IMPACT OF NITROGEN FERTILITY ON COTTON RESPONSE TO COTTON FLEAHOPPER-INDUCED INJURY

M. N. Parajulee
A. Hakeem
Texas A&M AgriLife Research
Lubbock, TX

Abstract

Cotton is affected by cotton fleahopper injury from about the fifth true-leaf through first week after initiation of flowering. Squares up to pinhead size are most susceptible to damage, and yield loss is most likely from feeding during the first three weeks of fruiting. Cotton fleahopper damage also delays crop maturity and thus increases the vulnerability of cotton to late season pests such as heliothine caterpillars and *Lygus* bugs. A three-year (2014-2016) study evaluated the impact of five nitrogen fertility rates on cotton response to cotton fleahopper-induced injury in the Texas High Plains. The five main-plot treatments included pre-bloom side-dress applications of augmented nitrogen fertilizer rates of 0, 50, 100, 150, and 200 lbs N/acre using a soil applicator injection rig. The sub-plot treatment included two cotton fleahopper augmentation treatments [5 cotton fleahopper nymphs (2014, 2016) or adults (2015) per plant versus no fleahopper augmentation as control] applied to each of the five nitrogen fertility rates two weeks into cotton squaring, the most critical phenological stage of cotton for cotton fleahopper management in the Texas High Plains. The infestations were designed to exert 20-25% square abscission. Cotton fleahopper induced fruit loss resulted in significant crop maturity delay in 2014, as measured by number of unopened bolls (7.7% non-harvestable bolls in the infested plots versus 1.8% in control plots) at harvest. There was no maturity delay penalty in 2015 or 2016 due to an unseasonably warmer fall each year. As expected, lint yield varied with N level regardless of the cotton fleahopper infestation in all three years. In uninfested control plots, lint yield displayed a characteristic staircase effect of nitrogen rate, with lowest lint yield in zero N and highest lint yield in 200 N treatments, with numerical increase in lint yield for each incremental nitrogen application of 50 lb/acre. Combined over all N treatments, the acute infestation of cotton fleahoppers rendered the lint yield reduction from 975 and 910 lb/acre in the uninfested control to 846 and 877 lb/acre in fleahopper augmented treatments in 2014 and 2015, respectively. In both years, cotton lint yield was not significantly affected by ~25% fleahopper-induced square loss three weeks into squaring at both zero N and 200 lb/acre plots, either via insect-induced pruning of undesirable fruit load (zero N) or compensation (200 lb N), whereas lint yield was significantly lower in fleahopper augmented 100 lb/acre plots compared to that in uninfested plots, clearly suggesting that the plant response to cotton fleahopper injury is greatly influenced by nitrogen fertility. In addition, plants fully compensated for manually pruned 100% square removal at the onset of cotton flowering.

Introduction

The cotton fleahopper is a significant economic pest of cotton in the Texas High Plains. Injury by cotton fleahoppers to squaring cotton often causes excessive loss of small squares during the early fruiting period of plant development (first 3 weeks of squaring). Both adults and immatures feed on new growth, including small squares. Greater damage is observed on smooth leaf varieties than on hirsute varieties (Knutson et al., 2013), which may extend the susceptible period into early bloom, especially under a high-input production regime. Cotton is affected by cotton fleahopper injury from about the fifth true-leaf through the first week after initiation of flowering. Squares up to pinhead size are most susceptible to damage, and yield loss is most likely from feeding during the first three weeks of fruiting (Reinhard, 1926). Cotton fleahopper damage also delays crop maturity and thus increases the vulnerability of cotton to late season pests such as heliothine caterpillars and *Lygus* bugs, particularly when natural enemies are destroyed by insecticides directed against cotton fleahoppers (Chen et al., 2007).

Predominantly, cotton fleahoppers feed upon pinhead-sized or smaller squares, which results in abortion of these young fruits, thereby impacting yields. While cotton fleahopper feeding preferences serve as a baseline for their management in cotton fields, a detailed understanding of cotton plant responses to fleahopper damage remains unachieved (Parajulee et al., 2006, Chen et al., 2007). Cotton plant growth is sensitive to numerous environmental and management input factors, particularly irrigation and nitrogen fertility. Cotton growth responses to various input factors are well-documented and growth models have been developed. However, the specific cotton plant responses to cotton fleahopper injury under a range of nitrogen fertility remain uninvestigated. This study was designed to evaluate the cotton crop growth parameters and lint yield following cotton fleahopper acute infestations under a range of nitrogen fertility rates.

