

EFFECT OF CGA 362622 ON COTTON GROWTH AND DEVELOPMENT

S.M. Hoffman and J.T. Cothren

Texas A&M University

Texas Agricultural Experiment Station

College Station, TX

Introduction

A new post-emergence sulfonyl urea herbicide developed by Syngenta, CGA 362622 (common name: trifloxysulfuron sodium), is purported to provide wide spectrum weed control. Among the important species controlled are morning glories, sedges and cocklebur (Hudetz et al., Personal Communication). Currently, CGA 362622 is labeled only for use at a rate of 0.076 oz ai / A to be applied over-the-top (OTT) to cotton. The low use rate and negligible environmental impact make it a very appealing choice in post-emergent weed management, especially as part of an overall management program utilizing a glyphosate herbicide such as Touchdown IQ. Like all sulfonyl ureas, applications of CGA 362622 result in inhibition of acetolactate synthase (ALS), the enzyme responsible for branch chain amino acid production. Thus, synthesis of valine, leucine, and isoleucine is inhibited. Consequently, a deficit of these vital amino acids leads to plant death. A build up of α -ketobutyrate, which is a precursor for isoleucine, may be a cause of plant death in addition to the shortage of essential amino acids (Devine, 1993). The manner by which CGA 362622 and ALS interact is not yet documented, but leaves of susceptible weeds turn yellow or red a few days following application and within 1 to 2 weeks the plants die (Hudetz et al., Personal Communication). Resistances to other sulfonyl ureas arising from an alteration of the ALS enzyme have been reported (Devine, 1993). The exhibited resistance of cotton to CGA 362622 is believed to be, at least in part, a function of the compound's poor translocation in cotton compared to that within weed species.

Variable response to CGA 362622 treatments have been observed under field conditions, but detailed studies of this response are lacking. In pea (*P. sativum* L.) and lentil (*L. culinaris* L.), very low rate applications of sulfonyl ureas result in temporary chlorosis at levels far below that needed to impact seed yield (Gealy, 1995). Application of CGA 362622 can result in highly variable cotton response (Figure 1). The observed symptoms are often characterized by chlorosis, or necrosis of the leaves, especially those within the terminal at application. This visual effect typically presents itself within a three-day period after initial application. One measure used to quantify plant response to stressful environments is photosynthetic rate, expressed by net CO₂ (Gealy, 1987). We propose to examine the relationships between overall photosynthetic rates, the short-term visual responses, and the impact on growth and yield of cotton resulting from CGA 362622 treatment.

Overall Objectives

- The overall objectives of this study were as follows:
- To evaluate the upper threshold responses of cotton to CGA 362622, and its innate resistance to the compound.
- To elucidate the optimum timing of application.

Both objectives were evaluated concurrently in field and greenhouse studies. Additionally, the field study evaluated the impact of varietal response to CGA 362622.

FIELD STUDY

Objectives

- Quantify cotton's response to CGA 362622 alone and tankmixed with glyphosate on two common picker varieties: Stoneville 4892 BR and DP 451 B/RR
- Document fruit initiation to evaluate the influence of CGA over-the-top applications on flowering.
- Quantify the impact of CGA 362622 on yield and fiber quality of cotton.
- Investigate the feasibility of using a CGA/Touchdown IQ tankmix over-the-top.

Materials and Methods

Location: Texas Agricultural Experiment Station (TAES), Burleson County, Texas
Soil Type: Ships clay integrating with Weswood silty clay loam
Planting Date: April 20th, 2001
Plant Density: Seeded @ 52,000 plants / A
Varieties: Stoneville 4892 BR and Delta Pine 451 B/RR
Application Date: May 18th, 2001
Irrigation: Furrow

Plot size: Four Rows
 Row Spacing: 40 inches
 Plot length: 32 ft
 GPA: 15 GPA
 Nozzle Spacing: 20 inch
 Tips: TeeJet XR 8003 VS

The treatments for each variety were arranged in a completely randomized block design with four replications. A small plot compressed air sprayer (Spider) was used to make all applications to cotton at the 4th true leaf stage of growth on May 18th 2000. Plots were maintained weed-free by manual and mechanical cultivation throughout the growing season. All other aspects of management followed the established local management practices.

