EFFECT OF COTTON PLANTING DATE AND NITROGEN FERTILIZATION ON *BERMISIA ARGENTILIFOLII* POPULATIONS

J. L. Bi and N. C. Toscano
Department of Entomology
University of California
Riverside, CA

Abstract

The impact of planting date and nitrogen fertilization on cotton plants, silverleaf whitefly, *Bermisia argentifolii* Bellows and Perring, population dynamics and the related physiological mechanisms involved in the process were investigated in a field in Riverside, California. Treatments consisted of early and late planting dates (26 April and 8 June,) and 4 levels of fertilization (0, 100, 150 and 200 Ibs N per acre) for each planting date. Applied nitrogen linearly increased seed cotton yield of early planted cotton and early planted cotton treated with chemical defoliant but had no effect on yield of late planted cotton. The nitrogen also resulted in increased densities of whiteflies. Also, early planted cotton supported higher densities of whiteflies than late planted cotton. Petiole glucose and fructose levels were significantly correlated with densities of whitefly adults during the peak population size on late planted cotton. A significant correlation between densities of adult whiteflies and other cotton physiological parameters occurred on only a few sampling dates.

Introduction

The silverleaf whitefly is a major pest of cotton and other crops (Gerling et al., 1980; Henneberry et al., 1995). Large populations of this insect can ingest sufficient quantities of plant phloem sap to cause severe reductions in yield. In addition, whitefly honeydew secreted can fall on cotton lint to produce "sticky" cotton, that causes problems during lint processing at textile mills (Henneberry et al., 1996). The honeydew deposited on leaves provides a suitable substrate for sooty mold development, which inhibits foliar photosynthesis (Yee et al., 1996).

Dietary nitrogen and carbohydrates impact survival, growth and reproduction of insects. Plant nitrogen fertilization has been shown to modify the dietary nitrogen concentration of the plants for phloem-feeding-insects to affect their population growth. However, the effect of nitrogen fertilization on plant carbohydrates and nitrogen and the related population growth of the insects are still poorly understood. Plant nitrogen fertilization effects on whiteflies under greenhouse conditions have been reported by several researchers. Blua & Toscano (1994) indicated subtle differences in silverleaf whitefly development at different levels of cotton nitrogen fertilization. Rubeiz et al. (1995) reported that there were no significant differences in populations of the sweetpotato whitefly, *B. tabaci* (Gennadius), between the control and the nitrogen fertilized cantaloupes. However, Bentz et al. (1995) found more *B. tabaci* on fertilized poinsettia plants than on nonfertilized controls. However, the effects of nitrogen fertilization on plant-whitefly interactions under field conditions have not been fully investigated. Our previous data indicated that nitrogen applied to late planted (20 May) cotton increased densities of whiteflies but had no effect on seedcotton yield. The present study was initiated to determine if different planting dates and different levels of nitrogen fertilization to cotton plants grown in field increased whitefly numbers, and to determine the related biochemical and physiological mechanisms.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:918-924 (2001)
National Cotton Council, Memphis TN

Materials and Methods

Experimental Plots

Cotton (*Gossypium hirsutum*, cv. Acala) was planted on 26 April for the early planting and 8 June for the late planting at the Agricultural Experimental Station, University of California, Riverside. Four nitrogen levels were evaluated using urea for each of the three factors in a split block design with four replicates. The plot size was 90 feet long and 19 feet wide with 7 feet of buffering area between neighboring plots in the same block. Each of the 5 blocks was separated by 2 rows of bare soil. Row spacing was 40 inches and there were 6 rows in each plot. Plants were thinned at the 4-node stage to a space of 4 inch intervals. Treatments consisted of soil applications of 0, 100, 150, and 200 lbs nitrogen per acre. The N treatments represented, respectively, sub-optimal, optimal, and supra-optimal nitrogen fertility for cotton in California. Soil application of nitrogen was performed by side-dressing when the plants were at the 7 node stage (6 July for the early planted cotton and 20 July for the late planted cotton). Prior to planting, five soil samples (within 6 inches of top soil) across each experimental plot were analyzed for residual total nitrogen. Chemical defoliant (Ginstar, from AgrEvo) at a rate of 32 oz/acre was applied on 18 October with a back-pack sprayer. Ten 3rd node cotton petioles in each plot were sampled twice (19 August and 24 September) during the cotton season to determine nitrate nitrogen levels. The field was furrow-irrigated. The frequency of irrigation was every two weeks prior to nitrogen fertilization and every week thereafter. The last irrigation date was 28 September.

Whitefly Densities

Densities of adult whiteflies were monitored throughout the cotton season. Sampling of adult whiteflies started in early September and densities were determined by counting numbers of whiteflies collected with an engine-powered vacuum over a 50 feet 3rd or 4th row in each plot.

Seed Cotton Yield and Plant Heights

Seedcotton was harvested on 20 November. Open bolls in a 30 row-feet of center row within each plot were hand-picked, dried and weighed. Heights of 30 randomly selected plants in the row chosen for harvesting from each plot were then measured.

