatment resulting in a numeric increase over the UTC (T-3 and T-4). Contrary to our study, Oosterhuis and Brown (2003) found numeric increases in LAI following one application of TRI.

SPECIFIC LEAF AREA (SLA)

Specific Leaf Area was obtained by dividing the leaf area by the dry weight of the leaves. No significant differences were found in the SLA for any of the foliar insecticide applications for either 2003 or 2004. All treatments resulted in an increase in the SLA over the UTC except for TRI 1 and TRI 2 after one application (Table 5). The treatments that showed an increase in the SLA showed increases in leaf material ranging from 1.81 cm^2/g per plant for CEN 3 to 4.93 cm^2/g per plant for CEN 1. After all PGR treatments were applied, CEN 1 was the only treatment that was consistently higher for SLA than the UTC. This indicates that CEN 1 had a higher surface area per gram of dry leaf weight than the UTC, which should provide more leaf area to intercept and potentially convert more light energy into carbohydrates. Also at T-3, there was an inverse relationship between the amount of insecticide applied and the SLA for all PGR treatments. Each additional application resulted in an average decrease of 9.24 cm^2/g (4.6 %) for CEN and 2.70 cm^2/g (1.4 %) for TRI. Oosterhuis and Brown (2003) suggested that the decreases in Specific Leaf Weight (SLW) associated with TRI application was possibly caused by improved translocation of photosynthates out of the leaf. SLW, measured as g/cm^2, is the inverse of SLA, cm^2/g. The results from this study

Table 5. Insecticidal treatment effects on Specific Leaf Area (SLA).

	SLA (cm^2/g)				
Treatment§	**T-0 ¶**	**T-1**	**T-2**	**T-3**	**T-4**
UTC	486.44 a †	171.16 a	169.42 a	195.10 a	162.50 a
Centric 1	315.45 a	176.09 a	169.45 a	203.05 a	180.98 a
Centric 2	537.47 a	174.93 a	193.21 a	197.72 a	162.42 a
Centric 3	625.65 a	172.97 a	164.46 a	184.57 a	162.57 a
Trimax 1	301.35 a	169.28 a	169.09 a	187.82 a	151.36 a
Trimax 2	517.49 a	168.95 a	162.86 a	186.74 a	161.86 a
Trimax 3	349.25 a	174.47 a	142.86 a	182.43 a	159.41 a
P value	0.53	0.69	0.07	0.78	0.15

† Means within a column followed by the same letter are not statistically different at $P<0.05$ according to the Tukey-Kramer procedure.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 DAIT)

show that after all insecticide applications were made, CEN 1 was the only PGR treatment that had a consistently higher SLA, and therefore lower SLW, than the UTC.

PARTITIONING COEFFICIENT

The Partitioning Coefficient (PC) was determined for the plots using the total biomass measurements that were taken at midseason (61 DAIT). The PC is a measure of the dry weight of the fruit (bolls and squares) divided by the dry weight of the vegetative biomass (leaves and stems). PC represents the amount of the biomass that is partitioned into the fruit in relation to vegetative biomass. Because of a significant interaction between the treatments and year, the PC data must be presented by year.

In 2003, the total biomass was numerically higher than the UTC for all PGR treatments with the exception of TRI 2 (Table 6). CEN 2 had a significantly higher fruit weight than the UTC at the a = 0.10 level. All PGR treatments had a numerically higher PC than the UTC with the exception of CEN 1. CEN 2 and TRI 3 had a significantly higher PC than the UTC at the a = 0.10 level. This means that with a ninety percent level of confidence, the CEN 2 and TRI 3 treatments partitioned significantly more photosynthate towards fruit production.

In 2004, the total biomass of CEN 3 was significantly lower than the UTC at the a = 0.10 level (Table 7). All PGR treatments except for TRI 3 resulted in numerically lower total biomass than the UTC at this time. CEN 1 and TRI 3 had the highest fruit weight at this time with weights of 47.99 g and 47.76 g per plant, respectively. The fruit weights at this midseason biomass were consistent with the end of season lint yield in that CEN 1 and TRI 3 were the highest yielding treatments in 2004. All three CEN

Table 6. Insecticidal treatment effect on biomass and the Partitioning Coefficient, 2003.

	Midseason Biomass Partitioning			
Treatment§	**Total (g)**	**Fruit (g)**	**Vegetative (g)**	**Partitioning Coefficient**
UTC	301.51 a ‡	105.71 a	195.80 a	0.53 a
Centric 1	306.21 a	101.88 a	204.33 a	0.51 a
Centric 2	363.85 a	148.23 a	215.63 a	0.69 a
Centric 3	312.89 a	114.84 a	198.05 a	0.58 a
Trimax 1	362.84 a	134.40 a	228.44 a	0.59 a
Trimax 2	293.88 a	106.30 a	187.58 a	0.56 a
Trimax 3	314.56 a	128.14 a	186.43 a	0.68 a
P value	0.29	0.08	0.52	0.06

‡ Means within a column followed by the same letter are not statistically different at P<0.05 according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

Table 7. Insecticidal treatment effect on biomass and the Partitioning Coefficient, 2004.

	Midseason Biomass Partitioning			
Treatment§	**Total (g)**	**Fruit (g)**	**Vegetative (g)**	**Partitioning Coefficient**
UTC	272.80 a ‡	42.05 a	230.75 a	0.18 a
Centric 1	234.75 a	47.99 a	186.76 a	0.27 a
Centric 2	213.24 a	41.46 a	171.78 a	0.24 a
Centric 3	198.98 a	43.44 a	155.54 a	0.28 a
Trimax 1	234.20 a	36.00 a	198.20 a	0.18 a
Trimax 2	270.31 a	42.68 a	227.64 a	0.19 a
Trimax 3	286.04 a	47.76 a	238.28 a	0.19 a
P value	0.08	0.85	0.36	0.13

‡ Means within a column followed by the same letter are not statistically different at $P<0.05$ according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

treatments resulted in a numeric increases in the PC over the UTC ranging from 0.06 for CEN 2 to 0.10 for CEN 3.

The PC for the PGR treatments was higher in 2003 than in 2004. The average PC at midseason in 2003 was 0.59 and the average for 2004 was 0.22. This discrepancy in the partitioning of biomass at this midseason measurement is most likely the result of the weather conditions during each growing season. The growing season in 2003 was a very dry, warm year with clear skies, while 2004 was wet with high amounts of cloud cover early which resulted in cooler temperatures. This cooler, wetter weather in 2004 could have slowed plant growth and delayed the onset of fruit by prolonging the vegetative growth of the plant. As shown in Tables 6 and 7, the total biomass at midseason was higher in 2003 than in 2004 and a higher percentage of the biomass was partitioned to the fruit.

ABSOLUTE GROWTH RATE (AGR)

The AGRs were determined for plant height, total number of nodes, stem weight, leaf weight, and total biomass. Data was taken at four dates for these parameters. AGRs were found across designated time intervals between the initial check for uniformity and subsequent applications and between each application. There were no significant differences in AGR for any of the treatments at the a = 0.05 level, with the exception of the AGR of plant height from T3-T4 in 2004 and the AGR of total biomass from T0-T1.

The UTC was numerically greater for the AGR of height (cm) after two applications (T0-T2) and again after three applications (T0-T3) when compared to CEN 2 and 3 and TRI 1 (Table 8). During these two time intervals the UTC grew 1.3 cm/day

Table 8. Insecticidal treatment effect on the Absolute Growth Rate (AGR) of plant height and total number of nodes across designated time intervals.

	AGR of Plant Height (cm/day)							
Treatment§	T0-T1 ¶	T0-T2	T0-T3	T0-T4	T1-T2	T2-T3	T3-T4	
							2003 ‡	2004 ‡
UTC	0.95 a †	1.30 a	1.51 a	1.08 a	1.49 a	1.89 a	0.31 a	1.09 a
Centric 1	0.93 a	1.23 a	1.42 a	1.02 a	1.41 a	1.83 a	0.33 a	0.53 a
Centric 2	1.03 a	1.21 a	1.41 a	1.07 a	1.34 a	1.82 a	0.49 a	0.60 a
Centric 3	0.93 a	1.16 a	1.40 a	1.02 a	1.35 a	1.73 a	0.40 a	0.60 a
Trimax 1	1.03 a	1.21 a	1.46 a	1.08 a	1.34 a	1.84 a	0.39 a	0.88 a
Trimax 2	0.99 a	1.24 a	1.47 a	1.09 a	1.41 a	1.98 a	0.37 a	1.04 a
Trimax 3	0.86 a	1.23 a	1.33 a	1.00 a	1.46 a	1.61 a	0.35 a	1.16 a
P value	0.32	0.80	0.26	0.49	0.79	0.23	0.65	0.24

	AGR of Nodes (nodes/day)						
	T0-T1	T0-T2	T0-T3	T0-T4	T1-T2	T2-T3	T3-T4
UTC	0.31 a	0.33 a	0.28 a	0.21 a	0.33 a	0.22 a	0.15 a
Centric 1	0.35 a	0.30 a	0.29 a	0.22 a	0.30 a	0.26 a	0.11 a
Centric 2	0.33 a	0.29 a	0.28 a	0.21 a	0.29 a	0.27 a	0.11 a
Centric 3	0.33 a	0.31 a	0.29 a	0.22 a	0.30 a	0.26 a	0.11 a
Trimax 1	0.34 a	0.31 a	0.30 a	0.21 a	0.30 a	0.27 a	0.12 a
Trimax 2	0.33 a	0.31 a	0.29 a	0.21 a	0.29 a	0.27 a	0.14 a
Trimax 3	0.30 a	0.34 a	0.28 a	0.22 a	0.34 a	0.22 a	0.14 a
P value	0.64	0.28	0.30	0.98	0.31	0.30	0.52

† Means within a column followed by the same letter are not statistically different at $P<0.05$ according to the Tukey-Kramer procedure.

‡ These data showed significant interaction between treatment and year, therefore the data is presented by year. Means within these columns followed by the same letter are not statistically different at $P<0.05$ according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 DAIT)

and 1.51 cm/day, respectively. In 2003, all insecticide treatments had a higher AGR for height than the UTC for the time interval following the third insecticide application (T3-T4).

Although no significant differences were noted, after one application (T0-T1), all PGR treatments resulted in numeric increases in the number of nodes developed by the plant per day (nodes/day) with the exception of TRI 3 (Table 8). Oddly, after the second application (T0-T2), all treatments reflected a decrease in nodes/day except for TRI 3. Once all three applications were made (T0-T3), the TRI treated plants showed an inverse relationship to the amount of insecticide applied. The AGR for nodal development following the third insecticide application (T3-T4) showed that all of the treated plants developed fewer nodes/day than the UTC. One reason for this could be that the UTC plants were partitioning photosynthates into vegetative growth and the treated plants were partitioning more energy into the fruiting structures during this time.

