EFFECT OF NITROGEN FERTILITY RATES ON COTTON CROP RESPONSE TO COTTON FLEAHOPPER DAMAGE

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Abstract

A long-term field study was conducted to examine the effect of soil nitrogen (residual nitrogen plus applied nitrogen) on cotton agronomic growth parameters and cotton compensation following cotton fleahopper induced fruit loss under a drip irrigation production system. Fixed-rate nitrogen application experimental plots, previously established and fixed for 12 years prior to the initiation of this study in 2014, consisted of five augmented nitrogen fertility levels (0, 50, 100, 150, and 200 lb/acre) with five replications. Each year, soil in each experimental plot was sampled for residual nitrogen analysis prior to planting. Rates of applied N exceeding 100 lb/acre resulted in 40-80 lb/acre residual nitrogen detection during the following season. Cotton fleahopper-induced fruit loss was generally compensated at low N as well as at high N, whereas optimum N was the most vulnerable to fleahopper-induced injury. Simulated fruit loss was generally compensated across all N application rates.

Introduction

Nitrogen fertility limits cotton production yields in the Texas High Plains. A Texas High Plains study under a limited irrigation production system (Bronson et al. 2006) characterized the effect of nitrogen application on leaf moisture and leaf nitrogen content in cotton and the resulting influence on cotton aphid population dynamics (Matis et al. 2008). Leaf nitrogen content did not vary with nitrogen application method (variable N versus blanket N application of an optimal amount), but both the blanket application and variable-rate application resulted in significantly higher leaf nitrogen contents than were noted in zero-augmented nitrogen plots. As nitrogen application rates were increased from zero to an optimum rate, a significant decrease in both aphid birth and death rates occurred, translating to a decrease in crowding and an increase in aphid survival (Matis et al. 2008). While these data help to characterize cotton aphid population dynamics between zero nitrogen fertility management and optimal nitrogen application rates, the population dynamics of cotton aphids and other cotton arthropods have not been examined under a full range of nitrogen fertility rates (Parajulee et al. 2006, 2008). In particular, no known study has produced plant growth parameters or fruiting profile data pertaining to a spectrum of nitrogen application rates in cotton. The objective of this study was to evaluate, in cotton growing under a subsurface drip irrigation production system, cotton crop growth parameters and cotton's ability to compensate for cotton fleahopper induced fruit loss as influenced by varying N fertilizer application rates.

Materials and Methods

The study was conducted at the Texas A&M AgriLife Research farm near Plainview, Texas. A 5-acre sub-surface drip irrigation system had been in place for 12 years prior to this study. Plot-specific nitrogen fertility treatments had been applied in a randomized block design with five replications since 2002. Five nitrogen application rates (0, 50, 100, 150, 200 lb/acre) had been deployed to the same experimental units consistently for 12 consecutive years to induce maximum discrimination among treatment plots through variation in soil residual nitrogen.

The study reported herein was conducted for six years (2014-2019). Soil residual nitrogen was monitored annually by taking two 24-inch core samples from each plot. 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. Regionally well-adapted cultivars were used in this study over the duration of the study: FM 9063B2F was planted on 19 May 2014, FM 9180B2F on 18 May 2015, FM 1900GLT on 27 May 2016 and 4 May 2017, and NG3406 B2XF on 25 May 2018 and 4 June 2019. The experiment consisted of a randomized block design with five treatments and five replications. The five treatments included side-dress applications of nitrogen fertilizer at rates of 0, 50, 100, 150, and 200 lb N/acre. Cotton was planted (56,000 seeds/acre) in 30-inch rows and was irrigated with a subsurface drip irrigation system.

Soil samples were taken from the experimental plots on 10 July (2014), 26 June (2015), 1 July (2016), 20 June (2017), 22 June (2018), and 26 June (2019) for residual nitrogen analysis. Crop growth and insect activity were monitored throughout the season. Fertility treatments were applied on 23 July (2014), 21 July (2015), 8 July (2016), 3 July (2017), 3 July (2018), and 19 July (2019) with a soil applicator ground rig. In 2014-2015, each plot received two cotton fleahopper treatments (5 adults per plant vs. no fleahopper as control), contained in multi-plant cages, within designated row sections two weeks into cotton squaring, the most critical phenological stage of cotton for fleahopper management in the Texas High Plains, to simulate an acute infestation of cotton fleahoppers. In 2016-2019, 100% squares were removed from treatment plots at first flower to simulate the cotton fleahopper induced square loss versus control (only data from 2018 and 2019 are included in this paper). Crop growth and fruiting patterns were monitored during the crop season. Pre-harvest plant mapping was done, and 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).

Results and Discussion

Averaged over the entire 17-year study, soil residual N levels were significantly higher in plots that received the three highest application rates of N fertilizer versus plots receiving 50 lb/acre N or no N augmentation (Fig. 1). The highest N augmentation plots (200 lb/acre) had significantly highest average residual N (84 lb/acre); the year-to-year residual N was always the highest amount in this treatment, at least numerically. The two second highest N augmentation plots (100 and 150 lb/acre) resulted in significantly higher amount of soil residual N compared to that in zero and 50 lb/acre plots.