Photosynthetic Rate and Stomatal Conductance

To search for the physiological and biochemical mechanisms of whitefly-cotton interactions affected by the nitrogen treatments, photosynthetic rate, stomatal conductance, soluble proteins, and soluble carbohydrates were monitored in cotton throughout the season. Photosynthetic rates and stomatal conductance were measured every week after the plants were fertilized using a LI-6200 portable photosynthesis system (LI-COR Inc., Lincoln, NE) equipped with a 1-L stirred cuvette. Measurements were taken near the plant terminal between 11.00 and 13.00 hours when ambient photosynthetic active radiation (PAR) exceeded 1700 μM m^{-2} s^{-2}. One 3rd main stem fully expanded leaf randomly selected from each of the 60 experimental plots was used for the measurement.

Soluble Proteins and Soluble Carbohydrates

Cotton petioles were sampled between the hours of 15.00-16.00 bi-weekly. Ten cotton petioles, from 10 individual plants in each plot, were excised, wrapped in aluminum foil and immediately dropped into liquid nitrogen to transport to a -80 C freezer. The sample was freeze-dried and then ground to powder for assays of soluble proteins and soluble carbohydrates. The 5th main stem petioles were sampled because the 5th main stem leaves were usually used for whitefly density estimates. Protein content was determined by the Bradford method. Ten milligrams of the tissue powder was vigorously vortexed in 1 ml of 0.1 M ice-cold phosphate buffer, pH 7.0, containing 1% PVP. The resulting mixture was centrifuged at 10,000 g at -2 C for 10 min, and the supernatant was used immediately for soluble protein measurements. A 50 μl aliquot of the supernatant was mixed with

150 μl of Bio-Rad protein assay reagent (Bio-Rad, Richmond, CA). Absorbance of the reaction mixture was then read at 595 nm and protein content was determined from a standard curve established using bovine serum albumin (Sigma Chemical Co.). Extraction and quantification of carbohydrates were determined following a standard method. Ten milligrams of the tissue powder were extracted three times, 8 min each time, in 1.2 ml of 80% ethanol in an 80 C water bath. Half a milliliter of the combined extract was pipetted into a centrifugal microfilter tube assembled with 20 mg of active charcoal to adsorb the colored pigments. The tube was covered and vortexed for 2 min and then centrifuged for 5 min to obtain a clear alcohol extract. Four 10 μl aliquots from each sample were pipetted into separate wells of a microplate and dried at 50 C for 15 min to remove alcohol. Thereafter, 20 μl of deionized water, 100 μl of glucose-6-P dehydrogenase/iodonitrotetrazolium violet mixture (glucose kit 115A, Sigma Chemical Co.) and 10 μl of phosphoglucose isomerase (PGI enzyme, 0.25 units) were added into each well of the microplate under reduced room illumination. The sample plates were incubated at 37 C for 15 min, and then absorbance was read at 492 nm using D-glucose as a standard. Subsequently, 15 μl of invertase (83 units) was added to each well, the microplate was reincubated at 37 C for a further 15 min and absorbance was read again at 492 nm for sucrose concentration.

Statistics
The least significant difference (LSD) test in two-way randomized complete block general linear models procedure (GLM) in SAS was used to analyze the data. In order to normalize the data, densities of whitefly adults from vacuum samples were transformed using the formula $(y + 0.5)^{1/2}$ and percent mortalities of bifenthrin treated adult whiteflies were Arcsine-transformed, before the analysis of variance or regression. To determine the relationship between plant physiological factors such as photosynthetic rate, stomatal conductance, sugars or proteins and densities of adult whiteflies, simple and multiple regression analyses were used.

Results

Residual Total Nitrogen in Soil and Nitrate Nitrogen in Cotton Petioles
Total soil nitrogen in all experimental plots prior to nitrogen treatments was consistent with a level of approximate 0.04% (Tables 1 and 2). There was a positive linear response between the levels of nitrate nitrogen in petioles of early or late planted cotton and nitrogen rate applied per acre on 19 August sampling date (Table 3). Nitrate nitrogen levels ranged from 426 to 477 ppm in petioles of early planted cotton and from 1530 to 2460 ppm in petioles of late planted cotton. Nitrate nitrogen content was near 4-fold higher in petioles of late planted cotton than in those of early planted cotton (Table 2). There were no significant differences ($P > 0.05$) in levels of nitrate nitrogen in petioles of early or late planted cotton samples on 24 September (Table 3). Also, the difference in amounts of nitrate nitrogen in cotton petioles sampled on 24 September from different planting dates was less striking (Table 3).

Whitefly Densities
The peak population growth of adult whiteflies occurred from mid-September to late October (Figures 1, 2 and 3). On early planted cotton, higher rates of nitrogen (150 and 200 lbs/acre) slightly enhanced whiteflies densities before early October compared to those on cotton treated with 0 and 100 lbs N per acre) and control but the differences were not significant ($P > 0.05$). The effect of nitrogen on densities of whiteflies thereafter was inconsistent and not clear (Figure 1). The relationship between nitrogen rates and densities of adult whiteflies on early planted cotton was not linear on all sampling dates as indicated by results of regression analysis (Table 6). On late planted cotton, there was a trend of positive response between nitrogen treatments and densities of adult whiteflies on most sampling dates during peak population growth (Figures 2 and Table 7). However, a linear response was only recorded on one sampling date, 22 September. The population levels of adult whiteflies were much higher on early planted cotton than on late planted cotton (Figures 1, 2 and 3). The average density of adult whiteflies during peak population growth was almost 70% higher on early planted cotton than on late planted cotton (Figure 3). In comparison with results from 1998, the mean density of whiteflies during peak population growth in 1999 was over 10-fold lower.