The AGR of stem weight (g/day) was numerically lower than the UTC for all treatments following the third insecticide application (Table 9). The AGR of stem weight of the CEN-treated plants followed a positive relationship to the amount applied during this same time period (T0-T3). All TRI treatments showed an inverse numerical response in AGR of stem weight at the midseason measurement (T0-T4). The UTC had the highest numerical AGR following two applications (T2-T3). In 2004, the UTC also had the highest AGR following the third application (T3-T4). Again this slowing in the growth rate in the PGR treatments vegetative material may be a reflection of the plant partitioning a greater proportion of the assimilated carbon into reproduction. Because

Table 9. Insecticidal treatment effect on the Absolute Growth Rate (AGR) of stem weight, leaf weight, and total biomass (stem weight + leaf weight) across designated time intervals.

AGR of Stem Weight (g/day)

Treatment§	T0-T1 ¶	T0-T2	T0-T3	T0-T4	T1-T2	T2-T3	T3-T4	
							2003‡	2004‡
UTC	0.07 a †	0.12 a	0.27 a	0.30 a	0.16 a	0.53 a	0.29 a	0.68 a
Centric 1	0.05 a	0.12 a	0.22 a	0.30 a	0.16 a	0.46 a	0.35 a	0.39 a
Centric 2	0.06 a	0.14 a	0.24 a	0.32 a	0.19 a	0.40 a	0.36 a	0.42 a
Centric 3	0.07 a	0.13 a	0.25 a	0.28 a	0.18 a	0.42 a	0.31 a	0.31 a
Trimax 1	0.06 a	0.11 a	0.23 a	0.33 a	0.15 a	0.38 a	0.42 a	0.48 a
Trimax 2	0.05 a	0.13 a	0.24 a	0.31 a	0.19 a	0.44 a	0.31 a	0.68 a
Trimax 3	0.04 a	0.12 a	0.23 a	0.29 a	0.18 a	0.52 a	0.27 a	0.58 a
P value	0.07	0.62	0.70	0.71	0.69	0.32	0.39	0.24

AGR of Leaf Weight (g/day)

	T0-T1	T0-T2		T0-T3	T0-T4	T1-T2	T2-T3	T3-T4
		2003‡	2004‡					
UTC	0.13 a	0.20 a	0.15 a	0.26 a	0.23 a	0.21 a	0.40 a	0.29 a
Centric 1	0.11 a	0.17 a	0.15 a	0.21 a	0.25 a	0.21 a	0.33 a	0.25 a
Centric 2	0.12 a	0.21 a	0.17 a	0.24 a	0.25 a	0.23 a	0.31 a	0.24 a
Centric 3	0.13 a	0.22 a	0.16 a	0.25 a	0.22 a	0.23 a	0.32 a	0.17 a
Trimax 1	0.13 a	0.17 a	0.15 a	0.25 a	0.26 a	0.18 a	0.35 a	0.27 a
Trimax 2	0.11 a	0.18 a	0.20 a	0.26 a	0.24 a	0.25 a	0.38 a	0.24 a
Trimax 3	0.10 a	0.15 a	0.22 a	0.24 a	0.24 a	0.23 a	0.45 a	0.25 a
P value	0.20	0.40	0.10	0.47	0.65	0.60	0.65	0.76

AGR of Total Biomass (g/day)

	T0-T1	T0-T2	T0-T3	T0-T4	T1-T2	T2-T3	T3-T4
UTC	0.16 bc	0.19 a	0.32 a	0.48 a	0.31 a	0.93 a	1.11 a
Centric 1	0.17 b	0.25 a	0.24 a	0.53 a	0.41 a	0.68 a	1.26 a
Centric 2	0.17 b	0.23 a	0.35 a	0.49 a	0.38 a	0.98 a	1.20 a
Centric 3	0.19 ab	0.27 a	0.25 a	0.42 a	0.44 a	0.71 a	0.97 a
Trimax 1	0.18 b	0.22 a	0.29 a	0.52 a	0.36 a	0.83 a	1.21 a
Trimax 2	0.14 c	0.23 a	0.29 a	0.48 a	0.38 a	0.84 a	1.17 a
Trimax 3	0.21 a	0.26 a	0.26 a	0.58 a	0.43 a	0.75 a	1.35 a
P value	0.05	0.31	0.21	0.58	0.32	0.23	0.59

† Means within a column followed by the same letter are not statistically different at P<0.05 according to the Tukey-Kramer procedure.

‡ These data showed significant interaction between treatment and year. Means within these columns followed by the same letter are not statistically different at P<0.05 according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 DAIT)

the UTC retained a higher rate of vegetative growth, this suggests that the PGR treatments may be accelerating a change in biomass partitioning through production and retention of more fruit or by some other unknown physiological response.

The AGR of leaf weight (g/day) numerically decreased following the third application (T0-T3) in all treatments except TRI 2 (Table 9). Following the second application (T1-T2) all treatments receiving two applications had a numerically higher AGR than the UTC. The AGR from the end of all applications to the midseason measurements (T3-T4) showed that all treatments had lower AGRs for leaf weight compared to the UTC. The CEN treatments also had an inverse relation to the amount of insecticide applied for this time interval. Leaf weight and leaf area were closely related for most all time intervals.

The AGR of total biomass (g/day) from T0-T1 for TRI 3 was significantly higher than the UTC (Table 9). Because only one application of insecticide had been made at this time, the differences can only be attributed to the first application of TRI. Following two applications, there was a positive relationship between the number of applications and the AGR of total biomass for the TRI treatments. All growth rates were higher than the UTC for this time with the increases ranging from 0.03 g/day for TRI 2 to 0.08 g/day for CEN 3. CEN-treated plants showed an inverse relation to the amount of insecticide applied for T0-T4. All PGR treatments resulted in numerical increases over the UTC after the second application (T1-T2). Increases ranged from 0.05 g/day for TRI 1 to 0.13 g/day for CEN 3. After all applications had been made (T3-T4), every treatment except CEN 3 responded with an increased AGR for total biomass relative to the UTC.

RELATIVE GROWTH RATE (RGR)

The RGR was determined for plant height, total number of nodes, stem weight, leaf weight, and total biomass. Data was taken for these parameters at the same four dates that were detailed previously. The sample size for the RGRs of biomass (stem weight, leaf weight, and total biomass) was six plants per plot and the data is presented as such. The RGR was found for the time interval between the initial check for uniformity and each insecticide application and for the time period between each subsequent application. No significant differences were detected in RGR for any of the treatments at the a = 0.05 level, with the exception of RGR of plant height from T3-T4 in 2004, RGR of total nodes from T1-T2, and the RGR of leaf weight from T0-T3.

All PGR treatments caused a numerical increase in the RGR of height over the UTC following one application (T0-T1) (Table 10). The RGRs were surprisingly uniform over the next three time intervals (T0-T2, T0-T3, and T0-T4). Two applications caused an inverse relationship for CEN and a positive relationship for TRI for T1-T2. The time interval between the third application and the midseason measurement (T3-T4) showed significant interaction for treatment and year and is therefore presented by year. There were significant differences in 2004 for the RGR of plant height, and both CEN and TRI followed a positive relationship to the amount applied. TRI 3 grew significantly taller than all of the CEN-treated plants during this time interval.

The RGRs of total nodes produced were all numerically higher than the UTC following one application (T0-T1) (Table 10). As with plant height, the RGRs between T0-T2, T0-T3, and T0-T4 were all relatively uniform within each time interval. TRI 3

Table 10. Insecticidal treatment effect on the Relative Growth Rate (RGR) of plant height and total number of nodes across designated time intervals.

	RGR of Plant Height (cm/day)							
Treatment§	T0-T1 ¶	T0-T2	T0-T3	T0-T4	T1-T2	T2-T3	T3-T4	
							2003 ‡	2004 ‡
UTC	0.053 a†	0.050 a	0.045 a	0.028 a	0.047 a	0.036 a	0.005 a	0.013 ab
Centric 1	0.054 a	0.050 a	0.045 a	0.028 a	0.046 a	0.036 a	0.006 a	0.007 d
Centric 2	0.058 a	0.049 a	0.044 a	0.028 a	0.043 a	0.036 a	0.008 a	0.007 cd
Centric 3	0.054 a	0.048 a	0.044 a	0.028 a	0.044 a	0.035 a	0.007 a	0.008 bcd
Trimax 1	0.056 a	0.048 a	0.044 a	0.028 a	0.043 a	0.036 a	0.007 a	0.011 abcd
Trimax 2	0.056 a	0.049 a	0.045 a	0.029 a	0.045 a	0.038 a	0.006 a	0.012 abc
Trimax 3	0.055 a	0.052 a	0.045 a	0.029 a	0.050 a	0.034 a	0.007 a	0.014 a
P value	0.81	0.62	0.92	0.27	0.30	0.83	0.55	0.03

	RGR of Nodes (nodes/day)						
	T0-T1	T0-T2	T0-T3	T0-T4	T1-T2	T2-T3	T3-T4
UTC	0.050 a	0.041 a	0.032 a	0.022 a	0.034 a	0.017 a	0.009 a
Centric 1	0.055 a	0.041 a	0.034 a	0.022 a	0.033 ab	0.020 a	0.007 a
Centric 2	0.053 a	0.039 a	0.032 a	0.021 a	0.029 b	0.021 a	0.007 a
Centric 3	0.054 a	0.041 a	0.034 a	0.022 a	0.032 b	0.021 a	0.007 a
Trimax 1	0.055 a	0.040 a	0.034 a	0.022 a	0.031 b	0.021 a	0.008 a
Trimax 2	0.056 a	0.041 a	0.034 a	0.022 a	0.031 b	0.021 a	0.008 a
Trimax 3	0.053 a	0.043 a	0.034 a	0.023 a	0.037 a	0.018 a	0.009 a
P value	0.75	0.22	0.43	0.40	0.03	0.43	0.64

† Means within a column followed by the same letter are not statistically different at P<0.05 according to the Tukey-Kramer procedure.

‡ These data showed significant interaction between treatment and year, therefore the data is presented by year. Means within these columns followed by the same letter are not statistically different at P<0.05 according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 DAIT)

and the UTC had a significantly higher RGR of total nodes than the other treatments after two applications were made (T1-T2). The RGRs for T2-T3, however, show that the other treatments were all higher than TRI 3 and the UTC.