Field Treatments		
No.	Abbreviation	ApplicationRate
1.	CGA_5	0.076 oz ai / A (5.3 g ai / ha) CGA 362622
2.	CGA_7	0.113 oz ai / A (7.9 g ai / ha) CGA 362622
3.	CGA_15	0.216 oz ai / A (15 g ai/ha) CGA 362622
4.	CGA_5TD	0.076 oz ai / A (5.3 g ai / ha) CGA 362622 1 qt / A Touchdown IQ
5.	CGA_7TD	0.113 oz ai / A (7.9 g ai / ha) CGA 362622 1qt / A Touchdown IQ
6.	TD	1qt / A Touchdown IQ
7.	STA	0.6 oz / A Staple® 1.5 pt / A Roundup Ultra®
8.	UTC	None

Data Collected

Visual injury ratings, heights and total node counts were taken for 14 days after treatment (DAT). At 7 and 14 DAT, leaf area and biomass partitioning data were collected by removing 6 plants from the outer rows of each plot.

At peak bloom fruiting information was entered into Plant Map Analysis Program (PMAP) to investigate any impacts on fruiting initiation (Landivar, 1993). At harvest, box mapping and yield data were collected. Yield was obtained by machine harvesting 32 ft from the middle-two rows of the four-row plots. Percent ginout was determined by using a 10-saw small plot gin.

Analysis

SAS® (version 8.0) statistical software was used for data analysis (SAS Institute, 2000). The General Linear Model (GLM) was utilized and means were separated by Fisher's Protected LSD with a 5% significance level.

Results and Discussion

Visual injury ratings (VIR) peaked at 5 to 7 DAT as leaves in the terminal at time of spraying became fully extended. Stoneville 4892 BR exhibited a more dramatic response to the entire range of treatments, resulting in a slower recovery. However, observed injury symptoms, if present, were the same on both varieties. CGA alone caused yellow spotting. The CGA/Touchdown mix resulted in either brown spots and wrinkling, or severe necrosis (Figure 1), with CGA_7TD impacting height. Touchdown alone showed no injury, and the Staple® treatment had necrotic spots on the leaves. At 5 to 7 DAT, plant height (Figure 2) and the visual injury ratings (Figure 3) showed similar trends for both the Deltapine and Stoneville varieties. Treatments with the highest injury ratings had the lowest average heights. The CGA/Touchdown IQ tankmix treatments both had a significant impact on plant height on the Stoneville variety, but only a marginal impact on the total nodes.

By 13 DAT, the visual signs of injury were greatly reduced (Figure 4). The leaves with visually evident injury were 4 to 5 nodes down from the terminal. The chlorosis observed with CGA_5 and CGA_7 was almost completely diminished at this time and showed virtual recovery. The only sustained damage was where the necrotic spots, caused by the CGA/Touchdown IQ combination, were removed from the leaves by the wind. The CGA_7TD treatment was significantly shorter at 13 DAT for both varieties. Stoneville 4892 BR showed stunting in response to all of the CGA and the Staple® treatments but the CGA_7TD response was much more pronounced. Deltapine 451 B/RR did not show a difference in node number throughout the observation period. Stoneville 4892 showed a numerical reduction in number of nodes in response to CGA_7TD. The range of averages for total nodes at 13 DAT was only 1.5 nodes (data not shown).

Samples for leaf area and dry weight determination of each treatment were collected at 7 and 14 DAT. CGA_7TD consistently had the lowest total dry weight and lowest dry weight from stems (data not shown). This data corresponds well to the level of stunting observed with the CGA_7TD treatment.