Plant Heights and Seed Cotton Yield
Applied nitrogen linearly ($P < 0.05$) stimulated vegetative growth of all the treated cotton (Table 4). Plant heights in the 0 lbs N/acre treatment to the 200 lbs N/acre treatment ranged from 73.8 to 85.1 cm in early planted cotton, 82.5 to 90.6 cm in early planted cotton with defoliator treatment, and 81.3 to 92.3 cm in late planted cotton (Table 4). On average, plant heights of late planted cotton were over 7% higher ($P < 0.05$) than those of early planted cotton. Applied nitrogen linearly increased seedcotton yield of early planted cotton and the cotton treated with chemical defoliant (Table 5). The 150 lbs N/acre treatment increased the yield by 35% compared to the control (0 N treatment) whereas differences in seedcotton yield from the 200, 150, and 100 lbs/acre treatments were not significant ($P > 0.05$). In early planted cotton treated with the defoliant, 150 lbs N/acre enhanced the yield by 40% in comparison with the control. There was no significant difference in yields between 200 and 150 lbs N/acre treatments. In late planted cotton, the yields among different treatments were similar, indicating applied nitrogen had no effect on seedcotton yield. The mean yield of early planted cotton was over 44% higher than that of late planted cotton and the difference in yields from early planted cotton and early planted cotton plus defoliant treatment was not significant ($P > 0.05$).

Photosynthetic Rate and Stomatal Conductance
The photosynthetic rates of cotton treated with different levels of nitrogen fertilizer and planting dates are shown in Figures 4, 5 and 6. In early planted cotton, there was a trend that the applied nitrogen enhanced the photosynthetic rate later in the season, starting 1 September. However, the differences were not significant ($P > 0.05$) on most of the sampling dates. The effect of applied nitrogen on photosynthetic rate on most of the sampling dates before 1 September was also not significant (Figure 4). Results of regression analysis indicated that applied nitrogen had no linear effect on cotton photosynthetic rates on most of the measuring dates (Table 8). A similar effect of nitrogen on photosynthetic rate was also found in late planted cotton (Figure 5 and Table 9). The mean photosynthetic rate of early planted cotton was 4 - 20% higher before 25 August than that of late planted cotton and thereafter the rate of late planted cotton was 10 - 18% higher than that of early planted cotton (Figure 6). The effects of nitrogen on stomatal conductance of leaves from different treatments on early or late planted cotton were not significant ($P > 0.05$) on most measuring dates (Figures 7 and 8). Also, applied nitrogen showed no linear effect on the stomatal conductance on most of the sampling dates (Table 8 and 9). The mean stomatal conductance was about 20% higher in late planted cotton than in early planted cotton on most of the measuring dates throughout the season (Figure 9).

Soluble Proteins and Soluble Carbohydrates
Nitrogen fertilizer effect on levels of soluble proteins in cotton petioles of both early and late planted cotton are shown in Figures 10, 11 and 12. Early in the season, especially before peak flowering of cotton plants (around early August for early planted cotton and around mid-August for late planted cotton), higher rates of nitrogen (150 and 200 lbs/acre) significantly increased levels of soluble proteins. Thereafter, the protein levels from all nitrogen treatments on early or late planted cotton was similar (Figures 10 and 11). Before mid-August, average levels of soluble proteins in petioles of early planted cotton were up to 1.3-fold less than levels measured in late planted cotton. Later in the season, mean levels of proteins from both planting dates were similar (Figure 12 and Table 9). The applied nitrogen altered glucose levels in cotton petioles from both planting dates (Figures 13, 14, 15, Tables 8 and 9). Generally, the nitrogen linearly

increased glucose levels in early planted cotton throughout the season whereas the linear increase in late planted cotton occurred only in later part of the season. Early in the season, average levels of glucose in late planted cotton were up to 41% higher compared to the levels in early planted cotton. The differences decreased towards the late part of the season. Nitrogen generally enhanced fructose levels in petioles of early planted cotton in early and late parts of the season (Figure 16 and Table 8). However, the levels of late planted cotton were not significantly ($P > 0.05$) affected in most of the sampling dates (Figure 17 and Table 9). The mean levels of fructose in early planted cotton were generally up to 40% lower than those in late planted cotton (Figure 17). Sucrose levels in early planted cotton were generally increased with the application of nitrogen (Figure 19 and Table 8). However, the levels in late planted cotton were generally not affected (Figure 20 and Table 9). Average levels of sucrose were strikingly affected by planting dates (Figure 21). In comparison with sucrose levels in late planted cotton, the levels in early planted cotton were 59% higher on 29 July and then declined until 8 September when levels began to rise again.

Relationship Between Whitefly Densities and Plant Physiological Parameters

Tables 6 and 7 show the relationships between densities of adult whiteflies and levels of glucose, fructose, sucrose, proteins, photosynthetic rate or stomatal conductance. Glucose and fructose levels were significantly correlated with densities of whitefly adults during the peak population size on late planted cotton. A significant correlation between densities of adult whiteflies and other cotton physiological parameters occurred on only a few sampling dates.