Treatments receiving two insecticide applications had a higher RGR of stem weight than the UTC for the time interval T0-T2 (Table 11). Increases in RGR ranged from 0.008 g/day for TRI 3 to 0.019 g/day for CEN 2. Both CEN and TRI showed a positive relationship to the amount of insecticide applied for T0-T3. CEN 1 was the only treatment that had a lower RGR than the UTC across the entire season (T0-T4).

The RGR of leaf weight was numerically increased over the UTC for the treatments receiving two applications of CEN (CEN 2 and CEN 3) from T0-T2 (Table 11). The PGR treatment CEN 1 had a significantly lower RGR of leaf weight than the UTC following the third application (T0-T3). During this same time interval, both CEN and TRI-treated plants related positively to the number of applications received, with CEN 1 and TRI 1 being the only two treatments below the UTC. Directly following the second application (T1-T2), CEN at 2 and 3 applications and TRI at 2 and 3 applications, all resulted in numerically higher RGRs than the UTC with increases ranging from 0.004 g/day for CEN 3 and 0.014 g/day for TRI 2. From T2-T3, TRI 3 was the only treatment that had a higher RGR than the UTC. After all applications had been made (T3-T4), both CEN and TRI caused an inverse relationship between RGR and the number of insecticide applications.

The RGR of total biomass somewhat mirrored the RGR of leaf weight because the leaf weight comprises the majority of the biomass. Treatments receiving two

Table 11. Insecticidal treatment effect on the Relative Growth Rate (RGR) of stem weight, leaf weight, and total biomass (stem weight + leaf weight) across designated time intervals.

	RGR of Stem Weight (g/day)						
Treatment§	**T0-T1 ¶**	**T0-T2**	**T0-T3**	**T0-T4**	**T1-T2**	**T2-T3**	**T3-T4**
UTC	0.186 a †	0.136 a	0.125 a	0.082 a	0.103 a	0.103 a	0.033 a
Centric 1	0.161 a	0.128 a	0.117 a	0.079 a	0.106 a	0.095 a	0.029 a
Centric 2	0.208 a	0.155 a	0.129 a	0.086 a	0.122 a	0.079 a	0.032 a
Centric 3	0.201 a	0.145 a	0.130 a	0.082 a	0.108 a	0.086 a	0.029 a
Trimax 1	0.209 a	0.143 a	0.123 a	0.087 a	0.101 a	0.085 a	0.040 a
Trimax 2	0.180 a	0.145 a	0.126 a	0.086 a	0.124 a	0.089 a	0.036 a
Trimax 3	0.127 a	0.144 a	0.131 a	0.085 a	0.123 a	0.105 a	0.030 a
P value	0.55	0.45	0.52	0.66	0.21	0.15	0.33
	RGR of Leaf Weight (g/day)						
	T0-T1	**T0-T2**	**T0-T3**	**T0-T4**	**T1-T2**	**T2-T3**	**T3-T4**
UTC	0.203 a	0.130 a	0.108 a	0.071 a	0.083 a	0.067 a	0.024 a
Centric 1	0.141 a	0.107 a	0.089 b	0.061 a	0.085 a	0.056 a	0.024 a
Centric 2	0.212 a	0.138 a	0.109 a	0.072 a	0.091 a	0.054 a	0.022 a
Centric 3	0.207 a	0.134 a	0.111 a	0.068 a	0.087 a	0.051 a	0.017 a
Trimax 1	0.176 a	0.113 a	0.095 ab	0.066 a	0.072 a	0.060 a	0.028 a
Trimax 2	0.180 a	0.129 a	0.106 a	0.070 a	0.097 a	0.062 a	0.021 a
Trimax 3	0.175 a	0.127 a	0.109 a	0.070 a	0.096 a	0.073 a	0.020 a
P value	0.14	0.10	0.04	0.36	0.27	0.57	0.73
	RGR of Total Biomass (g/day)						
	T0-T1	**T0-T2**	**T0-T3**	**T0-T4**	**T1-T2**	**T2-T3**	**T3-T4**
UTC	0.194 a	0.131 a	0.115 a	0.081 a	0.091 a	0.083 a	0.040 a
Centric 1	0.147 a	0.114 a	0.100 a	0.074 a	0.093 a	0.073 a	0.039 a
Centric 2	0.206 a	0.143 a	0.116 a	0.084 a	0.103 a	0.065 a	0.041 a
Centric 3	0.204 a	0.138 a	0.118 a	0.080 a	0.096 a	0.065 a	0.037 a
Trimax 1	0.183 a	0.122 a	0.105 a	0.079 a	0.083 a	0.072 a	0.046 a
Trimax 2	0.179 a	0.134 a	0.114 a	0.082 a	0.107 a	0.074 a	0.040 a
Trimax 3	0.175 a	0.133 a	0.117 a	0.082 a	0.105 a	0.087 a	0.038 a
P value	0.23	0.14	0.07	0.43	0.21	0.34	0.77

† Means within a column followed by the same letter are not statistically different at $P<0.05$ according to the Tukey-Kramer procedure.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ T-0 = Initial measurements prior to treatment applications to check for uniformity, T-1 = 7 days after first application, T-2 = 7 days after second app., T-3 = 7 days after third app., T-4 = Midseason measurements (61 DAIT)

applications (CEN 2 and 3 and TRI 2 and 3), all had a numerically higher RGR than the UTC for total biomass (Table 11). Following the third application (T0-T3), the PGR treatments again related positively to the amount of insecticide applied with CEN 1 being significantly lower than the UTC and the a = 0.10 level. As with the RGR of leaf weight, the time interval of T1-T2 resulted in CEN 2 and 3 and TRI 2 and 3 yielding numerically higher RGRs. The increases ranged from 0.005 g/day for CEN 3 to 0.016 g/day for TRI 2. Again, TRI 3 was the only treatment that had a higher RGR than the UTC for total biomass from T2-T3. The inverse relationship between the RGR and amount of insecticide applied was evident again for TRI from T3-T4.

PHOTOSYNTHESIS

Determinations of photosynthetic rates were dependent on many factors that were highly variable during the course of the two-year study. For example, temperature, humidity, plant water status, and light intensity (due to cloud cover) varied from one year to the next and sometimes within the same day of measurement. There was no effective way to normalize the data so that a statistical analysis across years could be completed. Because of this, and the variability of the readings between treatments within the same year, the photosynthetic rate data is presented separately by year.

In 2003, no significant differences were detected in the photosynthetic rate between any of the PGR treatments at any of the insecticide timings with the exception of the midseason (46 DAIT) measurements (Table 12). On this day, 46 DAIT, TRI 3 resulted in a significantly lower photosynthetic rate than all other treatments. This date

Table 12. Insecticidal treatment effect on photosynthetic rate, 2003.

	CO_2 Exchange Rate (μmol CO_2/m^2s)			
	6-20-2003 ¶	**7-1-2003**	**7-8-2003**	**7-29-2003**
Treatment§	**7 DAIT †**	**18 DAIT**	**25 DAIT**	**46 DAIT**
UTC	32.0 a ‡	34.0 a	32.5 a	40.8 a
Centric 1	30.9 a	36.1 a	30.9 a	39.2 a
Centric 2	31.8 a	33.9 a	30.6 a	38.2 a
Centric 3	33.5 a	34.6 a	32.6 a	39.3 a
Trimax 1	31.6 a	34.0 a	33.4 a	39.4 a
Trimax 2	31.1 a	32.3 a	28.4 a	38.2 a
Trimax 3	33.6 a	34.1 a	30.4 a	33.7 b
P value	0.78	0.58	0.39	0.03

‡ Means within a column followed by the same letter are not statistically different at $P<0.05$ according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ 6-20-2003 = After first application, 7-1-2003 = After second app., 7-8-2003 = After third app., 7-29-2003 = Midseason measurement

† DAIT = Days after initial treatment

also corresponded to a numerically higher rate for the UTC over all of the other treatments.

In 2004, no significant differences were detected in the photosynthetic rate between any of the PGR treatments at any of the timings (Table 13). There were, however, similar rate responses between the photosynthetic rates and the yield data for both years. In general, as more insecticide was applied, the photosynthetic rates and the yields were both decreased.

BOX MAPPING

Mean Boll Weight

No significant differences were found for mean boll weight for any of the foliar insecticide applications for either 2003 or 2004. An interaction between treatment and year predicated that the data be presented separately by year. In 2003, all PGR insecticide treatments resulted in numeric increases in mean boll weight with the exception of CEN 2 and TRI 1 (Fig. 1). The increases in boll weight ranged from 0.21 g per boll for CEN 1 to 0.42 g per boll for TRI 3. A positive relationship was found between mean boll weight and the number of TRI applications in 2003. For both insecticides, three applications resulted in the largest bolls. Applications of MC, a widely used PGR, increased mean boll weights by 7% (Fernandez, 1997). In 2004, all PGR treatments examined gave numerically lower mean boll weights than the UTC. The decreases ranged from 0.04 g per boll for CEN 1 to 0.25 g per boll for TRI 2.

Table 13. Insecticidal treatment effect on photosynthetic rate, 2004.

	CO_2 Exchange Rate (μmol CO_2/m^2s)		
	5-21-2004 ¶	6-4-2004	7-2-2004
Treatment§	1 DBIT †	14 DAIT	43 DAIT
UTC	22.1 a ‡	29.7 a	28.6 a
Centric 1	22.8 a	33.3 a	30.1 a
Centric 2	23.0 a	30.4 a	29.4 a
Centric 3	21.7 a	28.6 a	27.7 a
Trimax 1	22.7 a	27.2 a	29.4 a
Trimax 2	23.2 a	31.2 a	28.2 a
Trimax 3	22.7 a	29.8 a	27.5 a
P value	0.78	0.13	0.17

‡ Means within a column followed by the same letter are not statistically different at $P<0.05$ according to Fisher's LSD.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

¶ 5-21-2004 = Check for uniformity, 6-4-2004 = After first application, 7-2-2004 = After third app.

