EFFECT OF COTTON FLEAHOPPER DENSITY ON PRE-FLOWER FRUIT LOSS AND PLANT BIOMASS IN COTTON

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Abstract

L. T. Wilson's Agroecosystems Group in Texas (Texas AgriLife Research and Extension Center, Beaumont, Texas) has been developing a comprehensive Cotton Crop Production Decision System (*CropDSS*). They have already developed a physiologically based cotton model and the irrigation and fertilizer management advisors have been incorporated in the model. Current efforts aim to develop and deliver an integrated pest management advisor on top of the currently developed system. This project will ultimately deliver an integrated web-based cotton decision support system that will provide irrigation, nitrogen fertilization, and pest management decision assistance to cotton producers, consultants, and Extension agents. A unique feature of this model will be the tight integration of pest population dynamics with cotton phenological events, as predicted by the underlying mechanistic cotton model (Yang et al. 2009). Crop responses to pest injury such as compensatory growth, photosynthate reduction, and organ abscission will be directly incorporated into the cotton model. This tight pest-host plant integration will greatly improve pesticide application timing and effectiveness, and facilitate the design and implementation of integrated pest control measures. As part of this overall modeling effort, we are generating some experimental data on crop response to pest injury (cotton response to fleahopper injury) in Lubbock. In this paper, we report first-year experimental data on the effect of cotton fleahopper density on pre-flower fruit loss and plant biomass in cotton.

Introduction

As a major agricultural crop in Texas, cotton is subject to injury by a broad range of arthropod pests. Of approximately 25 arthropod pest species encountered in Texas cotton fields, western flower thrips (*Frankliniella occidentalis*), cotton fleahopper (*Pseudatomoscelis seriatus*), and western tarnished plant bug (*Lygus hesperus*) are among the most important pests in the High Plains region (Parajulee et al. 2008). Along with beet armyworms, cotton bollworm-tobacco budworm complex, and cotton aphids, these six insect species are responsible for an average annual loss of 218,000 bales of cotton and a total economic loss (crop loss plus pest management expense) of $101 million per year in the Texas High Plains (Parajulee et al. 2008).

Although pesticide use is an integral part of cotton pest management, increasing concerns regarding environmental and public safety and questions regarding the sustainability of current crop protection practices has increased the importance of developing integrated pest management approaches (Parajulee et al. 2008). However, the integration of these approaches has been hindered due to a lack of understanding of the biological and ecological interactions between target pests and their environment (Parajulee et al. 2008). In transitioning from pesticide-intensive to more sustainable knowledge-intensive integrated pest management systems, pest control measures will require design and implementation based on a broad understanding of the underlying agroecological interactions of cotton production systems (Luttrell 1994, Deguine et al. 2008). The multidisciplinary nature and inherent complexity of cotton cropping systems challenge producers and scientists as they transition toward such integration. This transition offers tremendous opportunities for scientists from different disciplines (entomologists, agronomists, ecologists, economists, among others) to cooperate as they integrate their respective expertise to develop management and decision making tools to optimize pest control and sustain crop production.

L. T. Wilson's Agroecosystems Group in Texas (Texas AgriLife Research and Extension Center, Beaumont, Texas) has been developing a comprehensive Cotton Crop Production Decision System (*CropDSS*). They have already developed a physiologically based cotton model and the irrigation and fertilizer management advisors have been incorporated in the model. Current efforts aim to develop and deliver an integrated pest management advisor on top of the currently developed system. This project will ultimately deliver an integrated web-based cotton decision support system that will provide irrigation, nitrogen fertilization, and pest management decision assistance to cotton producers, consultants, and extension agents. A unique feature of this model will be the tight integration of pest population dynamics with cotton phenological events, as predicted by the underlying mechanistic cotton model (Yang et al. 2009). Crop responses to pest injury such as compensatory growth, photosynthate reduction, and organ abscission will be directly incorporated into the cotton model. The objective of this study was to quantify the effect of cotton fleahopper density on pre-flower fruit loss and plant biomass in cotton.