Discussion

Nitrogen fertilizer treatments increased densities of adult whiteflies on late planted cotton at Riverside in California although there was lack of a general linear relationship between nitrogen rates and whitefly densities (Figure 2, Tables 6 and 7). This result is consistent with our findings in 1998.

There were differences in the results of whitefly densities and cotton physiological parameters in our experiment of 1999 compared to that of 1998. Several factors may contribute to the differences. Firstly, soil quality may be different although there were similar levels in levels of residual soil nitrogen. Prior to cotton planting in 1999, a leguminous pea crop was grown in the field. These plants were left in the soil when the growing season was over. Leguminous plants are a good source of manure to improve soil texture and soil fertility. This may contribute to the higher levels of NO_3-N in cotton petioles in control plots. Secondly, some square shedding (on average, 4-8 squares per plant were shed) on early planted cotton occurred at the end of August. Possibly, the shedding was caused by low night temperatures during that period. These factors may have a direct effect on cotton physiological status and therefore indirectly affect whitefly population dynamics. Also, the mean densities of adult whiteflies were far lower in 1999 than in 1998. This may also contribute, in part, to the differences.

Significant correlations between levels of glucose or fructose and densities of adult whiteflies were observed on late planted cotton. A similar relationship for glucose levels and whitefly densities was also found in results of the 1998 experiment. Glucose and fructose may therefore be important components determining whitefly population dynamics on cotton, by providing nutrients for whitefly development.

Nitrogen applied to late planted cotton was again found to have no effect on seedcotton yield, although the vegetative growth was linearly increased. In addition to higher densities of whiteflies, it is likely that the applied nitrogen further delayed the growing season of late planted cotton. It was reported that cotton growers in California usually applied 200 lbs N/acre to their cotton field. Apparently, the growers had no benefit from nitrogen fertilizer applications to late planted cotton; instead they suffered economic loses from nitrogen fertilizer cost, application cost, and the whitefly outbreaks.

In summary, applied nitrogen linearly increased seedcotton yield of early planted cotton and early planted cotton treated with chemical defoliant but had no effect on yield of late planted cotton. The nitrogen also resulted in increased densities of whiteflies. Also, early planted cotton supported higher densities of whiteflies than late planted cotton.

References

Bentz, J., J. Reeves, P. Barbosa & B. Francis, 1995. Within-plant variation in nitrogen and sugar content of poinsettia and its effects on the oviposition pattern, survival, and development of *Bemisia argentifolii* (Homoptera: Aleyrodidae). Environmental Entomology 24: 271-277.

Blua, M. J. & N. C. Toscano, 1994. *Bemisia argentifolii* (Homoptera: Aleyrodidae) development and honeydew production as a function of cotton nitrogen status. Environmental Entomology 23: 316-321.

Gerling, D., U. Motro & R. Horowitz, 1980. Dynamics of *Bemisia tabaci* (Gennadius) (Homoptera, Aleyrodidae) attacking cotton in the coastal plain of Israel. Bulletin of Entomological Research 70: 213-219.

Henneberry, T. J., D. L. Hendrix, H. H. Perkins, S. E. Naranjo, H. M. Flint, D. Akay, L. F. Jech & R. A. Burke, 1995. *Bemisia argentifolii* (Homoptera: Aleyrodidae) populations and relationships to sticky cotton and cotton yields. Southwestern Entomologist 20: 255-271.

Henneberry, T. J., D. L. Hendrix, H. H. Perkins, L. F. Jech & R. A. Burke, 1996. *Bemisia argentifolii* (Homoptera: Aleyrodidae) honeydew sugars and relationships to sticky cotton. Environmental Entomology 25: 551-558.

Rubeiz, I. G., M. Aslam, H. Chahine & A. Imad, 1995. Whitefly populations in greenhouse cantaloupe as affected by poultry manure and inorganic nitrogen fertilizer application. Biological Agriculture & Horticulture 12: 277-281.

Yee, W. L, N. C. Toscano, C. C. Chu, T. J. Henneberry & R. L. Nichols, 1996. *Bemisia argentifolii* (Homoptera: Aleyrodidae) action thresholds and cotton photosynthesis. Environmental Entomology 25: 1267-1273.

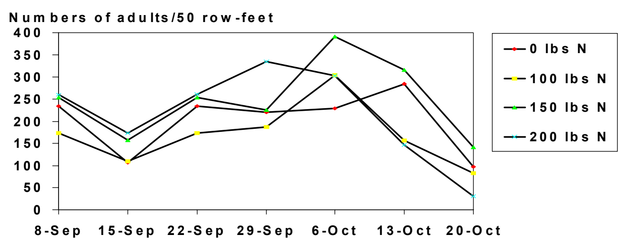

Figure 1. Effect of N fertilizer treatments on densities of adult whitefly on early planted cotton.

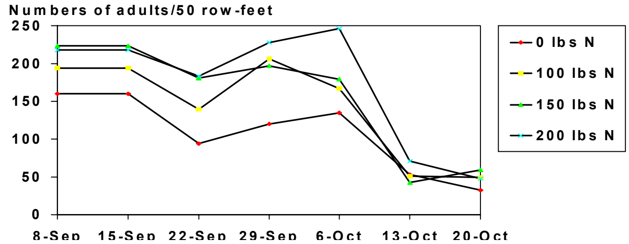

Figure 2. Effect of N fertilizer treatments on densities of adult whitefly on late planted cotton.

