QUANTIFICATION OF COTTON PLANT GROWTH RESPONSE TO COTTON FLEAHOPPER INFESTATIONS

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Abstract

Cotton fleahopper (*Pseudotomoscelis seriatus* Reuter) is an important early-season cotton pest in Texas. Cotton fleahopper adults and nymphs feed upon cotton squares, inflicting heavy early-season square loss, and potentially altering the cotton plant growth pattern. The growth responses of cotton cultivars to various levels of cotton fleahopper injury are yet to be clearly characterized. In this study, the plant growth responses of two commercially available cotton cultivars (DP 161B2RF and FM 9063B2F) to cotton fleahopper injury were evaluated versus control plants. Control plants received no insect augmentation. Cotton fleahoppers were laboratory-reared on green beans to third- and fourth-instar nymphs and then carefully released in cotton plant terminals at the rate of 4-6 nymphs per plant to create the "high" cotton fleahopper infestation treatment. Cotton plant growth, development, and yield parameters were then monitored. Cotton plant height, root length, numbers of nodes, leaves, fruits and root-shoot biomasses were recorded from treated and control plants. DP 161B2RF plants were significantly taller than those of FM 9063B2F. Early-season fleahopper-induced fruit losses did not affect the cotton plant growth. In both study years, no significant plant height differences were observed between cotton fleahopper-infested and control plots. Unusually high temperatures and low precipitation in 2011 complicated comparisons between years. No significant plant biomass differences between control and fleahopper-infested plants were observed in 2010. However, in 2011, total plant biomass was significantly higher in fleahopper-infested plots than in control plots. In both cultivars, lint yield data suggest that cotton plants were able to compensate for 15-20% of cotton fleahopper-induced early-season fruit loss.

Introduction

USDA statistics show that Texas is the leading state in terms of annual cotton production. Texas produced 43.5% of total U.S. cotton in 2010. The Texas High Plains represents the largest virtually contiguous area of cotton cultivation in the world. Economically, cotton yields in the United States are impacted annually by a number of arthropod pest species (Williams 2011), making arthropod pest management an important factor in growing cotton. In fact, cotton arthropod pests adversely impacted U.S. cotton lint yields by 3.91% in 2010 (Williams 2011). Of approximately 25 major arthropod pest species encountered in Texas cotton fields, the cotton fleahopper (*Pseudatomoscelis seriatus*) is among those which are economically important (Parajulee *et al.* 2006, and 2008; Parker *et al.* 2000), and according to Williams (2011), ranked fourth, at 0.36%, in 2010 U.S. cotton losses.

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. Cotton plant growth is sensitive to numerous environmental and management input factors. Cotton growth responses to various input factors are well-documented and growth models have been developed. However, the specific cotton plant responses to differential levels of injury inflicted by cotton fleahopper feeding remain unclear. In this study, a clearer understanding of these responses was the primary objective. A controlled experiment was conducted in a high-input subsurface drip-irrigated cotton field in the Texas High Plains to compare the responses of cotton, in terms of plant growth parameters and yields, to differential levels of early-season, induced cotton fleahopper injury. Two cotton cultivars were selected for testing.

Dr. 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 irrigation and fertilizer management applications, or "advisors" have been incorporated in the model. A current goal of Dr. Wilson's team is to develop an integrated pest management advisor to augment the current system, and the secondary objective of this study was to provide comprehensive cotton plant response data in furtherance of that goal.