† DBIT = Days before initial treatment, DAIT = Days after initial treatment

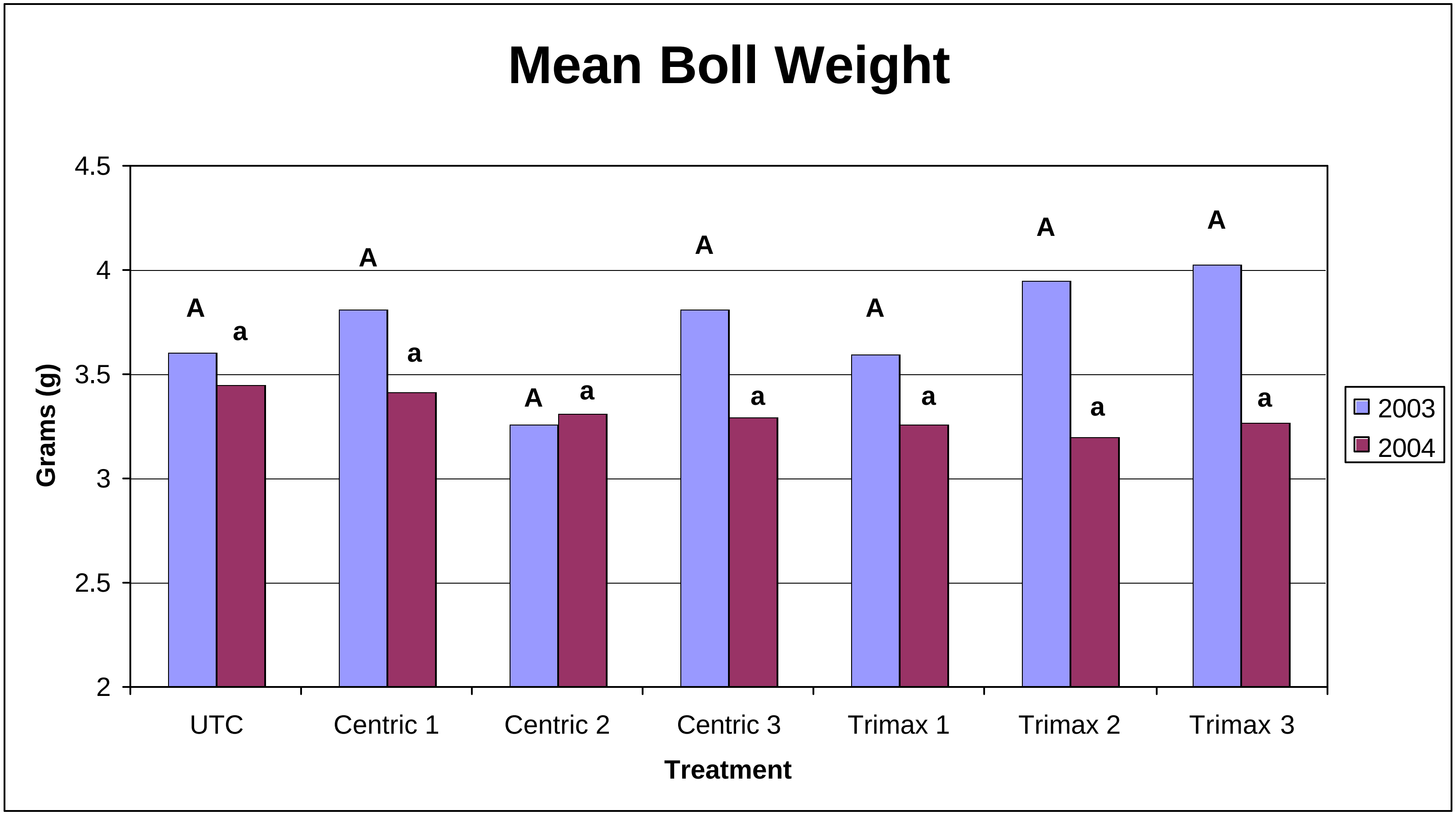

Fig. 1. Insecticidal treatment effect on mean boll weight. UTC = untreated control; Centric 1 = 1 application; Centric 2 = 2 apps.; Centric 3 = 3 apps.; Trimax 1 = 1 app.; Trimax 2 = 2 apps.; Trimax 3 = 3 apps. Means followed by the same letter are not significantly different at $p<0.05$ according to Fisher's LSD test.

Total Bolls per Plant

An interaction between treatment and year for total bolls per plant mandated that the data be presented separately by year. In 2003, CEN 1 and TRI 3 had significantly fewer bolls per plant than the UTC (Fig. 2). Each plant in these treatments averaged 2.74 fewer bolls than the UTC. No significant differences between treatments for bolls per plant were present in 2004; however, each treatment, with the exception of CEN 1 had a numeric increase in the number of bolls per plant. These numbers ranged from 0.08 bolls to 1.12 bolls per plant.

Yield Position

In 2003, boll retention at first and second fruiting positions, on the lower nodes (6-10), was numerically higher than the untreated control in treatments that received only one application of insecticide (Fig. 3). This higher retention in the first and second positions may partially explain the numerical increase in percent of lint yield in PGR treatments over the UTC, with the exception of TRI 2 (Fig. 4). Treatments with lower numerical yields had more total bolls than the higher yielding treatments in 2003 (Fig. 2), but the distribution of these bolls were in third and fourth positions and in nodal proximity to the apex. An explanation for greater boll numbers at these positions was not apparent. However, the plant can compensate for early fruit loss due to stress by setting bolls in the upper nodes and vegetative branches (Sadras, 1995).

In 2004, a numeric increase in early season square retention was observed for all treatments over the UTC (Fig. 5). Fernandez (1997) stated that fruit retention was 5.3% to 7.0% higher with multiple applications of the PGR MC. Again, this increase in

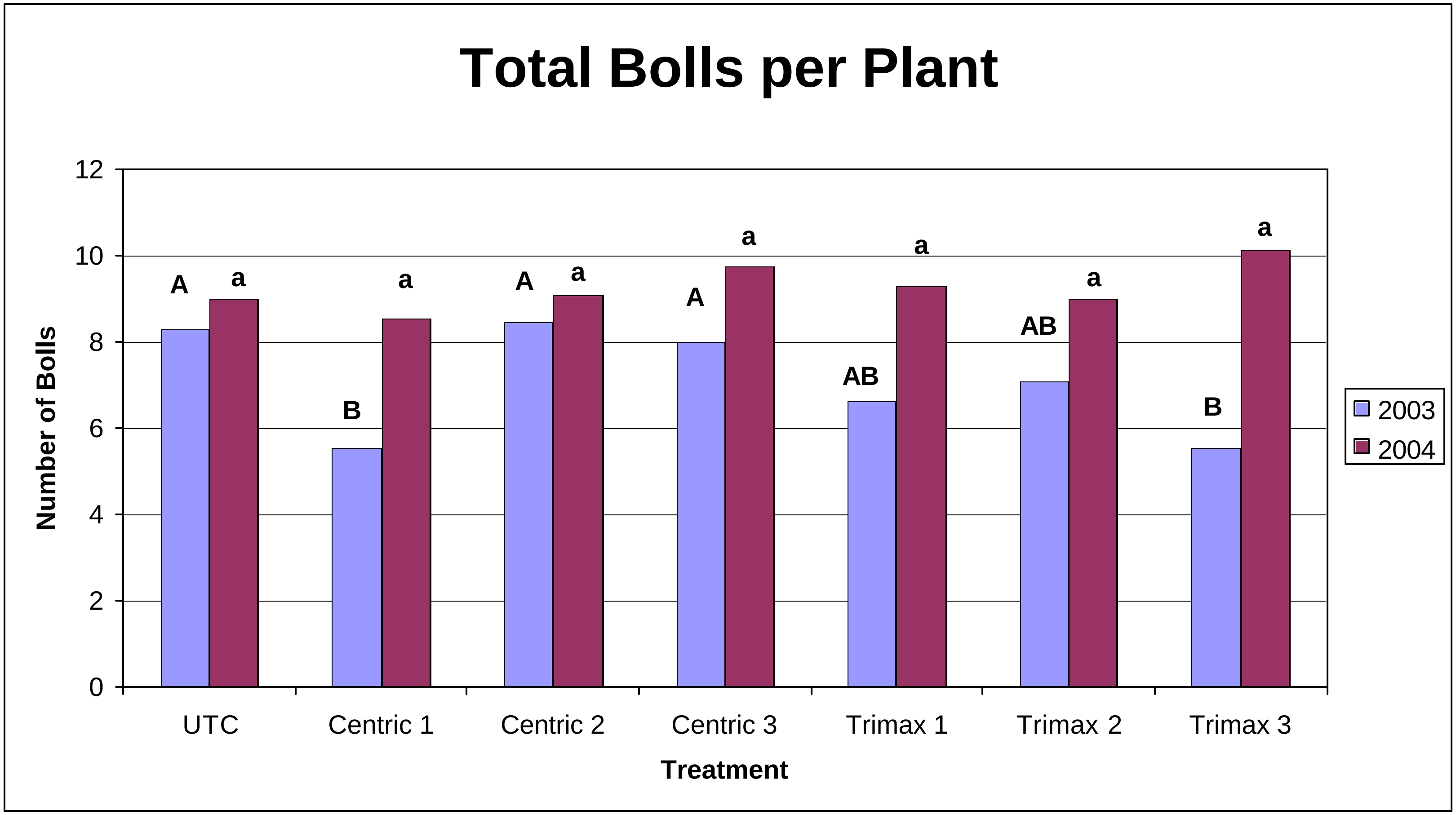

Fig. 2. Insecticidal treatment effect on total bolls per plant. UTC = untreated control; Centric 1 = 1 application; Centric 2 = 2 apps.; Centric 3 = 3 apps.; Trimax 1 = 1 app.; Trimax 2 = 2 apps.; Trimax 3 = 3 apps. Means followed by the same letter are not significantly different at $p<0.05$ according to Fisher's LSD test.