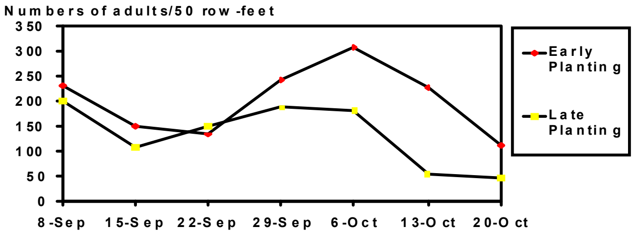

Figure 3. Effect of cotton planting dates on densities of adult whiteflies.

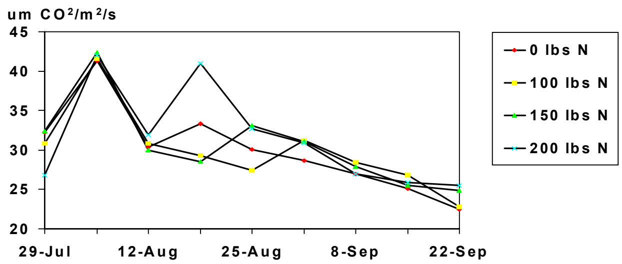

Figure 4. Effect of N fertilizer treatments on foliar photosynthetic rate of early planted cotton.

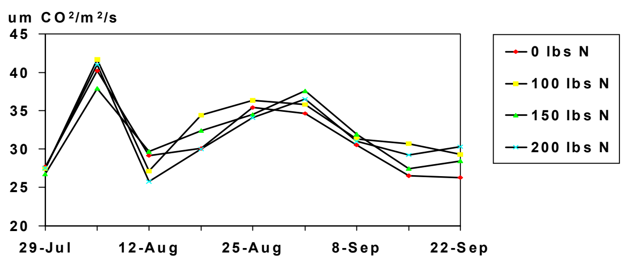

Figure 5. Effect of N fertilizer treatments on foliar photosynthetic rate of late planted cotton.

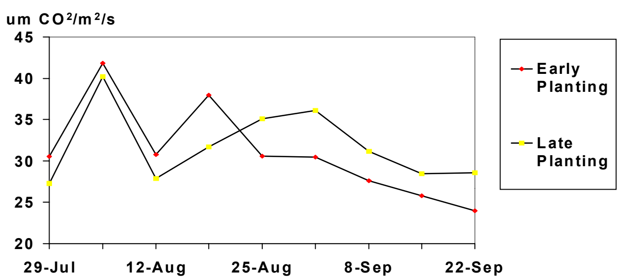

Figure 6. Effect of planting dates on cotton foliar photosynthetic rate.

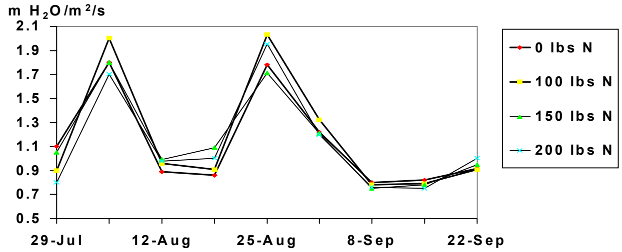

Figure 7. Effect of N fertilizer treatments on foliar stomatal conductance of early planted cotton.

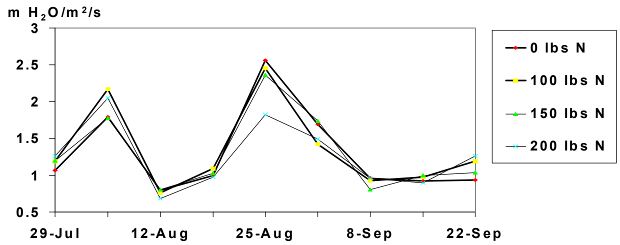

Figure 8. Effect of N fertilizer treatments on foliar stomatal conductance of late planted cotton.

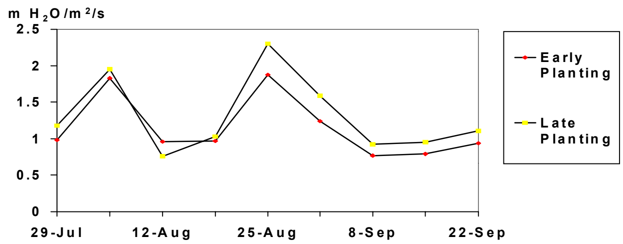

Figure 9. Effect of planting dates on cotton foliar stomatal conductance.

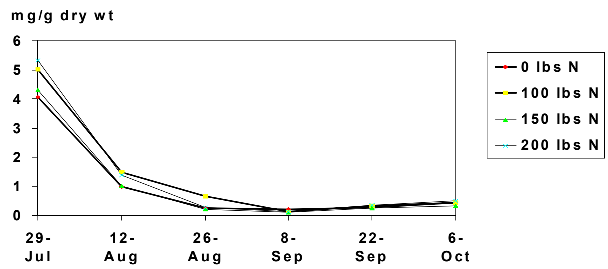

Figure 10. Effect of N fertilizer treatments on soluble protein levels in petioles of early planted cotton.