Materials and Methods

A 2-yr study was conducted in a "high-input" subsurface drip-irrigated cotton field at the Texas AgriLife Research farm near Lubbock, Texas (2010-2011). Two cultivars, DP 161B2RF and FM 9063B2F, were evaluated. Experimental plots measured 12 rows (40-inch spacing) by 100 ft, and were separated by 5-ft fallow alleys. Centrally located 10' sections of cotton were flagged in each plot for insect treatment deployment. Extraneous plants in each plot served as treatment buffers. In both years, experiments were laid out in a randomized complete block design with two cotton cultivars and two insect augmentation levels (control versus 4-6 cotton fleahopper nymphs per plant) with three replications. Woolly croton, a cotton fleahopper weed host, was harvested from locations in and near College Station, Texas, and then transported to Lubbock and placed in cold storage until fleahoppers were needed for the fleahopper augmented treatments. Conditions conducive to cotton fleahopper emergence were simulated in a laboratory environment in order to induce hatching of overwintered eggs embedded in the croton stems, and emerged cotton fleahoppers were subsequently reared using fresh green beans as a feeding substrate. At approximately ten days post-emergence, fleahopper nymphs were provided fresh cotton squares as a training substrate prior to field release. Considerable effort was expended to ensure synchronization of rearing efforts with cotton crop development for optimal release timing. Nymphal cotton fleahopper releases were initiated upon first observation of pinhead-sized squares in all plots, at which point cotton had progressed to the 4-5 true leaf stage. Weekly releases were conducted by aspirating third- to fourth-instar cotton fleahopper nymphs from the laboratory colony, transferring them into 0.75" X 1.5" plastic vials, then cautiously and methodically depositing them onto the terminals of plants in each treatment plot at the rates of 4-6 nymphs per plant.

Weekly monitoring of cotton fruiting patterns via COTMAN™ was initiated immediately prior to initial insect augmentation, and continued until physiological cotton cut-out [nodes above white flower (NAWF) = 5]. Plant biomass measurements were assessed at two-week intervals for a total of five sampling dates, and included detailed classification of plant parts. At each sampling date, five plants per plot were extracted from plots reserved specifically for destructive plant sampling. As may have been necessary for practical reasons, plants were stored in a large walk-in cooler (~41°F) until processing. As quickly as was feasible following plant extraction, plants were dissected and their variously classified parts separated for measurement. 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) were recorded. Separated plant parts were then exposed to low-intensity heat for duration sufficient to achieve thorough desiccation, after which "dry" biomasses of the variously classified plant parts were recorded. Yield monitoring was conducted by hand-harvesting in flagged portions of treatment plots.

Results and Discussion

Cotton Fruit Loss:

The fruit loss monitoring data, as acquired via the SQUAREMAN component of COTMAN™, showed that augmented cotton fleahopper nymphal infestations significantly increased the percentage of first-position cotton square loss in both years. Average percent square loss was significantly higher in DP 161B2RF than in FM 9063B2F in 2011 (Fig. 1), but not in 2010. Although cotton fleahopper nymphs were released weekly for three weeks, evidence of square loss was not apparent until the third week, suggesting a possible 1-2 week delay in cotton plant response to fleahopper-induced injury. This delay is further evidenced by cotton plant responses detectable as many as fourteen days beyond the final insect augmentation treatment.