Leaf area was measured at 7 and 14 DAT for both varieties (Figure 5). In DP 451 B/RR the CGA7_TD treatment had a significantly lower leaf area at 13 DAT. Impact of the treatments on leaf area in Stoneville 4892 BR was more pronounced than the impact on the Deltapine variety and showed a significant difference at both 7 and 13 DAT. At 13 DAT leaf area was significantly reduced compared to the untreated check for both of the tankmixes (CGA_5TD and CGA_7TD), the 3X rate of CGA alone (CGA_15), and the Staple® treatment in Stoneville 4892 BR.

Mid-Season mapping revealed that visual symptoms were completely alleviated by early bloom, with no significant differential in height (Figure 6). CGA_7TD was numerically shorter still but all other treatments showed very similar values, indicating a recovery of the plants. Early bloom plant mapping indicated DP 451 B/RR had a significantly fewer total reproductive nodes in the CGA_7TD treatment (Figure 6).

A large proportion of the total yield is harvested from fruit at the first position making any impact on fruiting at the first position extremely important. The only significant treatment effect seen in plant mapping at harvest was on the total weight of fruit at position 1 of DP 451 B/RR. Total weight at the first position was unaffected by the TD, CGA_5, and Staple® treatments. However, the value for CGA_5 was numerically much higher than the TD or Staple® treatments (Figure 7). Yield was not significantly affected by any of the treatments in Stoneville 4892 BR or DP 451 B/RR (Figure 8), nor were there any significant differences in lint quality or characteristics that corresponded to treatments.

Conclusions

- Considerable visual injury from CGA 362622 was observed at levels lower than those that affected seed cotton yield.
- Node at which fruit initiation occurred was not impacted by CGA 362622 treatments.
- Lint yield was not affected by CGA 362622. Rates of CGA 362622 labeled for application over-the-top exhibited the most rapid recovery from the chlorosis and necrosis following application of CGA 362622. CGA 362622 tankmixed with Touchdown IQ caused greater plant injury and a slower recovery than when applied alone. Tankmixing CGA 362622 with Touchdown IQ is not recommended for post-emergence over-the-top weed control.

GREENHOUSE STUDY

Objectives

- Investigate the plant response to a range of differential application timings of CGA 362622.
- Monitor photosynthesis of cotton following CGA 362622 application as an indicator of plant response.
- Examine flower initiation as influenced by over-the-top applications of CGA 362622.

Materials and Methods

Location: Greenhouse in Center for Southern Crop Improvement at Texas A & M University
Variety: Stoneville 4892 BR
Soil: Metromix 770
GPA: 15
Nozzle Spacing: 20 inches
Tips: TeeJet XR 8003 VS
MPH: 3

Applications were made using a CO2 pressurized hand boom. The greenhouse temperature was maintained between 71-95°F. There were three repetitions and the plants were arranged randomly and rotated on the greenhouse benches to avoid placement effects.

Greenhouse Treatments

No.	Abbreviation	Application Rate
1	CGA_5	0.076 oz ai / A (5.3 g ai / ha) CGA 362622
2.	CGA_7	0.113 oz ai / A (7.9 g ai / ha) CGA 362622
3.	CGA_5TD	0.076 oz ai / A (5.3 g ai / ha) CGA 362622 1 qt / A Touchdown IQ
4.	CGA_7TD	0.113 oz ai / A (7.9 g ai / ha) CGA 362622 1 qt / A Touchdown IQ
5.	TD	1 qt / A Touchdown IQ
6.	STA	0.6 oz / A Stapleâ 1.5 pints / A Roundup Ultraâ
7.	UTC	None

Each treatment was applied at 1st, 3rd, and 6th true leaf stages.

Data Collected

Plant height, visual injury ratings, and node counts were tracked following each of the applications. Visual injury ratings were recorded as a percent of leaf area affected with a rating of 100 meaning total chlorosis or necrosis of the leaf area. Net photosynthesis of the plants was determined following CGA 362622 treatment as another indicator of plant injury and recovery. A Li-Cor 6400 Portable Photosynthetic (Figure 9) Unit measured net photosynthesis, expressed as the assimilation of CO₂ (mmol CO₂ m⁻² s⁻¹). The initiation of fruit was also recorded.