Materials and Methods

The study was conducted at the Texas A&M AgriLife Research farm near Plainview, Texas. A 5-acre subsurface drip irrigation system has been in place for 16 years and nitrogen fertility treatments have been applied in a randomized block design with five replications since 2002 (Fig. 1). The present study utilized the same experimental set up as for the last 13 years. The field did not receive pre-plant fertility applications.

0	50	200	50	200
100	100	0	100	50
200	150	50	150	0
50	200	100	200	100
150	0	150	0	150

Figure 1. Helms Farm nitrogen study experimental plot layout following a five-treatment x five-replication randomized block design. Annually, each of the 25 plots received one of the five nitrogen augmentation treatments including 0, 50, 100, 150, or 200 lbs N/acre, Hale County, TX.

The experimental field was planted with FiberMax 9063B2R (June 16, 2014), Fibermax 9180 B2F (May 18, 2015), and FM1900GLT (May 27, 2016) at a targeted rate of 54,000 seeds/acre followed by an 'over-the-top' Caparol® 4L (prometryn; 3 pints/acre) application immediately after planting, with post-emergence herbicide applications of RoundUp® @ 32 oz/acre and Warrant® 3 pt/acre for weed management.

Soil residual nitrogen was monitored annually by taking three 24-inch core samples from each plot (Fig. 2). The 0-12 inch portions of each core were combined to form a single, composite soil sample, and likewise, the 12-24 inch portions were combined, resulting in two samples per experimental plot. Samples were sent to Ward Laboratories, Kearny, Nebraska for analysis.

Figure 2. A) Annual pre-season soil sampling of 25 sub-surface drip irrigated cotton plots; B) Annually near the time of first bloom, each plot received the same side-dressed nitrogen application treatment rate; C) Differential cotton plant growth responses are often visually apparent between plots receiving high and low N application rates, Hale County, TX.

Two 10-ft. sections of uniform cotton were flagged in the middle two rows of each 16-row main-plot that served as two insect treatment sub-plots (2014 and 2015) and three 10-ft sections in 2016 to accommodate for manual removal treatment. The sub-plot treatments included two cotton fleahopper augmentation treatments (5 cotton fleahopper nymphs per plant uncaged [2014] or 5 cotton fleahopper adults per plant in multi-plant cages [2015] and manual removal of 100% squares around the onset of cotton flowering stage [2016] versus no fleahopper augmentation or manual removal of squares as control) applied to squaring cotton within these designated row sections to simulate an acute infestation of cotton fleahoppers. This early squaring period is the most critical phenological stage of cotton for cotton fleahopper management in the Texas High Plains (Parajulee et al., 2006).

Cotton fleahoppers were reared in the laboratory from the overwintered eggs laid by reproductive females in woolly croton (Hakeem and Parajulee, 2015). The single release of cotton fleahoppers (nymphs in 2014 and 2016; adults in 2015) mentioned above was timed to simulate the acute heavy infestation of cotton fleahoppers (4-5 days of feeding) while cotton was highly vulnerable to the fleahopper injury. It was planned so that this arrangement would ensure 20-25% fleahopper-induced square damage on treatment plots. Seven days after cotton fleahopper augmentation, the entire test was sprayed with Orthene 97UP at 12 oz acre. In all three years, the entire test was kept virtually pest-free for the remainder of the crop-season to isolate the effect of cotton fleahopper injury only. Additional data collected included monitoring of plant height, plant biomass, root and shoot lengths, leaf chlorophyll content, leaf nitrogen content, and squaring patterns in all experimental units, starting from the first week of squaring (pre-release data) and approximately weekly thereafter well into the fall crop developmental period (Fig. 3). Final plant mapping and harvesting of test sections were performed after chemically-induced crop termination. Hand-harvested yield samples were obtained from each plot. Fiber samples were analyzed for lint quality parameters at the Cotton Incorporated Fiber Testing Laboratory (North Carolina). Data were analyzed using ANOVA and least significant differences separated the means at α=5%.

Figure 3. A) Blower sampling for arthropods, B) Processing of arthropod samples in the laboratory, C) Measuring leaf chlorophyll, D) Whole-plant sample collection for parameter estimation, E) Measuring leaf area, plant root and shoot biomass, F) cotton harvesting.