Methods

The study was conducted at the Texas AgriLife Research farm near Lubbock, Texas. A 5-acre subsurface drip-irrigated field was used to conduct this experiment. Two cultivars, DP 161 B2RF and FM 9063 B2F, were evaluated. Experimental plots were 12 rows wide and 100 ft long with 5-ft alleys separating plots. Pre-flower square loss treatment levels were achieved by augmenting natural populations of cotton fleahoppers with laboratory-reared nymphs weekly for two weeks during initial squaring. Four insect release treatments included augmentation of 0, 1, 2, and 4 bugs per plant. The test was deployed in a 2 (cultivars) x 4 (insect release treatments) factorial arrangement with a randomized complete block design. The test had 3 replications (3 blocks), for a total of 48 experimental plots (24 plots for plant parameters, insect sampling, and yield; 24 for plant biomass/destructive sampling).

Nymphal bug releases were initiated upon initial observation of pinhead-sized squares in all plots. Cotton fleahoppers were aspirated from a laboratory colony (3^{rd}-4^{th} instar) into 0.75-inch X 1.5-inch plastic vials, then carefully deposited at the terminal portion of each plant's main stem. Nymphs were released on July 12 and 20. Plant monitoring was conducted using the SQUAREMAN component of the COTMAN program on July 8, 19, 29, August 3, and 11. Complete in-season plant mapping was conducted on August 3. COTMAN SQUAREMAN plant mapping continued until crop cutout (nodes above white flowers, NAWF=5), after which heat unit accumulations were monitored to aid decisions related to timing of harvest-aid applications.

Absolute sampling was conducted in all treatment plots following each bug release, and weekly thereafter for five weeks, to estimate released fleahopper survival. In conducting absolute sampling, five plants per plot were covered quickly with a heavy-duty trash bag and cut at the base, transported to the laboratory, and frozen (to kill captured insects). Bugs were then counted.

Five plants per plot were removed from each of the 24 destructive sampling and dry biomass determination plots on July 13, 21, August 2, 16, and September 3. Plants were stored in a large walk-in cooler (~ 41 °F) until processing. Plant height, root length, and numbers of nodes, main stem leaves, reproductive branches and leaves, vegetative branches and leaves, and total fruits (squares, flowers, and bolls) in each fruiting position were recorded. Dry biomass weights for each of these plant parts were recorded as well.

Plots were harvested on October 27 by hand-picking harvestable bolls on two 10 row-ft sections per plot. Lint samples were analyzed for quality parameters at Cotton Incorporated's Fiber Testing Laboratory in North Carolina.

Results

Insect Sampling

Cotton fleahopper nymphal survivorship was approximately 20% across all augmentation treatments. Actual cotton fleahopper nymphal densities in augmented plots were 0.23, 0.43, and 0.77 nymphs per plant in 1, 2, and 4 fleahopper(s)/plant augmented plots, respectively (Fig. 1). No fleahoppers were retrieved from control plots.

Percent Fruit Abscission

Cotton fleahopper-induced fruit abscission rates varied with cotton cultivar. In DP 161 B2RF, 2 and 4 fleahoppers per plant resulted in significantly higher fruit abscission followed by 1 per plant and non-augmented plots, whereas all three treatments resulted in similar levels of abscission in FM 9063 B2F (Fig. 2). Although only one year of data exists, it appears that cultivar FM 9063 B2F is more sensitive to cotton fleahopper infestations at low densities. Overall, both cultivars received about 28-29% fruit abscission at the highest fleahopper density.

Cotton Fleahopper Infestation and Fruiting Patterns

Cotton fruiting pattern did not significantly vary between the two cultivars, but the cotton fleahopper infestation significantly delayed crop cut-out (NAWF=5) versus control plots. In both cultivars, crop maturity, as measured in terms of crop cut-out date, was delayed by one week regardless of fleahopper density (Fig. 3). It was rather unexpected to observe similar fruiting patterns between cultivars, despite the fact that a low-level infestation (1 fleahopper per plant) caused 12% fruit abscission in DP 161 B2RF and 23% abscission in FM 9063 B2F, a notable difference. This clearly suggests that these two cultivars respond to cotton fleahopper infestations differently.

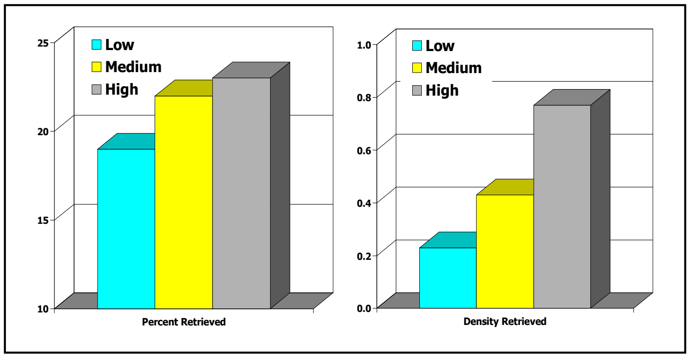

Figure 1. Percentage (left) and actual cotton fleahopper densities (right) retrieved from cotton experimental plots 48 h after nymphs were released. Low=1, Medium=2, and High=4 nymphs augmented per plant, Lubbock, TX, 2010.