Results and Discussion

Injury in all instances, regardless of application timing began with a loss of leaf turgor and drooping of the leaves on the day following treatment. Loss of leaf turgor progressed to chlorosis, and in extreme cases necrosis, peaking by 7 days after treatment (Figure 10). The appearance of the plant response was quicker than seen in the field study, but the symptoms were very similar (Figure 11). Plants responded to CGA 362622 at all application timings, but response was most severe in the 1st leaf application timings (Figure 12). The 1st leaf treatment exhibited almost complete chlorosis of the leaves by 4 DAT for all treatments except UTC and Touchdown IQ alone. While not as severe as the injury seen following the 1st leaf application, the 3rd leaf stage application of CGA resulted in a highly variable plant response (Figure 13). Applications at the 3rd and the 6th leaf stages of plant growth showed a much lower proportion of the leaf area affected at 3 to 4 DAT (Table 1). The rate of recovery from the visual injury was more rapid, and recovery more complete, with later leaf stage applications. After a recovery period (14 days), the 6th leaf application treatments with levels of CGA at the labeled over-the-top rate of application (CGA_5) showed a complete recovery and were indistinguishable from the UTC. Applications at the 6th leaf stage of CGA_7TD, CGA_7 and Stapleâ treatments still showed persistent injury to some leaves at 14 DAT. The chlorosis and necrosis was more persistent when applications were made at the 3rd and 1st leaf stages. A larger proportion of the leaf area still showed chlorosis or necrosis at 16 DAT as compared to later leaf stage timings (Table 1).

The impact of the chemical treatments on net photosynthesis was documented only after the visual injury symptoms became apparent. For the 1st leaf application the photosynthetic rate in the CGA 362622 and Stapleâ treatments dropped to negligible levels (Figure 14). The photosynthetic rates remained low for 8 days, which was a longer overall recovery period than was required for other application timings. Over the recovery period (1 to 9 DAT), all of the CGA and Stapleâ treatments at the 3rd leaf application timing had lower photosynthetic rates than the UTC and Touchdown IQ treatments (Figure 15). As chlorosis faded, the level of photosynthesis also returned to the levels of the UTC. Like earlier application timings the 6th leaf application timing showed reduced levels of photosynthesis from plants with highest injury ratings. However, in the 6th leaf application the disparity between plants showing a response and UTC was not as striking (Figure 16).

Applications made at the 3rd and 6th leaf stages did not differ in fruit initiation for any treatment. At the 1st leaf stage application there was no difference between treatments in the initiation of the first reproductive node; however, a five-day differential was observed for both the tankmix and Stapleâ treatments.

Conclusions

- Application of CGA 362622 at the 6th leaf stage of development offers the least injury and fastest recovery of the application timings tested.
- Net photosynthesis was impacted for 8 to 9 days by all treatments except TD and UTC regardless of the application timing. Furthermore, the degree of photosynthetic reduction was dependent upon the severity of visual injury symptoms.
- Fruit initiation was affected only by the 1st leaf stage application of CGA 362622, which showed delays in fruiting for the tankmix and Stapleâ treatments

Future Research

Aspects in addition to those we have examined here seem to be involved in the response of cotton to CGA 362622. Future research should investigate the impact of time of day of application and ambient temperature at application on the response of cotton to CGA 362622.

Works Cited

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- Gealy, D.R. 1987. Gas exchange properties of jointed goatgrass (*Aegilops cylindrical*). *Weed Sci.* 35:482-489.
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- Landivar, J.A. 1993. A plant map analysis program for cotton- PMAP. Texas Agricultural Exp. Sta. MP. 1740. Texas Agric. Exp. Stn., College Station, TX.
- SAS Institute. 1999-2000. The SAS System for Windows, Release 8.0. SAS Institute Inc. SAS Campus Dr., Cary, NC.

Table 1. Percentage of Leaf Area with Chlorosis or Necrosis.