<u>Results and Discussion</u>

In all three study years, soil residual N levels were significantly higher in plots that received the two highest application rates of N fertilizer versus plots receiving lower-rate N applications or no N augmentation (Fig. 4). For each year, the highest N augmentation plots (200 lb/acre) had highest average residual N, at least numerically. Plant dry biomass followed the trend of residual N profile with respect to nitrogen-augmentation rates (Figs. 4-5). Measured leaf chlorophyll content varied with nitrogen application level, and leaf chlorophyll contents from cotton in those plots which received 0 lb N/acre or 50 lb N/acre were significantly lower than all others (Fig. 6). Cotton in plots which received the three highest nitrogen application rates (100, 150, and 200 lb N/acre) exhibited relatively consistent leaf chlorophyll readings (Fig. 6). Leaf area and leaf N content followed a similar trend as for leaf chlorophyll readings, indicating that all plant growth parameters were affected by the rates of N augmentation.

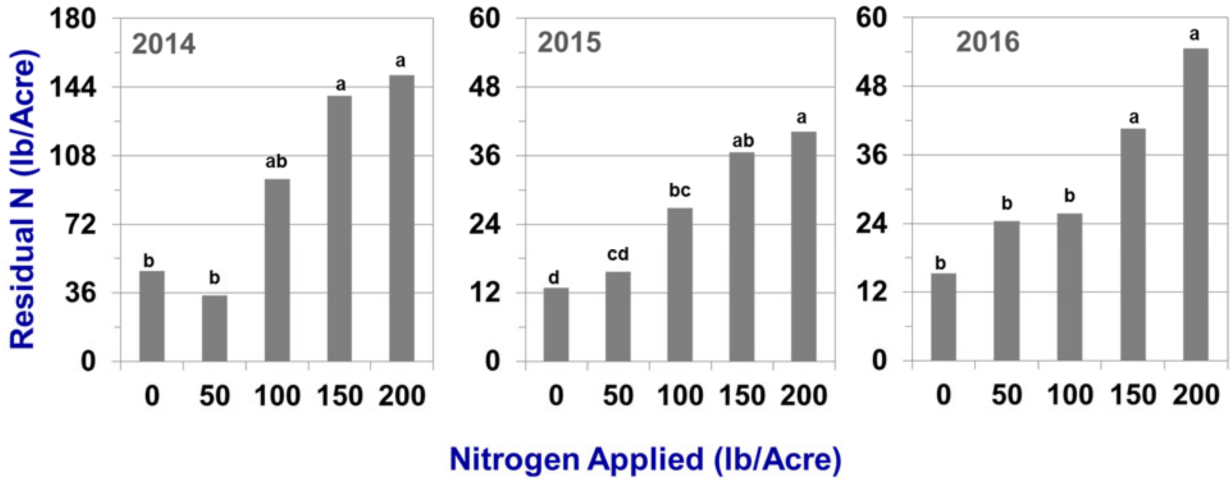

Figure 4. Effect of prior year's N application (0, 50, 100, 150, and 200 lb per acre) on residual N accumulation for the current crop year.

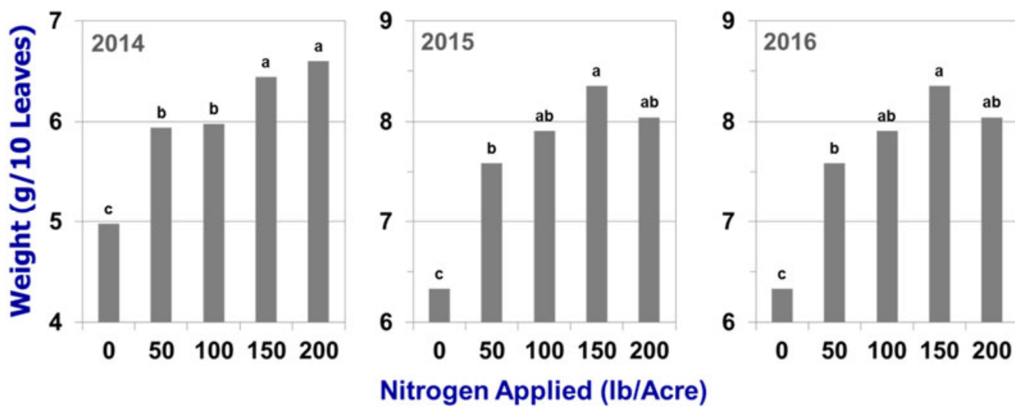

Figure 5. Effect of residual N from the previous crop year on plant dry biomass during the early crop growth period in succeeding years.