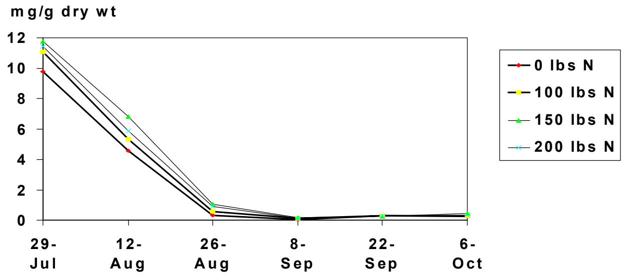

Figure 11. Effect of N fertilizer treatments on soluble protein levels in petioles of late planted cotton.

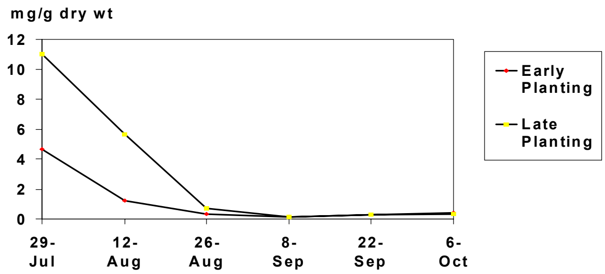

Figure 12. Effect of planting dates on soluble protein levels in cotton petioles.

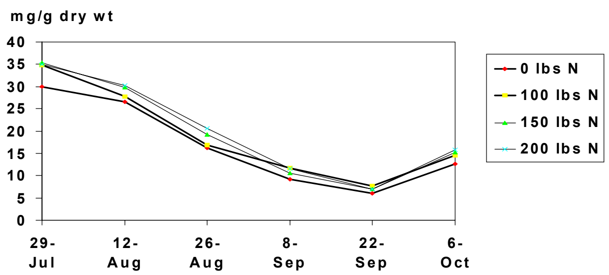

Figure 13. Effect of N fertilizer treatments on glucose levels in petioles of early planted cotton.

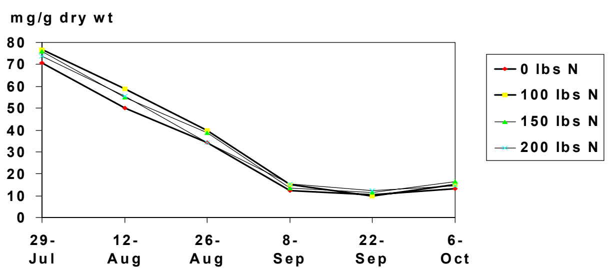

Figure 14. Effect of N fertilizer treatments on glucose levels in petioles of late planted cotton.

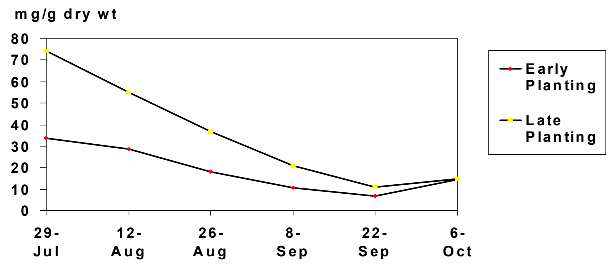

Figure 15. Effect of planting dates on glucose levels in cotton petioles.

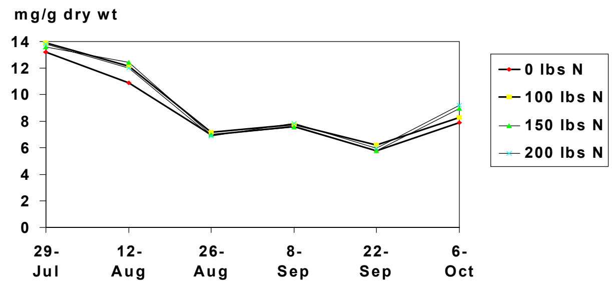

Figure 16. Effect of N fertilizer treatments on frucose levels in petioles of early planted cotton.

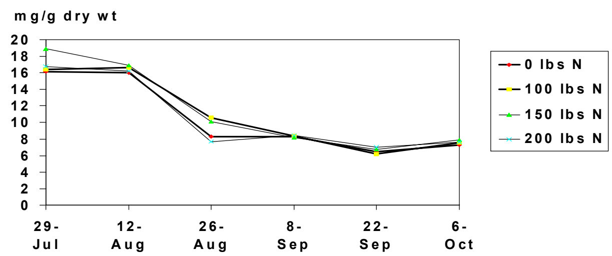

Figure 17. Effect of N fertilizer treatments on fructose levels in petioles of late planted cotton.

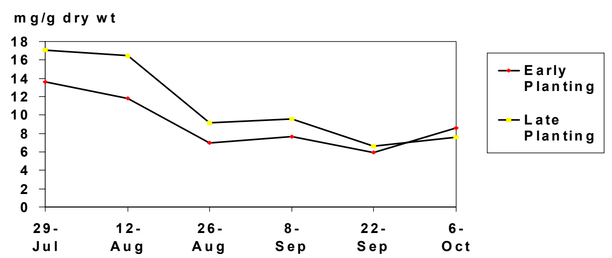

Figure 18. Effect of planting dates on fructose levels in cotton petioles.