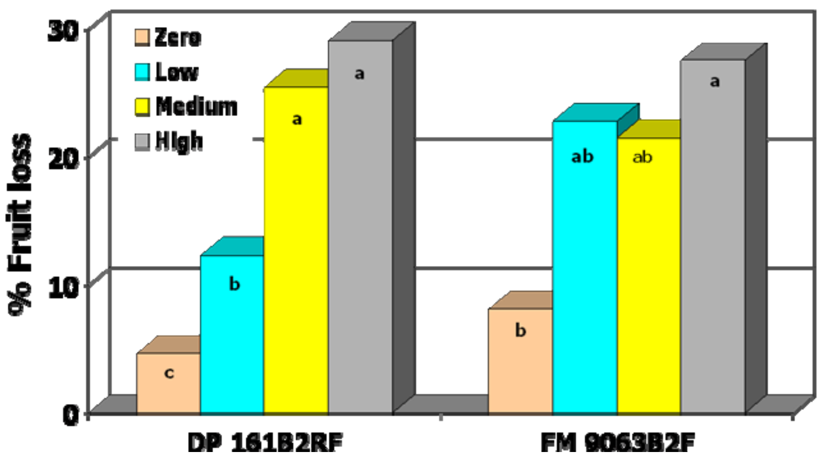

Figure 2. Percent first position square loss in cotton plots receiving various levels of fleahopper releases four weeks into squaring, Lubbock, TX, 2010. Bars within a cultivar with different letters are statistically different (P <0.10).

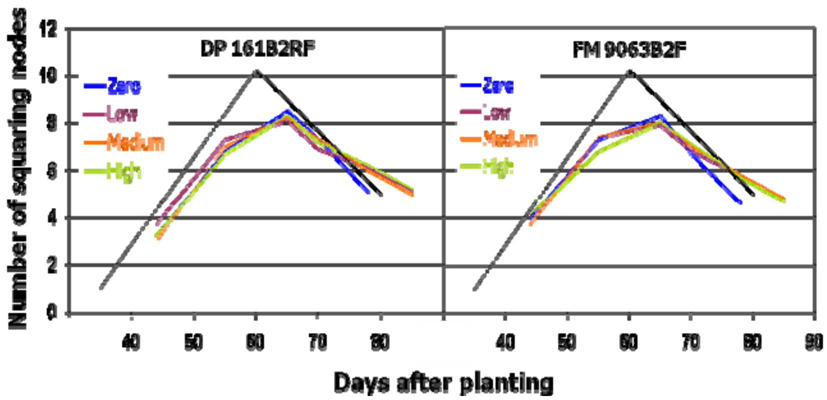

Figure 3. Fruiting profiles (number of squaring nodes/plant/week) as influenced by four cotton fleahopper release treatments in two cotton cultivars, Lubbock, TX, 2010.

Cotton Fleahopper Infestation and Plant Biomass

The effects of fleahopper infestation and resulting fruit abscission on plant biomass were clearly evident at two weeks after infestation. By 101 DAP, whole-plant biomass increased with low-level fleahopper infestation in both cultivars. Also, the majority of whole-plant biomass increase in low-level infested plants is accounted for by increased total fruit or fruit biomass. However, cultivars responded differently at medium and higher fleahopper densities (Fig. 4). DP 161 B2RF compensated for the fruit loss inflicted by higher densities, thus biomass was similar to that observed in control plots, whereas FM 9063 B2F did not appear to compensate for fruit losses resulting from the highest density (Fig. 4).