Nitrogen fertility level influenced boll maturity. Bolls in zero applied N plots tended to mature significantly earlier than in N augmented plots. Laboratory measurement of boll exocarp penetrability showed that bolls from zero N augmented plots required significantly greater pressure to puncture the exocarp versus that required to do so for bolls from N augmented plots. Variation in soil residual N levels, coupled with variable N application, resulted in phenotypic expression of nitrogen deficiency in cotton across treatment plots, especially between zero N plots and N augmented plots (Fig. 2).

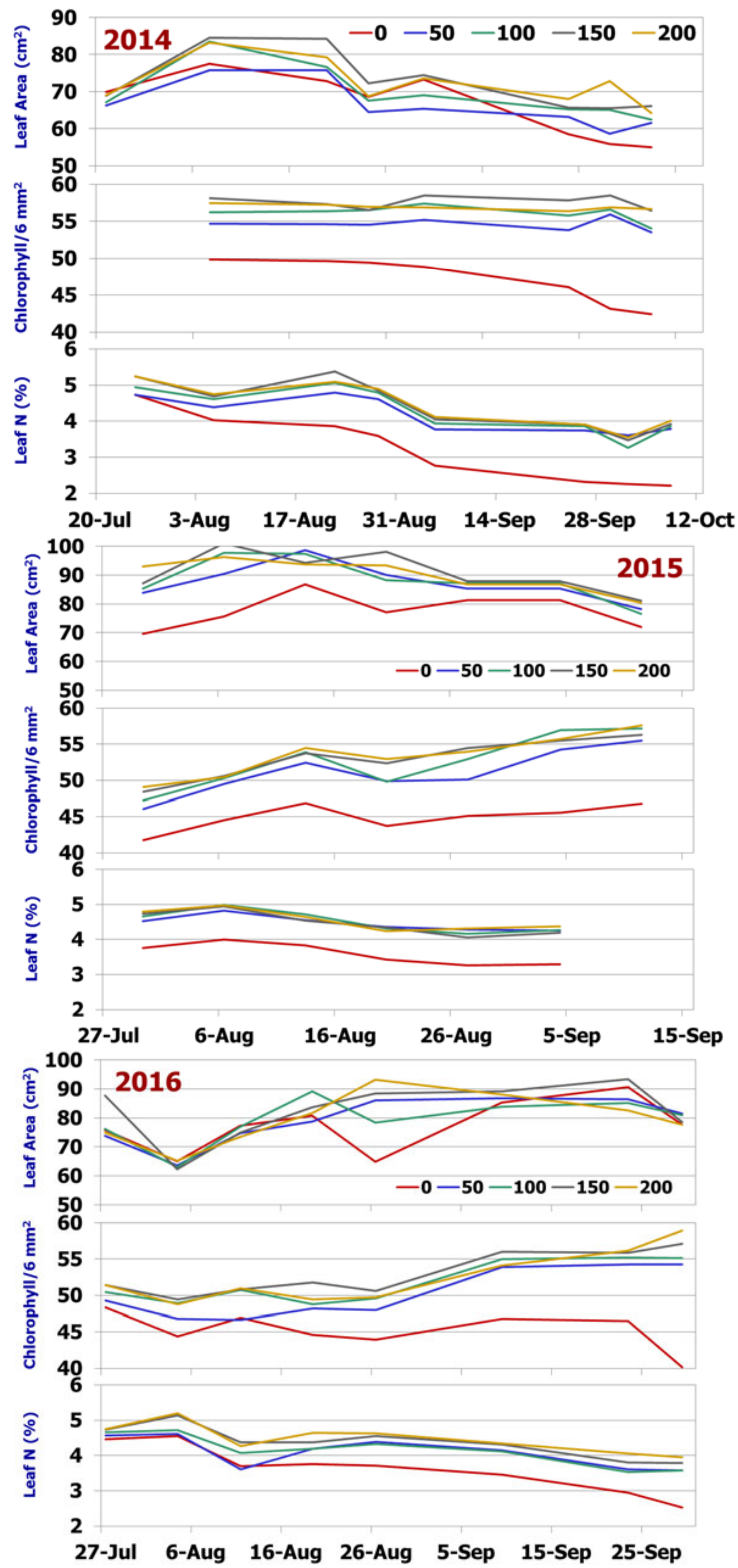

Figure 6. Temporal dynamics of leaf growth (leaf area), chlorophyll concentration, and percentage leaf nitrogen content measured on fifth mainstem leaf as influenced by the variable rates of augmented nitrogen (lb N/acre).