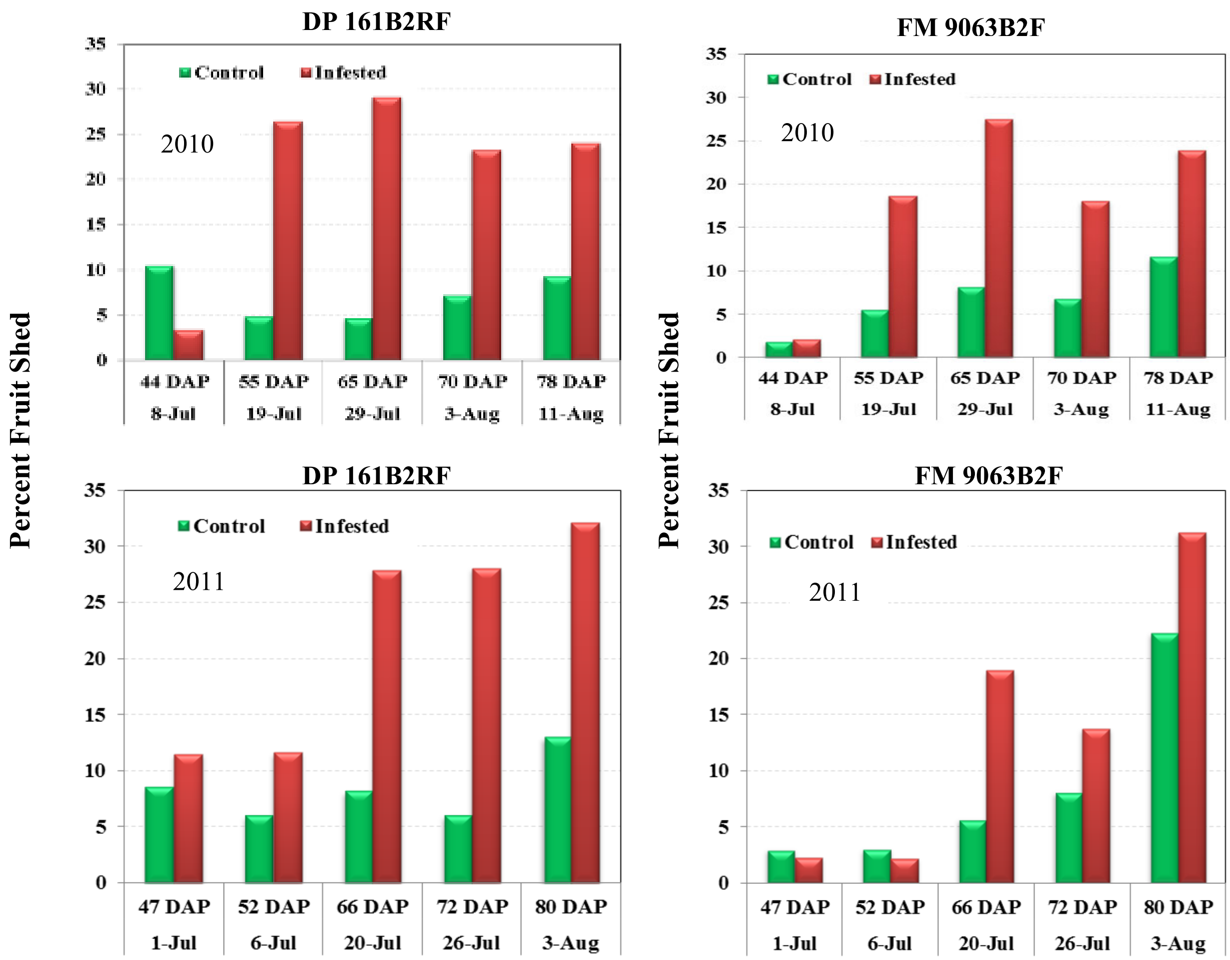

Figure 1. Percent first-position fruit shed induced by cotton fleahopper injury.

Plant Height:

Overall, plants were significantly taller in 2010 than in 2011, likely owing to the more favorable 2010 growing season. In both years, DP 161B2RF plants were significantly taller than those of FM 9063B2F (Fig. 2). In neither study year were significant plant height differences observed between cotton fleahopper-infested and control plots. In 2011, cotton fleahopper-infested plants were slightly, numerically taller than their control counterparts (Fig. 2). Cotton fleahopper-induced fruit shed, as indicated by 5-30% first-position square loss, was insufficient to significantly alter cotton plant heights in these two cotton cultivars.