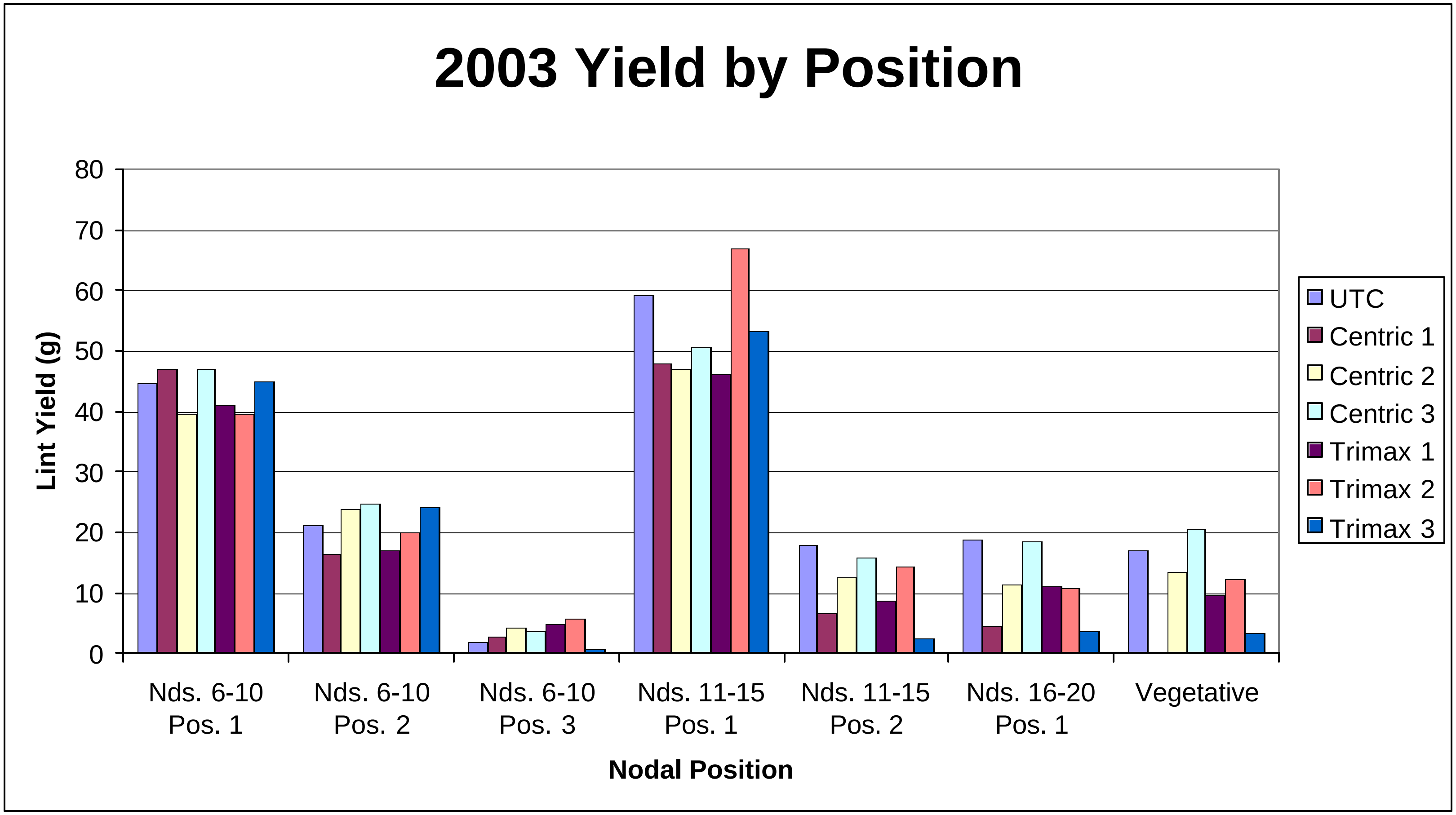

Fig. 3. 2003 insecticidal effect on distribution of total yield by position.

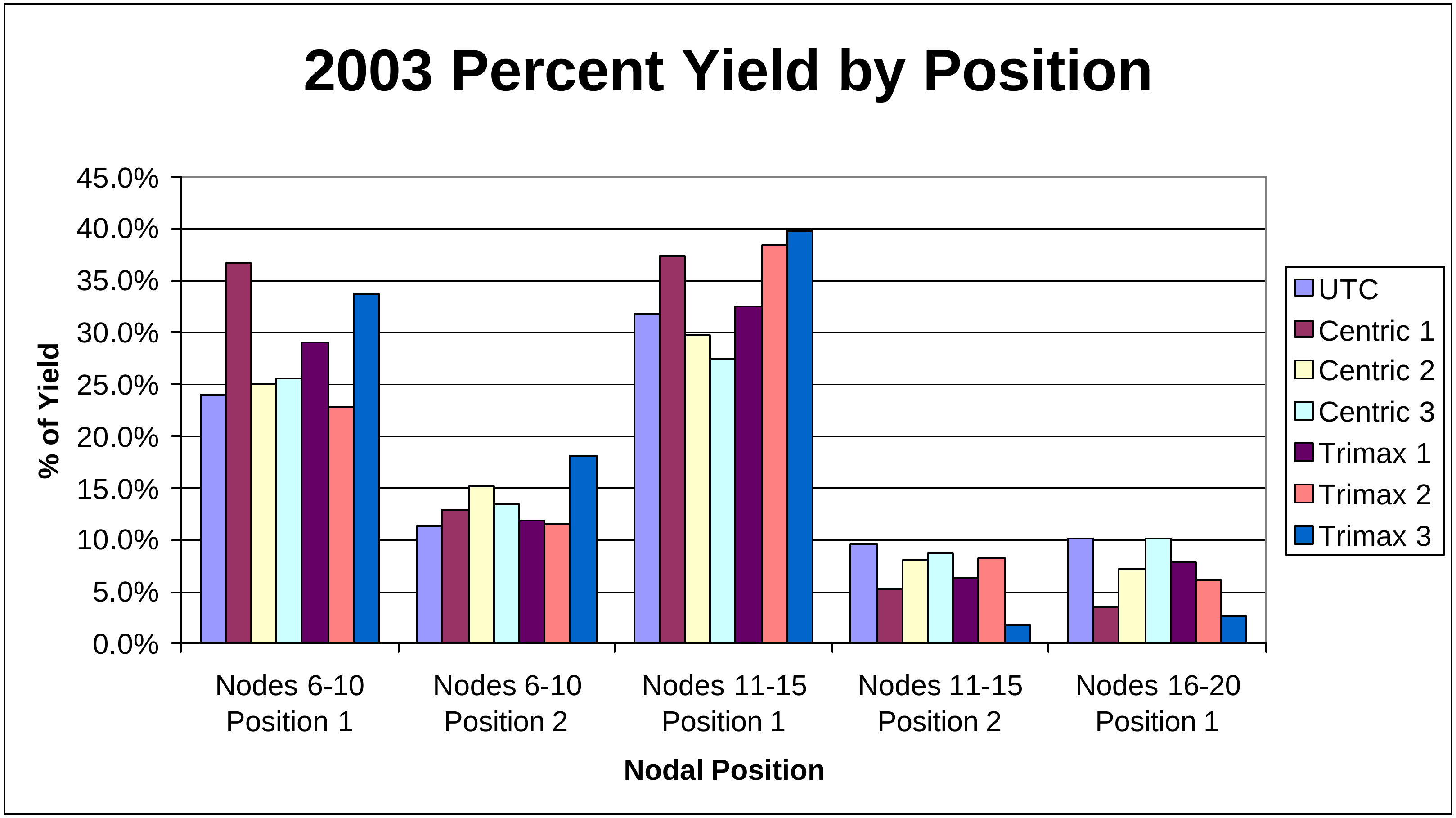

Fig. 4. 2003 insecticidal effect on distribution of percent yield by position.

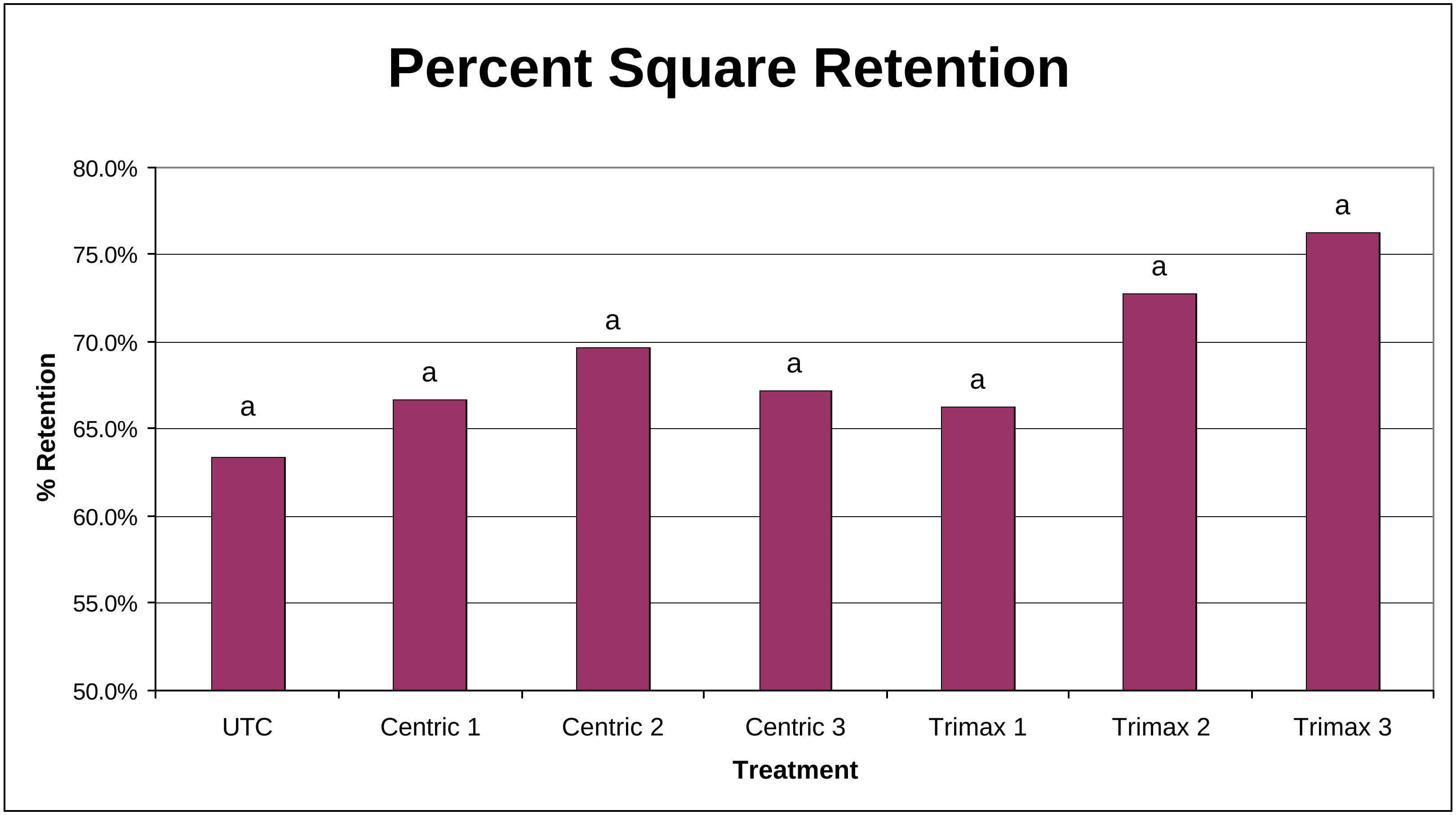

Fig. 5. Insecticidal treatment effect on percent square retention following the second application in 2004. UTC = untreated control; Centric 1 = 1 application; Centric 2 = 2 apps.; Centric 3 = 3 apps.; Trimax 1 = 1 app.; Trimax 2 = 2 apps.; Trimax 3 = 3 apps. Means followed by the same letter are not significantly different at $p<0.05$ according to Fisher's LSD test.

potential yield was not evident in the box mapping data (Fig. 6). Box mapping data suggested that the highest percentage of yield came from nodal positions 11 to 16 in all treatments (Fig. 7).