One week of cotton fleahopper infestation resulted in significant square abscission in cotton fleahopper augmented plots, but negligible square abscission (2-4% or less) was observed in uninfested control plots. While total square density did not vary across N treatments, cotton fleahopper-induced square abscission levels varied significantly (14-27%) with N application rates in 2014, but it did not vary across N treatments in 2015 or 2016. In general, higher N rate favored lesser impact of cotton fleahopper injury in 2014. In 2015 and 2016, square abscission rates were similar at ~25% across all N treatments.

As expected, lint yield varied with N level regardless of the cotton fleahopper infestation (Figs. 7-8). In uninfested control plots in 2014, lint yield displayed a characteristic staircase effect of nitrogen application rate, with lowest lint yield (862 lb/acre) in zero N and highest lint yield (1,081 lb/acre) in 200 N treatments, with numerical increase in lint yield for each incremental nitrogen application of 50 lb/acre. In 2015, all N augmented plots had higher lint yield than on zero N plots, but the crop response to variation in N density was not well defined. Combined over all N treatments, the acute infestation of cotton fleahoppers rendered the lint yield reduction from 975 lb/acre and 910 lb/acre in the uninfested control to 846 lb/acre and 877 lb/acre in fleahopper augmented treatments in 2014 and 2015, respectively. In both years, cotton lint yield was not significantly affected by ~25% fleahopper-induced square loss three weeks into squaring at both zero N and 200 lb/acre plots, either via fleahopper-induced pruning of undesirable fruit load (zero N) or compensation (200 lb N). On the other hand, lint yield was significantly lower in fleahopper augmented 100 lb N/acre plots compared to that in uninfested plots, clearly suggesting that the plant response to cotton fleahopper injury is greatly influenced by the availably of nitrogen fertility.

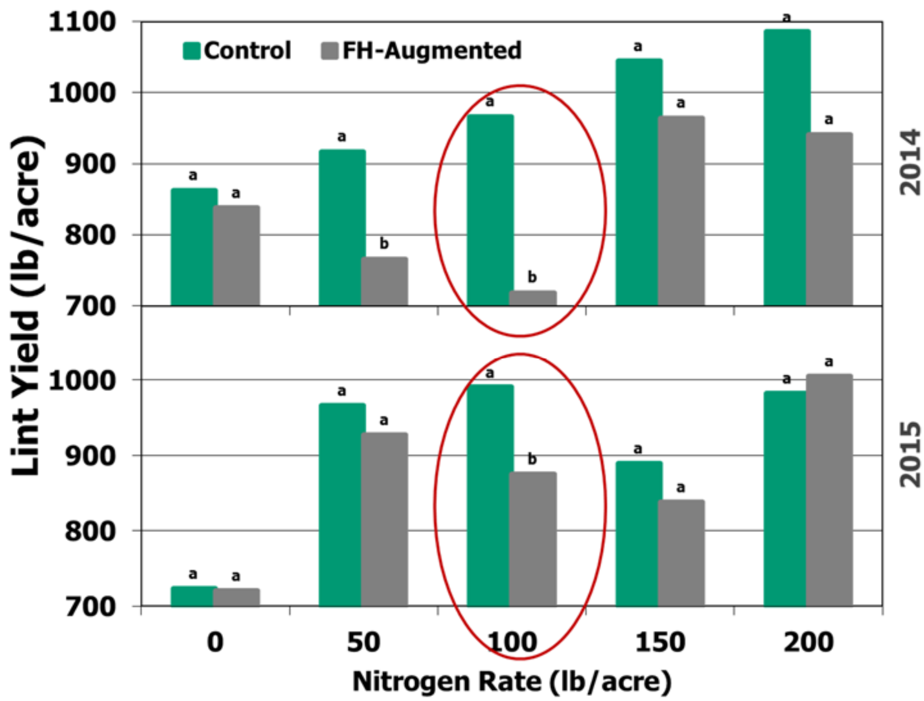

Figure 7. Effect of nitrogen augmentation rates (0, 50, 100, 150, and 200 lb per acre) on cotton lint yield following a single acute infestation of cotton fleahopper versus uninfested control, 2014-2015, Hale County, TX.