		Days After Treatment					
		Treatment	0	1	4	9	16
1st Leaf Application	CGA_5	0	33	95		41.6	33.2
	CGA_7	0	33	95		75	39.3
	CGA_5TD	0	33	95		68.3	19
	CGA_7TD	0	33	95		96	31.6
	TD	0	0	0		0	0
	STA	0	33	95		37.6	33.5
	UTC	0	0	0		0	0
3rd Leaf Application	CGA_5	0	90	62.5	54.8	60	10
	CGA_7	0	95	70	40	30.3	37
	CGA_5TD	0	77	55	63.3	65.3	46
	CGA_7TD	0	77	58.5	63.3	60	67
	TD	0	0	0	5	0	0
	STA	0	22	60	44	47.6	15
	UTC	0	0	0	0	0	0
6th Leaf Application	CGA_5	0	33	33	45	15	0
	CGA_7	0	33	33	50	35	5
	CGA_5TD	0	33	33	25	13	0
	CGA_7TD	0	16	33	55	45	12
	TD	0	0	0	0	0	0
	STA	0	0	25	20	10	5
	UTC	0	0	0	0	0	0

Figure 1

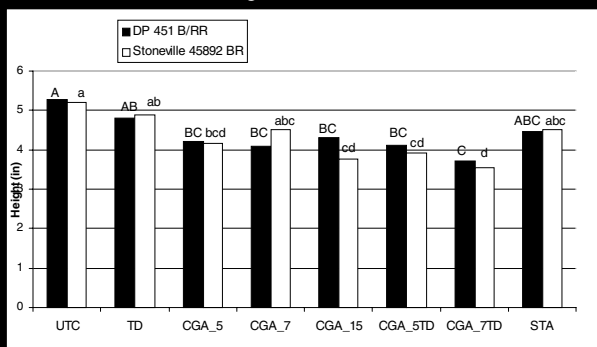


CGA7_TD at 5 DAT

The plants exhibited a wrinkling of leaves, and holes in the leaves. The holes are believed to be where necrotic spots were knocked out by the sustained strong winds (20-25 mph) in the period immediately following application.

Figure 2

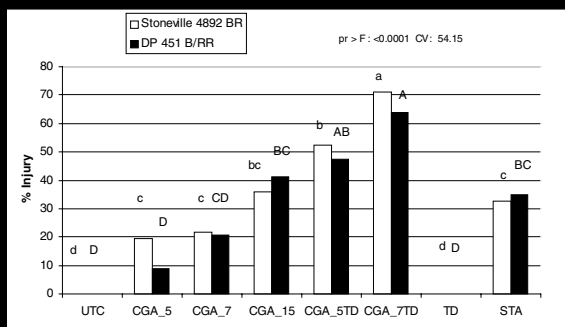
Heights at 7 DAT



In Stoneville 4892 BR all of the treatments containing CGA (except CGA_7) exhibited shorter height than the UTC and TD at 7 DAT. DP 451 B/RR had numerical differences but none were statistically significant. Due to the rapid recovery by the plants this difference in heights was eliminated by 13 DAT in the DP variety and by early bloom on the Stoneville variety.

Figure 3

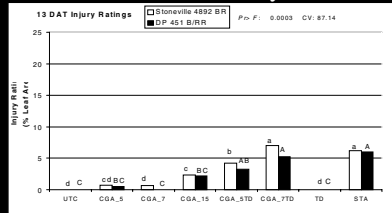
5 Days After Treatment



Injury ratings reached their maximums at 5-7 DAT with some treatments having as many as 70% of plants affected

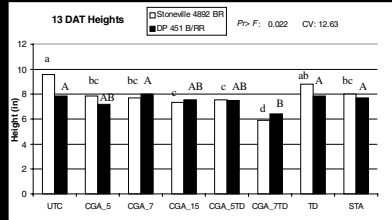
Figure 4

13 Days after Treatment



13 DAT Injury Ratings

By 13 DAT the visual symptoms were greatly reduced, less than 10% of plant surfaces showed any injury at this time the only lingering injury was where the necrotic spots caused by the CGA/Touchdown IQ tankmix had been knocked out by the wind.