LINT YIELD

Similar to data for number of bolls, boll size, and distribution, no significant differences were found in lint yield for any of the foliar insecticide applications for either 2003 or 2004. Two treatments, CEN 1 and 2, along with TRI 1 yielded numerically higher than the UTC for both years (Table 14). Compared to the UTC, CEN 1 yielded 75 kg/ha more on a numerical basis, but the p value of 0.85 indicates that the likelihood of biological significance is highly improbable. CEN 3 and TRI at 2 and 3 applications yielded numerically lower that the UTC. TRI 2 yielded the lowest at 1196.34 kg/ha which was 32.51 kgs below that of the UTC.

In 2003, all three treatments of CEN numerically increased yield over the UTC (Fig. 8). For TRI, however, one application numerically increased yield over the UTC, whereas two and three applications were slightly lower than the UTC. There was a definite trend in the yield data showing that each additional insecticide application lowered the yield below the subsequent application. The 2004 yield data showed similar rate responses to the 2003 data in that each additional application numerically lowered yield. TRI 3 was the only exception to these responses in the second year (Fig. 8). The 2004 yield data show that TRI 3 had the highest numerical yield although it was not significant. The effect of these insecticides on lint yield is not fully understood. There

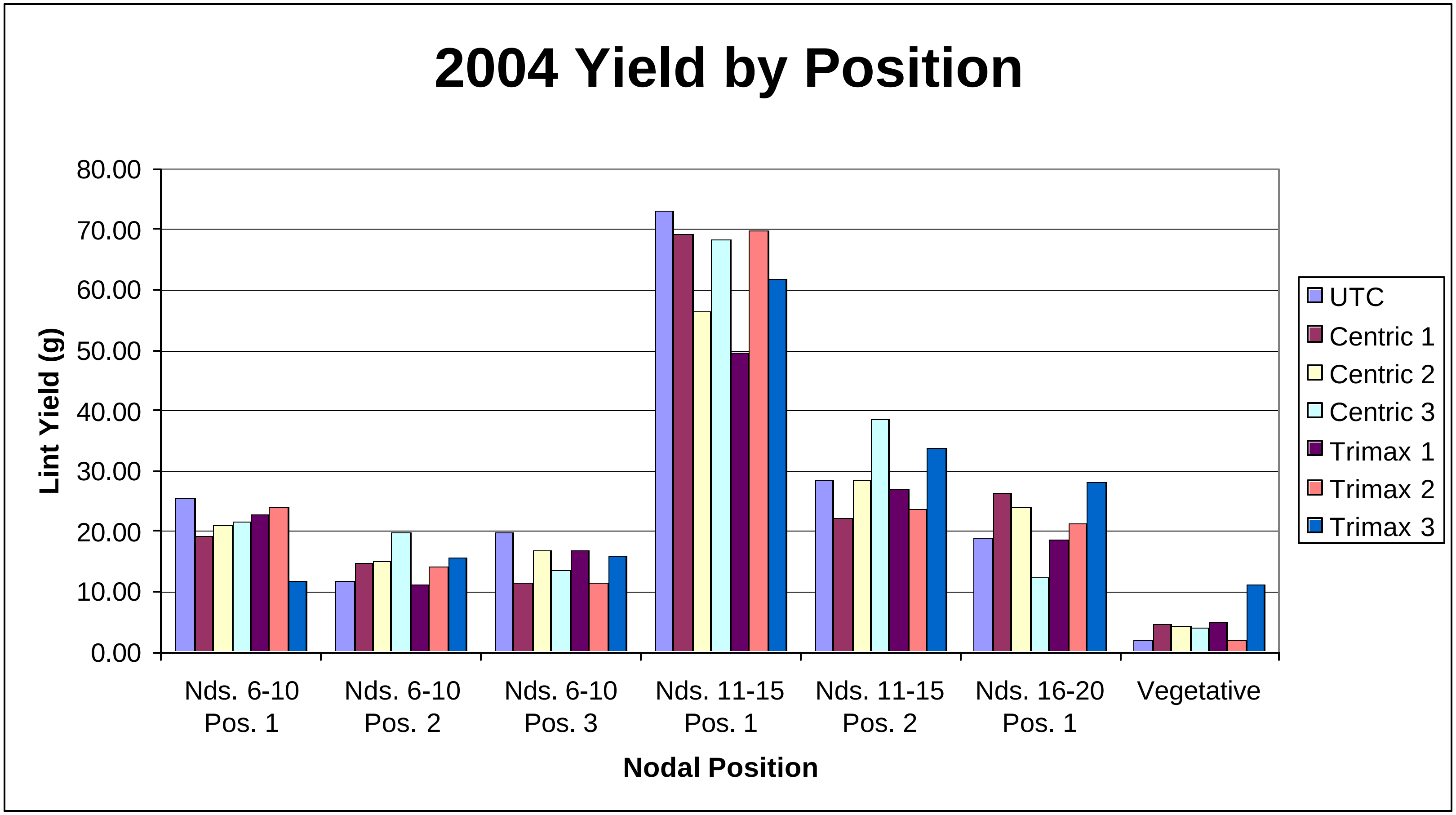

Fig. 6. 2004 insecticidal effect on distribution of total yield by position.

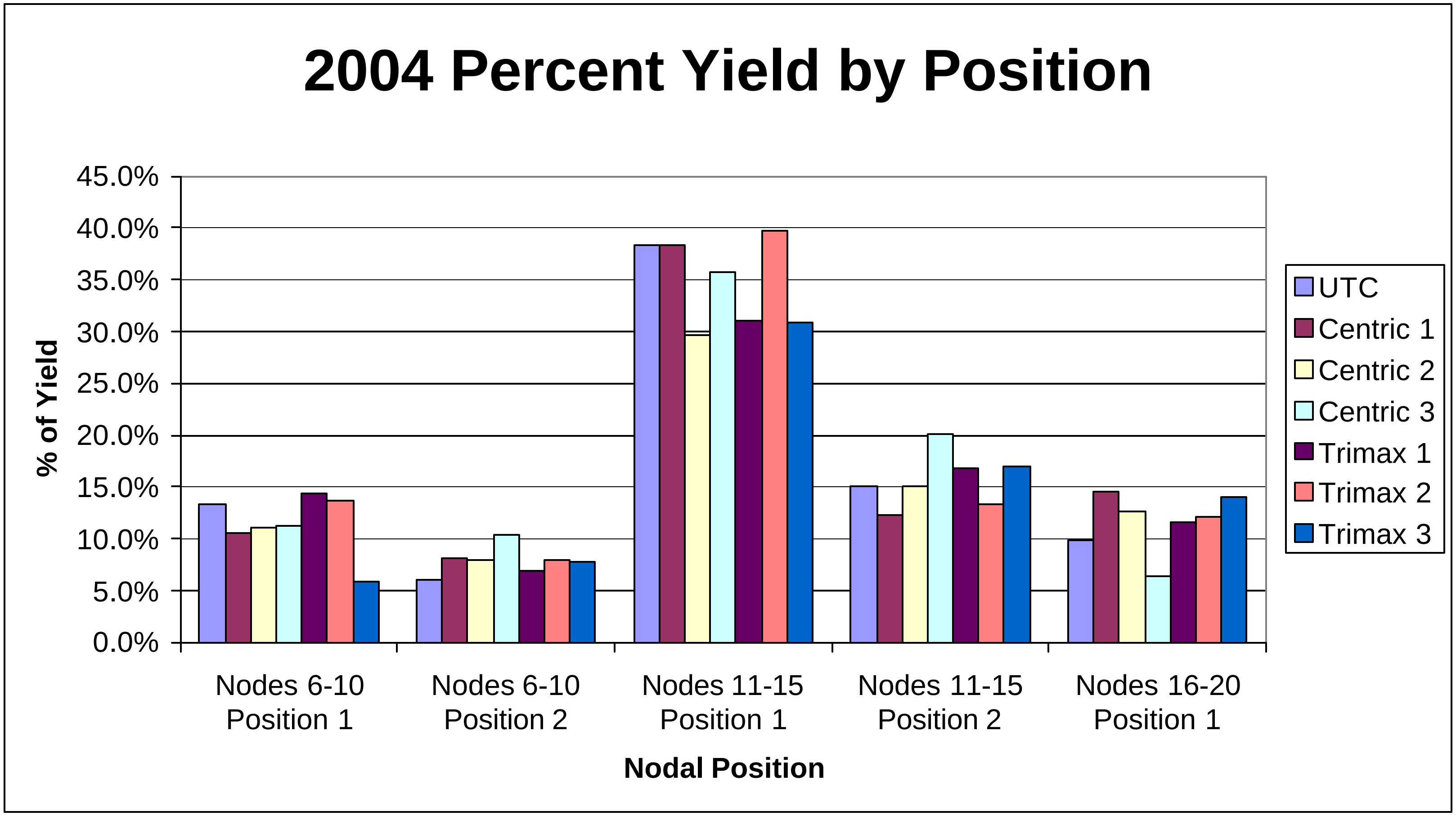

Fig. 7. 2004 insecticidal effect on distribution of percent yield by position.

Table 14. Insecticidal treatment effect on lint yield.