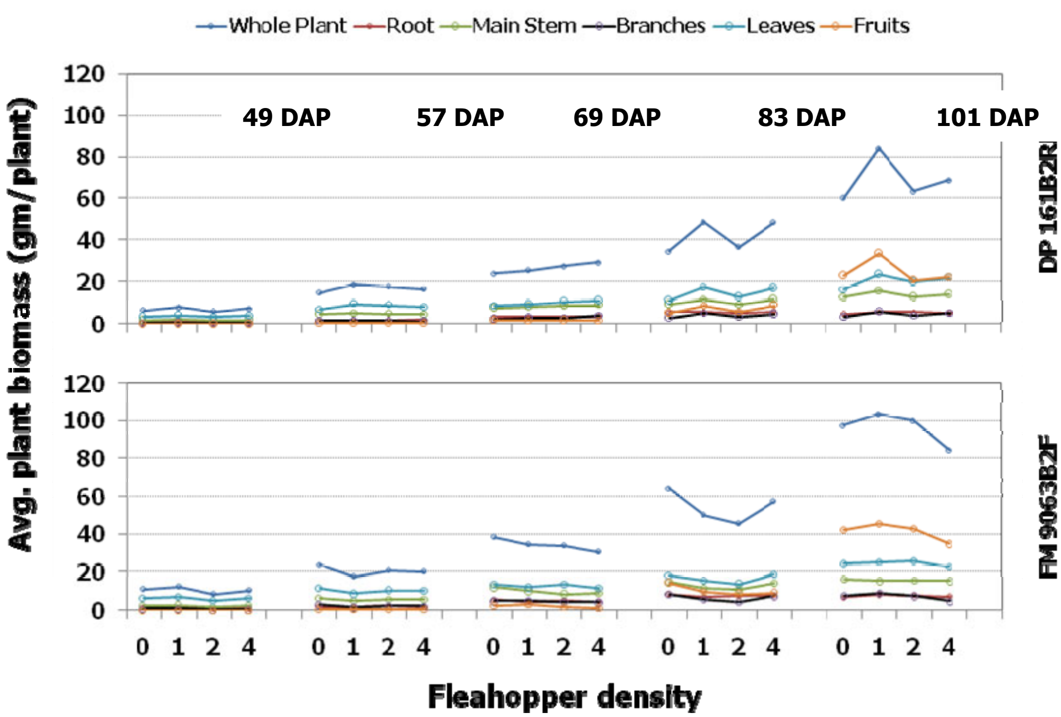

Figure 4. Average plant part-specific biomass as influenced by four fleahopper treatments on two cotton cultivars. Biomass measurements were taken on 49, 57, 69, 83, and 101 DAP (days after planting), Lubbock, TX, 2010.

Lint Yield and Compensatory Response

Both cultivars generally compensated for up to 30% of pre-flower fruit loss, but compensatory patterns varied between cultivars. It is also noteworthy that both cultivars responded to the low cotton fleahopper density by producing first position fruits, but they tended to produce more fruits on lateral fruiting nodes. However, FM 9063 B2F lost significantly more fruits from first-position fruiting nodes, and was unable to compensate by adding more lateral positions (Fig. 5). The compensatory response during the active fruiting period (Fig. 4) did not continue through boll formation and boll maturity in FM 9063 B2F. It is possible that the increased fruit set in this cultivar, in response to fleahopper-induced pre-flower fruit loss, might have repartitioned its energy allocation toward vegetative growth, rather than reproductive growth. Analyses of other plant parameters such as plant height, root length, and leaf counts/biomass may explain this phenomenon, and will be discussed in future publications.

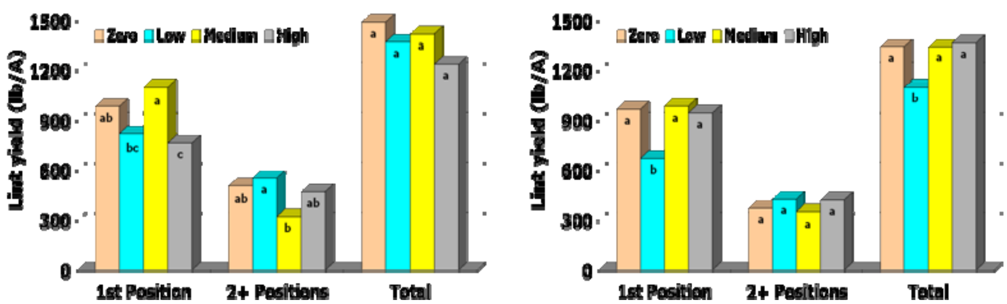

Figure 5. Lint yield (lb/acre) contributed by first fruiting positions, lateral positions, and total lint yield as influenced by fleahopper augmentation in two cotton cultivars (left - DP 161 B2RF, right - FM 9063 B2F), Lubbock, TX, 2010.

Acknowledgements

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