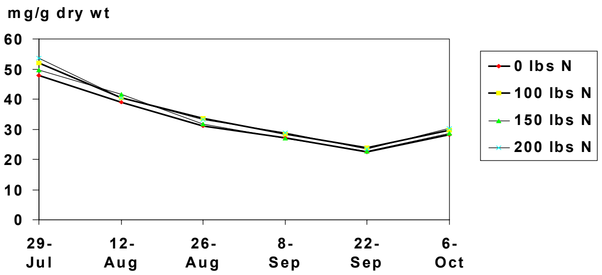

Figure 19. Effect of N fertilizer treatments on sucrose levels in petioles of early planted cotton.

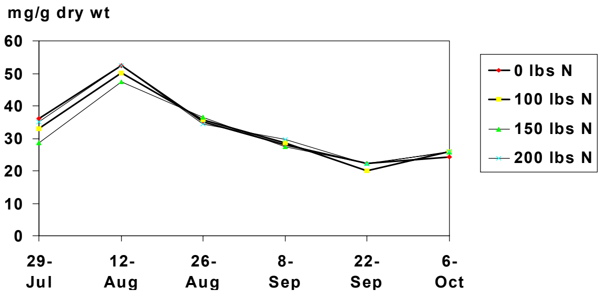

Figure 20. Effect of N fertilizer treatments on sucrose levels in petioles of late planted cotton.

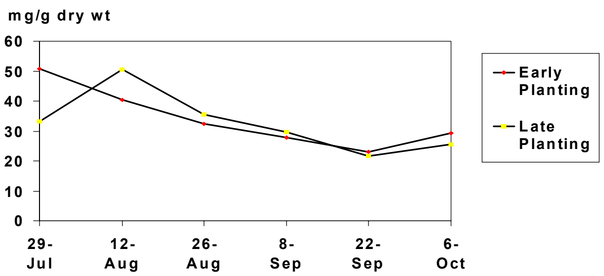

Figure 21. Effect of planting dates on sucrose levels in cotton petioles.

Table 1. Residual soil nitrogen levels in experimental plots prior to nitrogen treatments

Experimental Plots Prior to Nitrogen Treatments	Residual Soil Nitrogen[1] Levels (%) Early Planting	Early Planting + Ginstar	Late Planting
0	0.048 (0.002)[2] a	0.038 (0.001) a	0.041 (0.001) a
100	0.049 (0.002) a	0.038 (0.002) a	0.040 (0.002) a
150	0.047 (0.002) a	0.038 (0.002) a	0.038 (0.002) a
200	0.049 (0.002) a	0.040 (0.002) a	0.039 (0.002) a

[1]Soil nitrogen was analyzed for total Kjeldahl nitrogen.

[2]Means in columns followed by same letter are not significantly different at P < 0.05. Numbers in parentheses are standard errors.

Table 2. Mean levels of residual soil N, petiole NO_3-N, plant height and seedcotton yield

	Treatments: Early Planting	Early Planting + Ginstar	Late Planting
Residual soil N (%)	0.05 (0.001) a	0.04 (0.001) a	0.04 (0.001) a
Petiole NO_3-N Levels (ppm) (8/19)	440.8 (39.0) b		2142.5 (245.9) a
Petiole NO_3-N Levels (ppm) (9/24)	100.5 (3.0) a		143.0 (17.6) a
Plant Heights (cm)	80.5 (0.4) b	86.2 (0.4) a	86.0 (0.5) a
Seedcotton Weight (g/10 row-meter)	2851.7 (139.8) a	3153.0 (184.1) a	1979.6 (66.6) b

Means in rows followed by different letter are significantly different at P < 0.05. Numbers in parentheses are standard errors.

Table 3. Effect of nitrogen treatments on NO_3-N levels in cotton petiole.

Nitrogen Treatments (lbs/acre)	NO_3-N Levels (ppm) Early Planting 8/19	Early Planting 9/24	Late Planting 8/19	Late Planting 9/24
0	426 (91) a	96 (6) a	1530 (308) c	134 (18) a
100	427 (78) a	105 (4) a	1900 (372) bc	188 (62) a
150	433 (74) a	99 (9) a	2734 (516) a	144 (26) a
200	477 (79) a	102 (4) a	2406 (660) ab	106 (12) a

Means in columns followed by different letter are significantly different at P < 0.05. Numbers in parentheses are standard errors.

Table 4. Effect of nitrogen treatments on vegetative growth of cotton.

Nitrogen Treatments (lbs/acre)	Plant Heights (cm) Early Planting	Early Planting + Ginstar	Late Planting
0	73.8 (0.90) c	83.5 (0.92) c	81.3 (0.76) c
100	78.5 (0.58) b	82.5 (0.68) c	82.3 (0.64) c
150	84.4 (0.52) a	90.6 (0.86) a	88.1 (1.13) b
200	85.1 (0.70) a	88.3 (0.63) b	92.3 (1.29) a

Means in columns followed by different letter are significantly different at P < 0.05. Numbers in parentheses are standard errors.

Table 5. Effect of nitrogen treatments on seedcotton yields.

Nitrogen Treatments (lbs/acre)	Seedcotton Weight (g/10 row-meter) Early Planting	Early Planting + Ginstar	Late Planting
0	2358.2 (241.9) b	2707.5 (361.1) b	1833.9 (111.2) a
100	2836.4 (319.8) ab	2816.8 (341.9) b	1982.3 (81.1) a
150	3184.8 (317.1) a	3792.9 (342.6) a	2093.8 (191.2) a
200	3027.3 (115.7) ab	3294.9 (307.1) ab	2008.4 (141.3) a

Means in columns followed by different letter are significantly different at P < 0.05. Numbers in parentheses are standard errors.