Treatment§	seedcotton	seedcotton to gin	lint from gin	ginout	lint
	kg/ha	g	g	%	kg/ha
UTC	2915.45 a †	150.36 a	63.71 a	0.42 a	1228.85 a
Centric 1	3162.07 a	150.53 a	62.79 a	0.42 a	1303.85 a
Centric 2	2983.57 a	150.41 a	63.77 a	0.42 a	1253.30 a
Centric 3	2949.69 a	150.30 a	63.15 a	0.42 a	1227.17 a
Trimax 1	3023.69 a	150.32 a	63.08 a	0.42 a	1254.91 a
Trimax 2	2833.98 a	150.08 a	63.60 a	0.43 a	1196.34 a
Trimax 3	2896.55 a	150.78 a	63.89 a	0.42 a	1225.21 a
P value	0.66	0.24	0.63	0.41	0.86

† Means within a column followed by the same letter are not statistically different at P<0.05 according to the Tukey-Kramer procedure.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

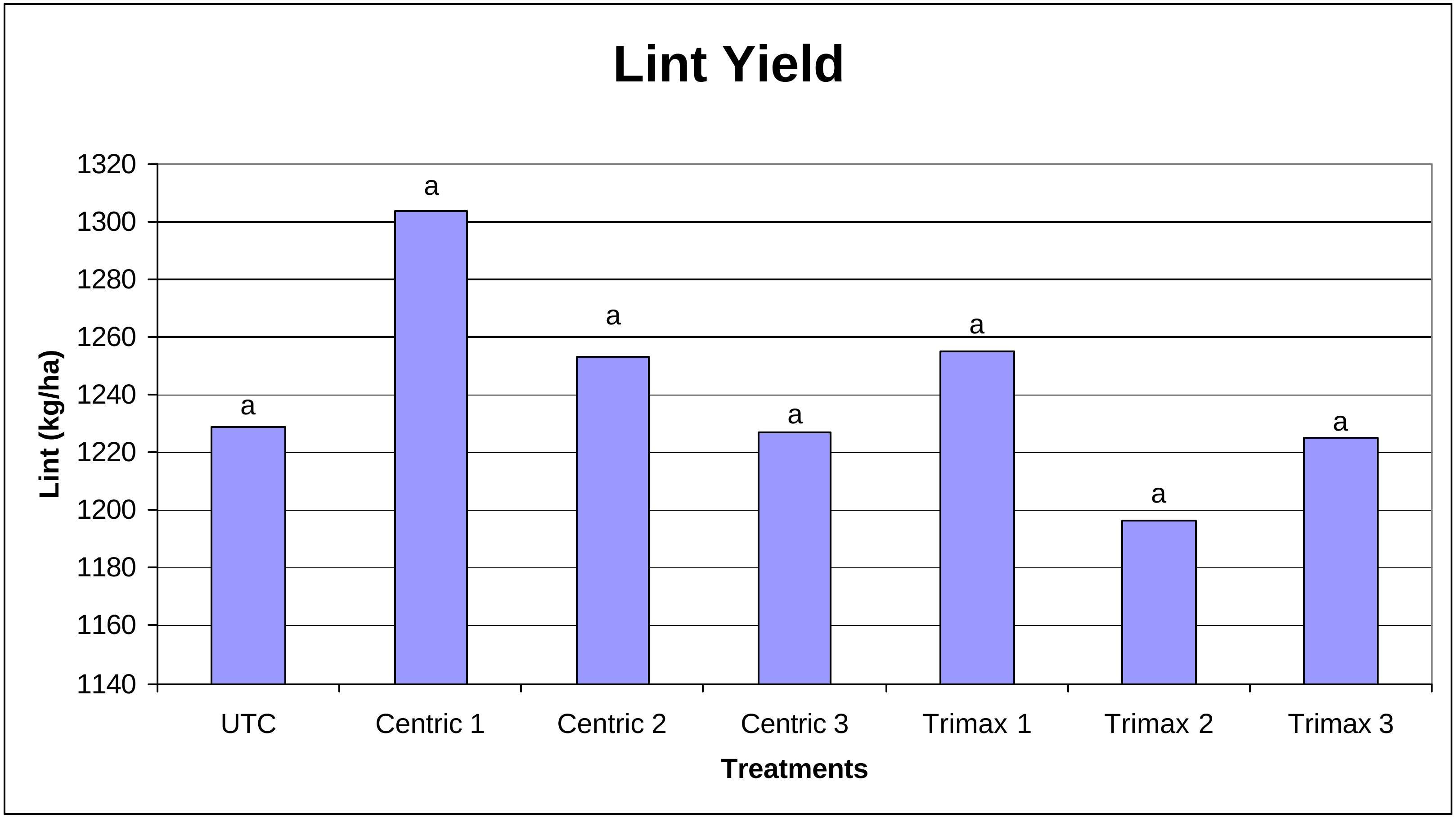

Fig. 8. Insecticidal treatment effect on total lint yield. UTC = untreated control; Centric 1 = 1 application; Centric 2 = 2 apps.; Centric 3 = 3 apps.; Trimax 1 = 1 app.; Trimax 2 = 2 apps.; Trimax 3 = 3 apps. Means followed by the same letter are not significantly different at $p<0.05$ according to Tukey-Kramer's test.

are certain rate responses that are hard to ignore; however, it is also difficult to explain how TRI 3 could yield the least in 2003 and the most in 2004.

LINT QUALITY

Lint quality analysis failed to show differences for any of the foliar insecticide applications for 2003 or 2004. The only exception was for the leaf content of CEN 3, which was significantly lower than all other treatments (Table 15). Although this is a desirable effect, it is hard to say that the insecticide applications were the cause of the lowered trash content. All results for fiber characteristics were within acceptable ranges for both years.

Table 15. Insecticidal treatment effects on lint quality.

Treatment§	micronaire	length	uniformity	strength	elongation
	value	100ths of an inch	%	g/tex	%
UTC	4.43 a †	1.08 a	82.85 a	28.36 a	6.20 a
Centric 1	4.34 a	1.09 a	82.69 a	29.79 a	5.90 a
Centric 2	4.63 a	1.08 a	82.88 a	29.26 a	5.90 a
Centric 3	4.50 a	1.09 a	82.85 a	29.48 a	5.83 a
Trimax 1	4.50 a	1.10 a	83.19 a	29.56 a	6.04 a
Trimax 2	4.38 a	1.09 a	82.21 a	28.91 a	6.28 a
Trimax 3	4.48 a	1.09 a	82.69 a	28.64 a	5.76 a
P value	0.33	0.86	0.57	0.67	0.39

Treatment§	leaf	rd	b	cg
	%	%	value	value
UTC	4.00 a	67.71 a	8.51 a	50.38 a
Centric 1	4.25 a	67.96 a	8.40 a	48.88 a
Centric 2	4.00 a	68.18 a	8.61 a	49.00 a
Centric 3	2.88 b	69.75 a	8.86 a	45.13 a
Trimax 1	4.13 a	68.16 a	8.65 a	46.38 a
Trimax 2	3.88 a	68.19 a	8.56 a	47.50 a
Trimax 3	3.75 a	68.78 a	8.56 a	46.50 a
P value	0.01	0.40	0.53	0.29

† Means within a column followed by the same letter are not statistically different at $P<0.05$ according to the Tukey-Kramer procedure.

§ UTC = Untreated Control, Centric 1 = 1 application, Centric 2 = 2 apps., Centric 3 = 3 apps., Trimax 1 = 1 app., Trimax 2 = 2 apps., Trimax 3 = 3 apps.

CONCLUSIONS

Pesticides constitute a large portion of production inputs for cotton. Therefore, reducing or enhancing pesticide efficacy presents an avenue to increase profit. Pesticides that contain both insecticidal and growth enhancing properties may be a viable option to increased profitability. TRIMAX™ and Centric® 40WG, both nitroguanidines, are effective as cotton insecticides (Moore et al., 2003). A field study was conducted to determine if these two insecticides also exhibit growth enhancing or yield enhancing properties above that expected from the insecticidal properties of the chemicals.

No significant differences in lint yield were observed between any of the insecticide PGR treatments. However, with the exception of TRI 3, there was a general trend for numeric decreases in lint yield with each additional insecticide application for both chemistries. CEN 1, CEN 2, and TRI 1, however, all resulted in numeric increases in lint yield over the UTC for both years. Compared to the UTC, CEN 1 yielded 75 kg/ha more lint per year. CEN 2 and TRI 1 yielded 24.06 kg/ha and 26.06 kg/ha more than the UTC, respectively.

No significant differences were detected in any of the growth parameters that were measured (height, total nodes, stem weight, leaf weight, total biomass, and leaf area). Numerical differences were noted that resulted in trends, but rate responses did not follow any logical pattern. All PGR treatments except CEN 3 were numerically taller than the UTC at the end of the season. Total nodes were numerically greater for the UTC over all PGR treatments. The stem weights of the PGR treatments were all numerically lower than the UTC with the exception of TRI 3. This response was unexpected since all treatments but CEN 3 were taller than the UTC. There was a positive relationship between the amount of insecticide applied and the leaf weight after three applications (T-3). This increase in leaf weight corresponded to positive relationships for leaf area and LAI in the TRI-treatments, but showed an inverse relationship for the CEN-treated plants. Every PGR treatment except for TRI 3 resulted in a lower numeric leaf area. The total biomass, consisting of stem weight and leaf weight, of the treated plants was numerically lower than the UTC for all treatments except TRI 1. TRI gave a positive relationship between the number of insecticide applications and total biomass.

Numerous trends and rate responses were observed in the AGRs and RGRs, but no significant differences were evident. PGR treatments resulted in an inverse relationship to the amount of insecticide applied for SLA, which suggests that the leaves became thicker or denser with added applications.

Photosynthesis measurements failed to show any significant differences, although in general, as more insecticide was applied, the photosynthetic rates decreased along with lint yield.

Boxmapping data was inconclusive and sometimes contradictory. For example, in 2003 all PGR treatments resulted in numerically higher mean boll weights with the exception of CEN 2 and TRI 1, but in 2004, all PGR treatments gave numerically lower mean boll weights than the UTC. In 2003, there were significantly fewer bolls per plant for CEN 1 and TRI 3 than the UTC.

Based on the data collected during the course of this two-year study, there is no conclusive evidence that supports TRIMAX™ or Centric® 40WG as being growth and or yield enhancers in cotton.