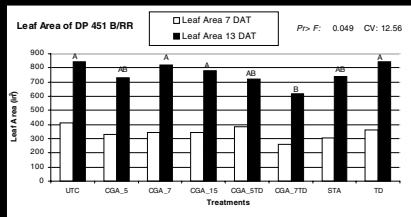


13 DAT Heights

Treatment CGA_7TD caused significantly lower heights at 13 DAT in both varieties. Stoneville 4892 also had heights lower than UTC in all treatments except TD.

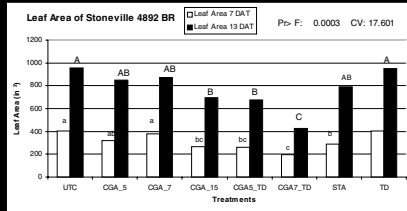
Figure 5

Leaf Area



DP 451 B/RR

There were no significant differences at 7 DAT. At 14 DAT only CGA_7TD had an average leaf area significantly different from the untreated check.



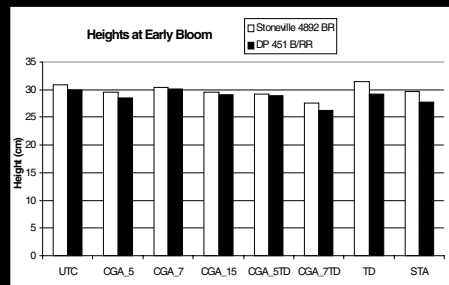
Stoneville 4892 BR

At 7 DAT the CGA/Touchdown tankmixes and the highest rate of CGA and the Staple treatment all showed a significantly lower leaf area than the UTC.

At 13 DAT CGA_7TD was substantially lower than all other treatments while TD, Staple and both treatments of CGA alone were not significantly different from the UTC.

Figure 6

Mid-Season Mapping



Stoneville variety:

Only numerical differences were found by mapping were height and internode length

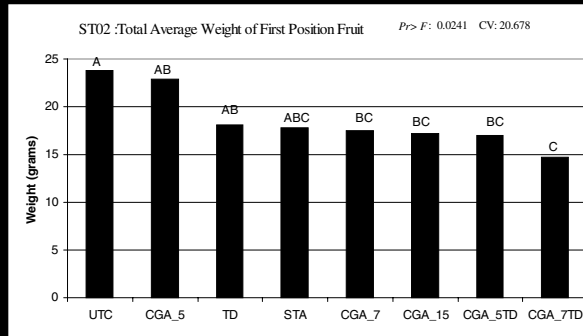
DP Variety:

No significant differences in height. CGA_7TD had a total of 7 reproductive nodes whereas all other treatments averaged 11

By time of early bloom stage the visual injury was completely alleviated and there was no significant differential in height indicating a recovery by the treated plants

Figure 7

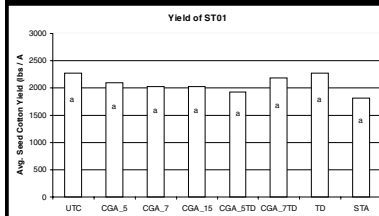
Differences in Fruiting Position



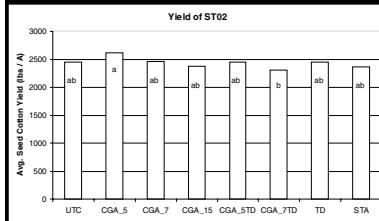
There was only one factor in fruit positioning which proved to be significantly different between the treatments. Total fruit weight at position one was reduced in all the of the treatments except Touchdown alone and the suggested OTT rate CGA_5.