Table 6. Results of regression analysis between [1]densities of adult whiteflies and amounts of N applied to cotton, or physiological status of early planted cotton.

	Adults & N		Adults & Glucose		Adults & Fructose		Adults & Sucrose		Adults & Protein		Adults & Photosynthetic Rate		Adults & Stomatal Conductance	
Date	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2	R	R^2
9/8	0.3742	0.0206	0.6280	0.0020	0.1371	0.0188	0.8295	0.0004	0.1187	0.0571	0.6914	0.0043	0.6398	0.0058
9/16	0.0627	0.0895									0.6984	0.0041	0.4409	0.0161
9/22	0.3742	0.0206	0.9296	0.0001	0.0349	0.0374	0.7597	0.0008	0.1004	0.0712	0.5653	0.0089	0.0809	0.0769
9/30	0.1242	0.0565												
10/6	0.3232	0.0259	0.1521	0.0173	0.0757	0.0245	0.0227	0.0434	0.4350	0.0162				
10/13	0.6019	0.0074												
10/20	0.4345	0.0359												

[1]Densities of whitefly adult were transformed using $(y + 0.5)^{1/2}$.

Table 7. Results of regression analysis between [1]densities of adult whiteflies and amounts of N applied to cotton, or physiological status of late planted cotton

	Adults & N		Adults & Glucose		Adults & Fructose		Adults & Sucrose		Adults & Protein		Adults & Photosynthetic Rate		Adults & Stomatal Conductance	
Date	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2	R	R^2
9/8	0.1580	0.1134	0.7301	0.0018	0.3399	0.0158	0.4736	0.0084	0.3413	0.0510	0.4592	0.0326	0.6971	0.0091
9/16	0.1580	0.1134									0.5494	0.0211	0.9742	0.0001
9/22	0.0543	0.2003	0.0047	0.1277	0.0038	0.1346	0.0005	0.1939	0.9001	0.0008	0.6565	0.0119	0.3986	0.0419
9/30	0.2664	0.0714												
10/6	0.2671	0.0709	0.0000	0.3143	0.0051	0.1286	0.2193	0.0263	0.5459	0.0216				
10/13	0.7113	0.0078												
10/20	0.2142	0.0853												

[1]Densities of adult whitefly were transformed using $(y + 0.5)^{1/2}$.

Table 8. Results of regression analysis between physiological status of early planted cotton and amount of nitrogen applied to the cotton

	Glucose & N		Fructose & N		Sucrose & N		Protein & N		Photosynthetic Rate & N		Stomatal Conductance & N	
Date	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2
7/29	0.0059	0.0621	0.3958	0.0062	0.053	0.0315	0.0789	0.0807	0.0092	0.1555	0.0525	0.0094
8/5									0.5797	0.0084	0.5505	0.0094
8/12	0.0036	0.0701	0.0001	0.1196	0.0538	0.0310	0.6563	0.0054	0.9666	0.0000	0.3618	0.0225
8/19									0.3318	0.0245	0.2052	0.0430
8/25	0.0004	0.1026	0.7956	0.0006	0.0389	0.0355	0.8443	0.0010	0.1646	0.0496	0.7849	0.0020
9/1									0.1666	0.0500	0.9255	0.0002
9/8	0.0012	0.0844	0.4545	0.0048	0.2188	0.0129	0.3490	0.0236	0.9381	0.0002	0.6181	0.0068
9/15									0.6984	0.0041	0.4409	0.0161
9/22	0.1101	0.0209	0.3450	0.0074	0.2395	0.0118	0.6041	0.0073	0.0440	0.1041	0.2519	0.0345
10/6	0.0128	0.0518	0.0005	0.0999	0.0933	0.0239	0.8429	0.0011				

Table 9. Results of regression analysis between physiological status of late planted cotton and amount of nitrogen applied to the cotton

	Glucose & N		Fructose & N		Sucrose & N		Protein & N		Photosynthetic Rate & N		Stomatal Conductance & N	
Date	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2	P	R^2
7/29	0.4086	0.0117	0.1345	0.0382	0.0586	0.0525	0.0408	0.2164	0.8509	0.0021	0.3622	0.0490
8/5									0.9011	0.0009	0.5136	0.0251
8/12	0.0538	0.0593	0.6511	0.0036	0.5100	0.0072	0.1185	0.1345	0.4274	0.0371	0.4847	0.0287
8/19									0.3318	0.0245	0.9540	0.0002
8/25	0.7114	0.0020	0.7986	0.0009	0.9103	0.0002	0.3898	0.0436	0.5444	0.0216	0.3083	0.0597
9/1									0.2823	0.0671	0.7186	0.0078
9/8	0.0313	0.0259	0.9142	0.0001	0.2262	0.0082	0.1106	0.1232	0.8279	0.0028	0.7657	0.0053
9/15									0.5494	0.0211	0.9742	0.0001
9/22	0.0839	0.0497	0.0662	0.0547	0.8947	0.0003	0.9062	0.0008	0.1524	0.1163	0.0957	0.1545
10/6	0.0439	0.0643	0.1119	0.0434	0.0722	0.055	0.3808	0.0453				