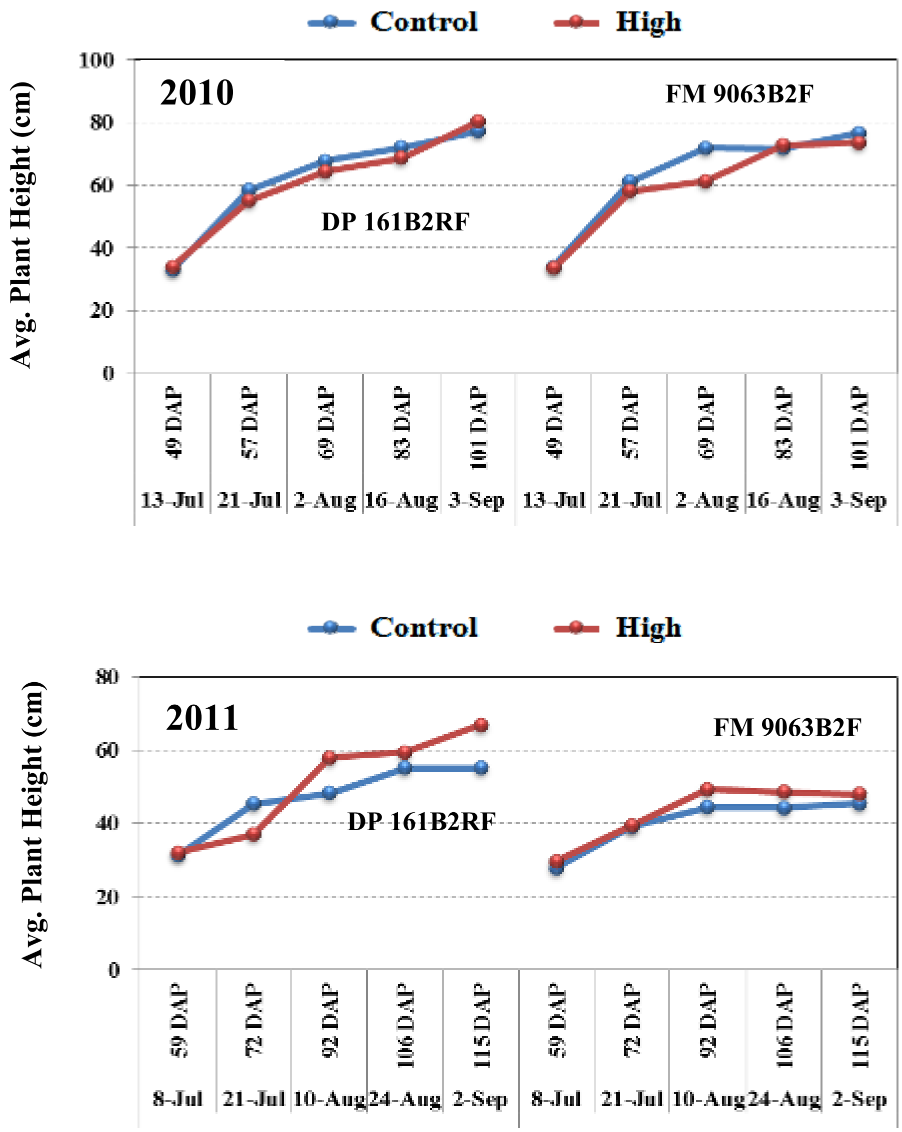

Figure 2. Effect of fleahopper injury on plant height.

Plant Biomass:

Cotton plant growth was rapid and total plant biomass significantly increased weekly until 80 DAP. No significant plant biomass differences between control and fleahopper-infested plants were observed in 2010 (Fig. 3). However, in 2011, total plant biomass was significantly higher in fleahopper-infested plots than in control plots (Fig. 3), primarily due to significant increases in root, branch, and fruit biomasses. As was previously mentioned, FM 9063B2F plants were significantly shorter than DP 161B2RF plants in both years. However, FM 9063B2F plants exhibited significantly greater leaf, root, branch, fruit, and total biomasses than their DP 161B2RF counterparts in 2010. More seasonable growing conditions in 2010 may have facilitated expression and observation of this varietal difference.

Figure 3. Effects of cotton fleahopper injury on the biomass of segregated cotton plant parts.

<u>Lint Yield:</u>

For both cultivars, plants were significantly shorter and lint yields were numerically lower in 2011 compared to that in 2010. There were no statistical differences in lint yields between these two years (Fig. 4). Neither cultivar showed statistical differences in lint yield between cotton fleahopper-infested and control plots. DP 161B2RF controls consistently exhibited higher numerical lint yields than their fleahopper-infested counterparts. Fleahopper-infested FM 9063B2F plants produced numerically higher second-position-or-greater lint yields than control plants, suggesting the possibility of a fruiting pattern response to infestation. These observations suggest the possibility of a differential varietal response to cotton fleahopper infestation; however, for clarification, further study with higher cotton fleahopper densities is recommended. Our data revealed that cotton may easily compensate for 5-30% fleahopper-induced, first-position fruit loss. The compensatory capacity of FM 9063B2F numerically exceeded that of DP 161B2RF in both years. Regardless of year, cultivar, or treatment, first-position contributions to total lint yield exceeded combined contributions from other fruiting positions.