Figure 8

Yield Data

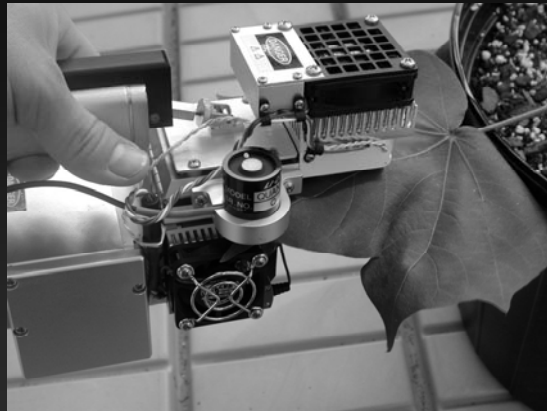


Stoneville 4892 BR
No significant differences in yield across all treatments



DP 451 B/RR
All treatments showed no significant differences in yield from UTC. CGA_5 was significantly higher than CGA_7TD.

Figure 9



Li-Cor 6400 is used to measure the net assimilation of CO₂ of the leaf area in the chamber

Figure 10

Progression of Injury



Injury in all instances, regardless of application timing began with a loss of leaf turgor and drooping.

This then progressed to chlorosis and in extreme cases, necrosis.

Figure 11

Plant Response to 6th Leaf Application



1 DAT CGA_7TD Injury

The loss of turgor, drooping and chlorosis seen in plants grown in the greenhouse are consistent with the phenotypes seen in the field study at 3-7 DAT



1 DAT Staple Injury

The formation of brown spots on the young leaves is consistent with the phenotype seen in the field study

Figure 12

1st Leaf Application Resulted in Severe Injury

7 DAT 1st Leaf Application (L to R)

- UTC -has grown steadily since treatment.
- CGA_5 -shows severe stunting and chlorosis.
- CGA_7TD -has abscised its 1st true leaf and is completely chlorotic



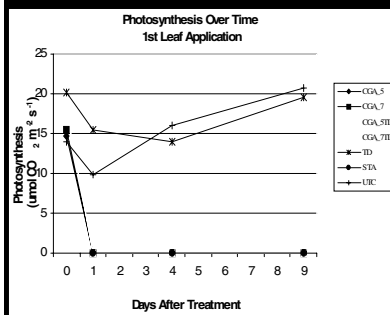
Figure 13



Cotton response to CGA is highly variable with a range from no injury to severe chlorosis and necrosis.

Figure 14

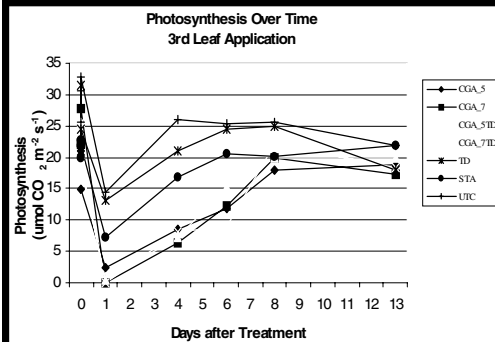
Photosynthesis Readings 1st Leaf Stage



By 1 DAT the photosynthetic activity of all plants treated with CGA or Staple dropped to negligible levels that were sustained for 8 days.

Figure 15

Photosynthesis Readings 3rd leaf stage

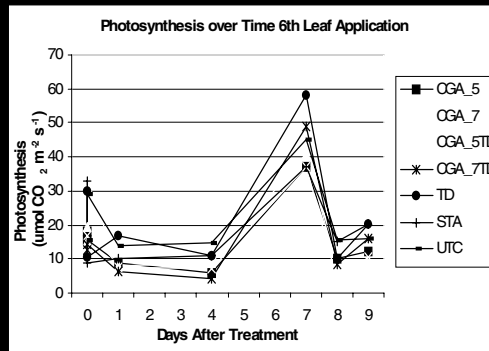


Over the recovery period (1-9 DAT) all of the CGA treatments had lower levels of photosynthetic activity. This corresponds to their higher injury ratings

Photosynthesis Readings

Figure 16

6th Leaf Stage



Compared to the earlier timings the 6th leaf application showed a much closer distribution of photosynthetic activity