As expected, lint yield varied with N level regardless of the cotton fleahopper infestation. 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 50 to 100 lb/acre plots (only 100 lb/acre treatment in 2015) compared to that in uninfested plots (Fig. 2), clearly suggesting that the plant response to cotton fleahopper injury is greatly influenced by nitrogen fertility. At 100 lb/acre N, plants were unable to compensate the cotton fleahopper-induced yield loss consistently in both years of the study, which may likely be attributed to N limitation (Fig. 2). On the other hand, simulated damage mimicking cotton fleahopper severe infestation (100% square loss at first flower) through manual pruning was generally compensated regardless of the applied N rates, except that there was a marginal reduction in yield at highest N levels in 2018 (Fig. 3).

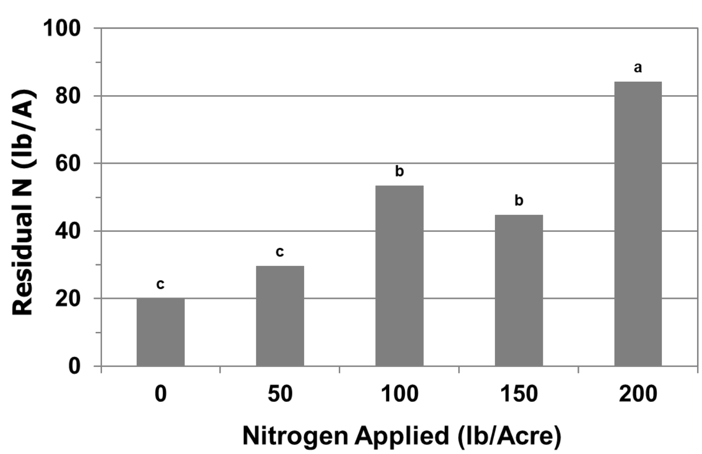

Figure 1. Average (2002-2019) yearly residual nitrogen as influenced by varying rates of applied nitrogen.

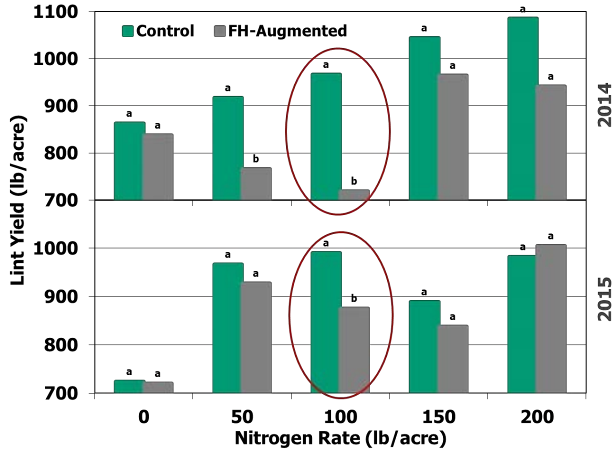

Figure 2. Effect of nitrogen augmentation rates on lint yield following a single acute infestation of cotton fleahopper versus uninfested control, 2014-2015.

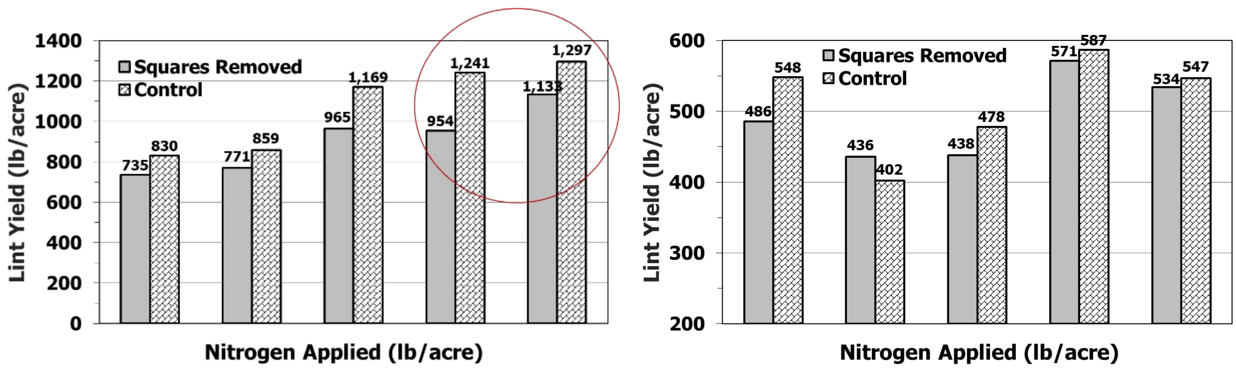

Figure 3. Effect of nitrogen augmentation rates on lint yield following a simulated severe infestation of cotton fleahopper versus uninfested control, 2018-2019.

Acknowledgments

Cotton Incorporated Core Program and Plains Cotton Growers, Inc. provided partial funding for this long-term nitrogen fertility study.

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