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APPENDIX A

CROP PRODUCTION PRODUCTS USED IN

THE BRAZOS BOTTOMS 2003-2004

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

Preplant

Broadleaf weeds (primarily *Amaranthus sp.*) and annual grasses	Treflan® 4EC - trifluralin: 1.86 L ha^{-1} a,a,a-trifluoro-2,6-dinitro-*N*,*N*-diprophyl-*p*-tolidine

Early Season

Thrips (*Thrips tabaci*) Cotton Fleahoppers (*Pseudatomoscelis seriatus* Rueter)	Temik® 15G – aldicarb: 5.61 kg ha^{-1} [2-methyl-2-(methylthio)propionaldehyde0-(methylcarbamoyl)] Bidrin® 8 – dicrotophos: 0.29 L ha^{-1} Dimethyl phosphate of 3-hydroxy-*N*,*N*-dimethyl-*cis*-crotonamide
Broadleaf weeds (*Ipomea sp.*)	Roundup Weathermax® - glyphosate: 1.61 L ha^{-1} N(phosphonomethyl)glycine, potassium salt form

Mid- to Late Season

Cotton Bollworm (*Heliothis zea*)	Capture® 2EC - bifenthrin: 0.30 L ha^{-1} (2 methyl[1,1'-biphenyl]-3-yl)methyl 3-(2-chloro-3,3,3-trigluoro-1-propenyl-2,2-dimethylcyclopropanecarboxylate
Boll Weevil	Fyfanon® - malathion: 0.87 ha^{-1} O,O-dimethyl phosphorodithioate of diethyl mercaptosuccinate

Plant Growth Regulator	Pix® - mepiquat chloride: 0.58 L ha^{-1} N,N-dimethylpiperidinium chloride
Harvest Aids	Dropp® 50WP – thidiazuron: 0.11 kg ha^{-1} N-phenyl-N'-1,2,3-thiadiazol-5-ylurea
	Def® 6 - tribufos: 0.58 L ha^{-1} and 0.94 L ha^{-1} *S,S,S*-tributyl phosphorotrithioate
	Prep® - ethephon: 0.58 L ha^{-1} (2-choloroethyl) phosphonic acid

APPENDIX B

EQUATIONS

Leaf Area Index (LAI)

$$\mathrm{LAI} = \frac{\text{leaf area}}{\text{soil area}}$$

Specific Leaf Area (SLA)

$$\mathrm{SLA} = \frac{\text{leaf area}}{\text{dry wt. of leaves}}$$

Partitioning Coefficient (PC)

$$\mathrm{PC} = \frac{\text{dry wt. of fruit}}{\text{dry wt. of vegetative biomass}}$$

Absolute Growth Rate (AGR)

$$\mathrm{AGR} = \frac{n_2 - n_1}{t_2 - t_1}$$

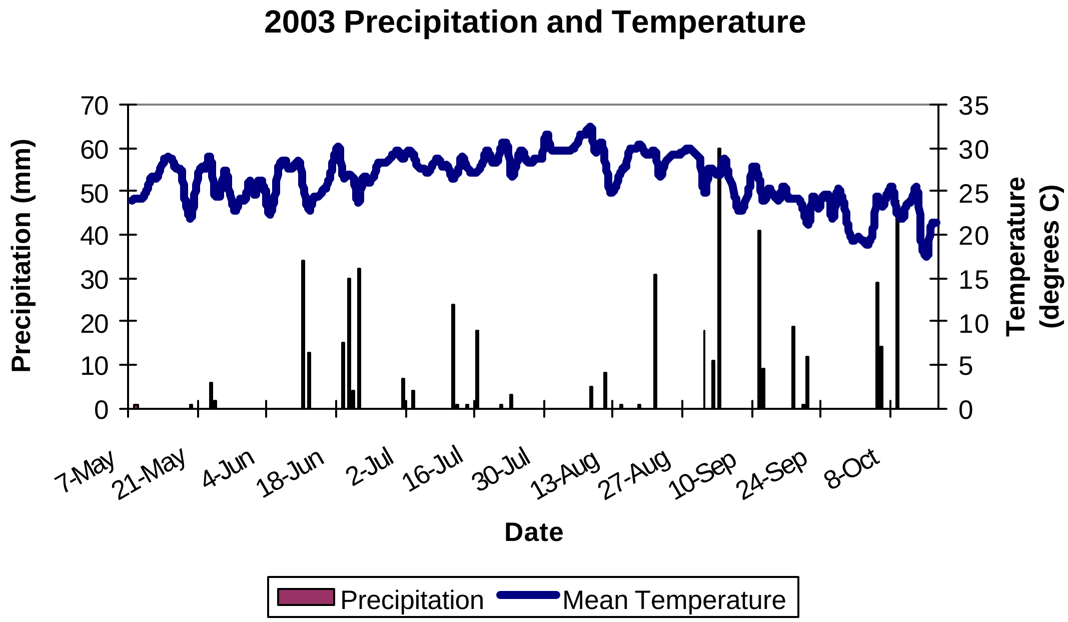
Relative Growth Rate (RGR)

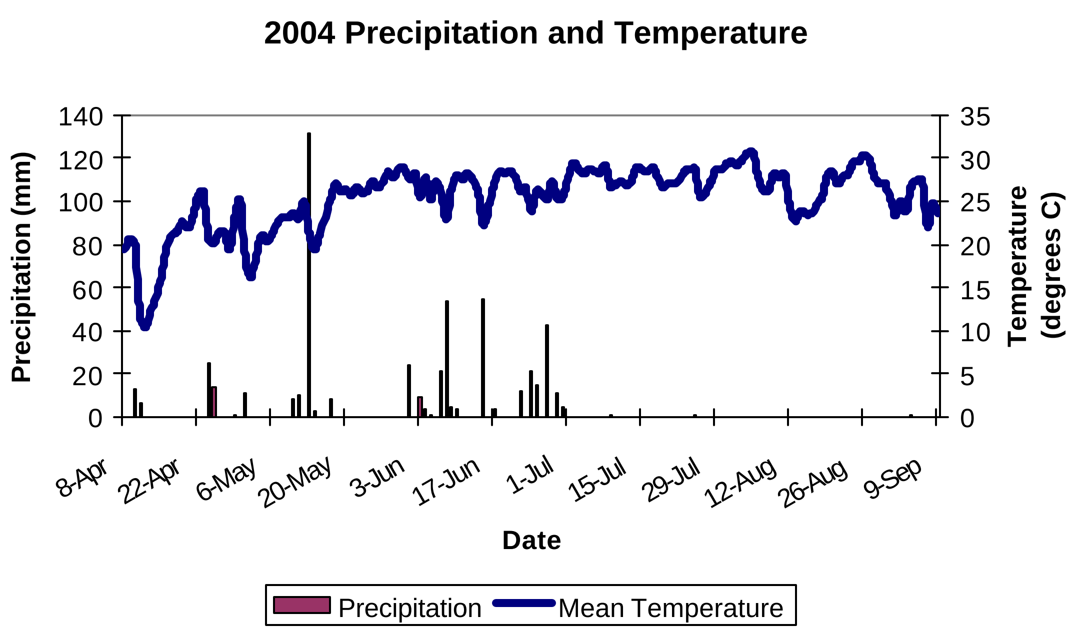
$$\mathrm{RGR} = \frac{\ln(n_2) - \ln(n_1)}{t_2 - t_1}$$

n_2 = dry weight of sample 2
n_1 = dry weight of sample 1
t_2 = sampling date of sample 2
t_1 = sampling date of sample 1

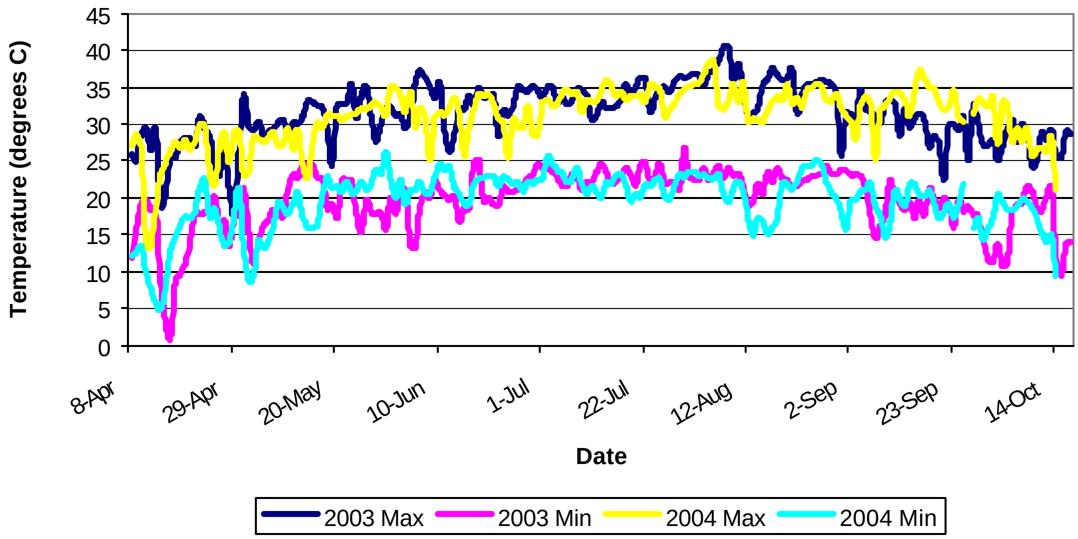
APPENDIX C

WEATHER DATA

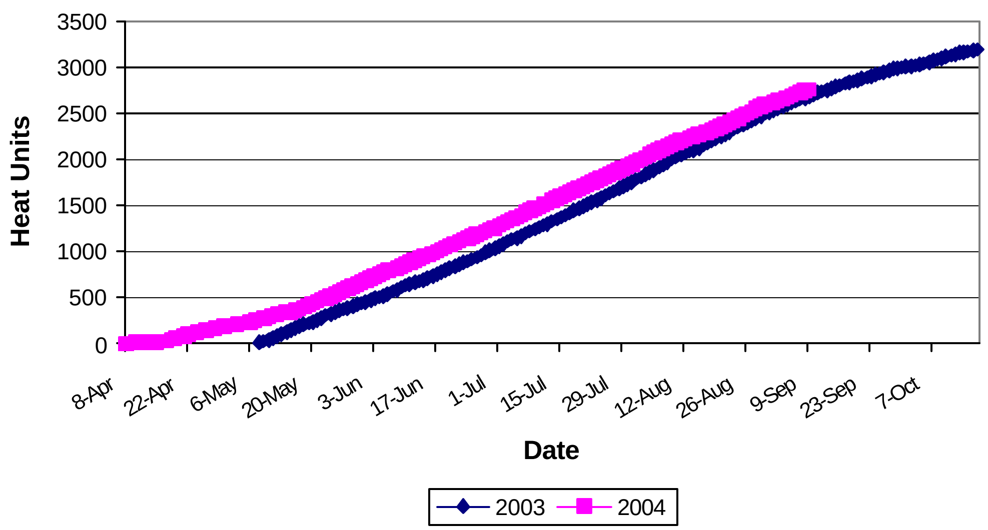




Maximum and Minimum Temperatures



Heat Unit Accumulation



VITA

Cy Christopher McGuire, son of Mike and Jo McGuire, was born in Abilene, Texas on December 25, 1980. Cy grew up in Haskell, Texas working on the family farm in Haskell and Knox Counties with his dad. He graduated from Haskell High School in May of 1997. He received his Bachelor of Science degree in Agronomy, from Texas A&M University in May of 2003. He began work on his Master of Science program immediately following his B.S. degree. While working towards his M.S. degree in Molecular and Environmental Plant Sciences under Dr. J. Tom Cothren, Cy was a member of the Texas A&M University Cotton Physiology Workgroup where he achieved Varsity Crew status. He completed his requirements for graduation in May 2005. His permanent address is:

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