In 2016, lint yield was significantly lower in zero-N plots compared to all other N-augmented plots in uninfested control treatment. Manual removal of squares around the onset of first flowering stage of cotton did not negatively impact the final lint yield (Fig. 8). On the other hand, approximately 25% square loss due to cotton fleahopper injury reduced lint yield across all N treatments. A significant reduction was observed at 50 N plots as was the trend in previous years (50 and 100 lb treatments in 2014 and 100 lb treatment in 2015), further validating that the plant response to cotton fleahopper injury is significantly influenced by the availably of nitrogen fertility.

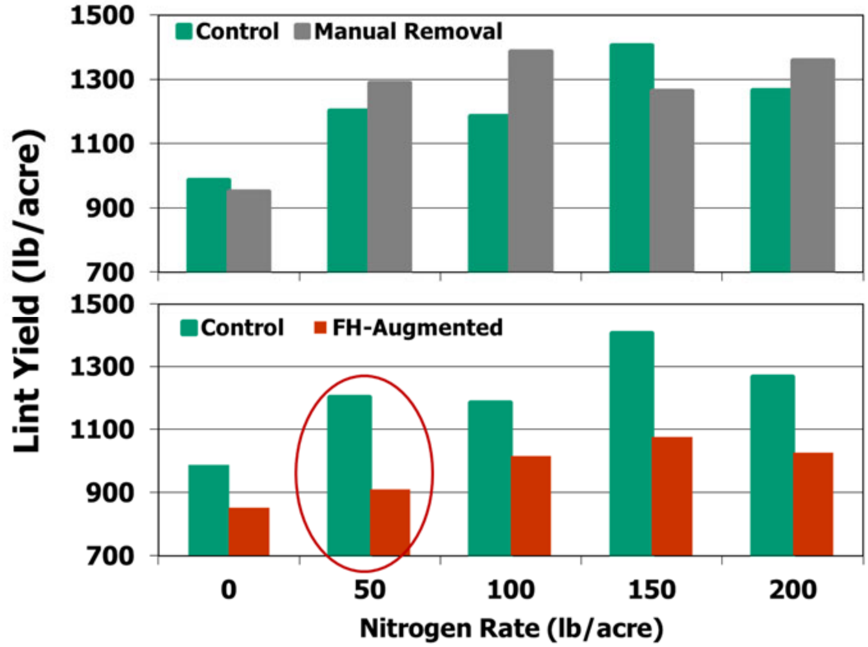

Figure 8. Effect of nitrogen augmentation rates (0, 50, 100, 150, and 200 lb per acre) on cotton lint yield following a manual removal of 100% of the squares up to the pre-flower stage of cotton versus control plants (above) and single acute infestation of cotton fleahopper versus uninfested control (below), 2016, Hale County, TX.

Acknowledgments

Cotton Incorporated Core Program and Plains Cotton Growers, Inc. have provided funding for this long-term nitrogen fertility study. Stanley Carroll, Sean Coyle, and Tahammal Hussain helped with the study.

References

Chen, C., A. K. Barman, and M. N. Parajulee. 2007. Cotton response to early square loss by the cotton fleahopper in the Texas High Plains, pp. 1662-1669. Proceedings, Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Hakeem, A., and M. N. Parajulee. 2015. Moisture conditions for laboratory rearing of cotton fleahoppers from overwintered eggs laid on woolly croton plants. *Southwestern Entomologist* 40: 455-462.

Knutson, A., K. Mekala, C. W. Smith, and C. Campos. 2013. Tolerance to feeding damage by cotton fleahopper (Hemiptera: Miridae) among genotypes representing adapted germplasm pools of United States upland cotton. J. Econ. Entomol. 106: 1045-1052.

Parajulee, M. N., R. B. Shrestha, and J. F. Leser. 2006. Influence of tillage, planting date, and *Bt* cultivar on seasonal abundance and within-plant distribution patterns of thrips and cotton fleahoppers in cotton. *International Journal of Pest Management* 52: 249-260.

Reinhard, H. J. 1926. The cotton fleahopper. Texas Agric. Exp. Sta. 57-426-12M Bull. 339, Agricultural and Mechanical College of Texas, College Station, TX.