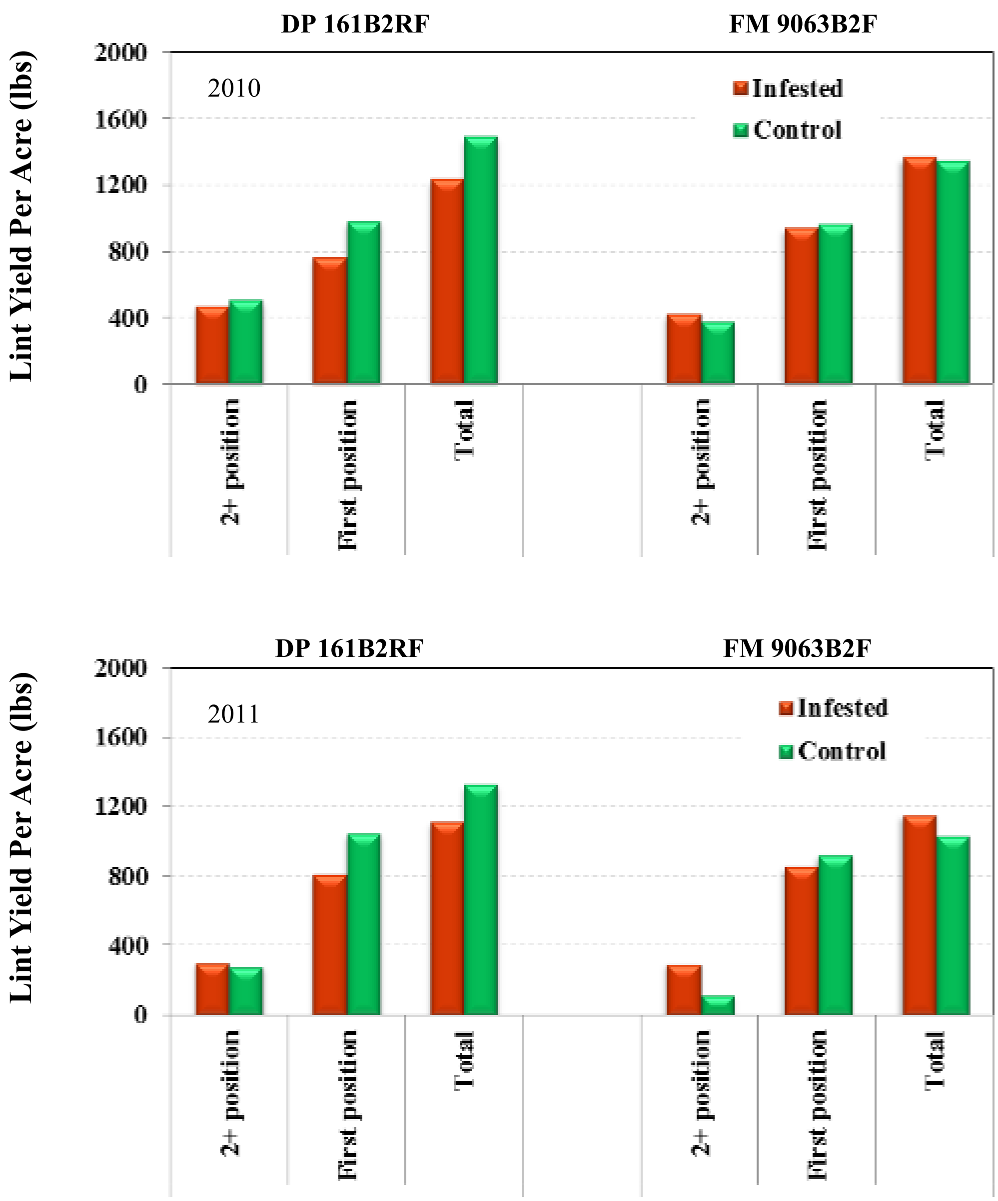

Figure 4. Effects of cotton fleahopper infestations on cotton lint yield.

Summary

It is clear that the stark contrasts between the two studies' growing seasons complicated analyses and interpretation of results. Although in 2011, cotton fleahopper-infested plants were numerically taller than their control counterparts, two-year combined data analysis failed to reveal significant differences in plant height between fleahopper-infested and control plots. In general, early-season fleahopper-induced fruit loss did not result in statistical differences in plant biomass. Yield data suggest that cotton plants are able to compensate for 5-30% of early-season fruit loss induced by cotton fleahoppers in both cultivars. Future investigation may provide clearer answers to questions posed in this study.

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