DISCRIMINATION OF ABIOTIC AND BIOTIC STRESSORS IN COTTON USING REMOTE MEASUREMENTS

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Abstract

Reniform nematode, *Rotylenchulus reniformis*, is a highly detrimental pest in cotton and necessitates improved understanding of both detection and control options. Genetic resistance is a more consistent and effective management tool than nematicides. However, knowledge is lacking to inform prioritization of nematode resistance over industry-leading susceptible varieties relative to nematode pressure and production environment. Field research underway at College Station and Wall, TX aims to better inform the decision of when to prioritize reniform nematode resistance in cotton variety selection, and to improve in-field assessment of reniform nematode distribution and severity with remote measurements. Measurements included, canopy area, canopy volume, canopy height, and GRVI (Green-Red Vegetative Index). PHY 443 W3FE (resistant) was compared to PHY 480 W3FE (susceptible) under four different nitrogen rates, 0, 22, 45, and 67 kg ha^{-1}. Trials were duplicated under irrigated dryland regimes at each location to impose a secondary abiotic stress. The resistant variety increased cotton lint yields by 436 kg ha^{-1} when compared to the susceptible variety (p <.0001). Supplemental irrigation increased lint yields by 213 kg ha^{-1} (p <.0001). There was no difference among nitrogen rates in PHY 480 W3FE (susceptible) (p >0.05), but the highest nitrogen rate, 67 kg N ha^{-1}, increased lint yields in PHY 443 W3FE (resistant) compared to 22 and 45 kg N ha^{-1} (p = 0.09). Irrigation increased plant height by 3 cm (p <.0001). The resistant variety was taller than the susceptible variety in irrigated trials, but not in rainfed trials (p = 0.04). GRVI was higher in plots receiving the highest rate of nitrogen, 67 kg ha^{-1}, than plots receiving the middle two rates, 22 and 45 kg ha^{-1} (p = 0.01). PHY 443 W3FE (resistant) produced higher GRVI values than PHY 480 W3FE (susceptible) (p = 0.01). Nematode populations were 32% higher in irrigated trials (p = 0.002) than rainfed. PHY 443 W3FE resulted in 54% less nematodes than PHY 480 W3FE (p <.0001). Early results indicate that GRVI was affected by nitrogen rate and genetic resistance but was not affected by irrigation regime. Plant height was a consistent indicator of reniform nematode severity and was not influenced by nitrogen rate.

Introduction

Reniform nematode infestations can be challenging to identify and monitor in large scale cotton operations. The soil-borne pathogen persists in large population sizes once established in a field. They are easily transferred between and throughout fields with ground-disturbing equipment. Many of the above-ground symptoms caused by reniform nematodes are similar to those of nutrient deficiency, drought stress, and other common pests or disease. Due to these similarities in symptoms, and the microscopic size of the pest, lab confirmation is required to diagnose an infestation. Field research is being conducted to improve in-field assessment of reniform nematode distribution and severity using remote measurements, and to determine whether remote measurements can distinguish reniform nematode stress from abiotic stresses (N and water status).

Methods

Trials were conducted in 2021 at both College Station and Wall, Texas in fields with known reniform nematode presence. PHY 443 W3FE (resistant) and PHY 480 W3FE (susceptible) were selected for similar maturity and differing genetic resistance. Four nitrogen treatments were selected according to soil analyses, 0, 22, 45, and 67 kg ha^{-1}, and side-dress applied at pinhead square. Trials were duplicated within each location to include a rainfed and irrigated trial. All trials were arranged in a randomized complete block design with four replications. Measurements were analyzed using linear mixed models in SAS, treating variety, N rate, and irrigation status as fixed effects, and location and block nested within location as random effects. Differences were identified using Tukey s HSD (± = 0.1). A DJI Phantom 4 Pro UAV equipped with an RGB camera on a gimble and a Sentera NDVI sensor fixed nadir was used for all flights. Pix4D Capture was used for flight management and Pix4D Mapper was used to stitch all imagery

for analysis. All remote derived measurements, canopy percentage, canopy height, canopy volume, and GRVI (Green-Red Vegetation Index) were calculated using QGIS. Reflectance data was captured with a SpectraWiz Blue Wave spectrometer and the Sentera spectral sensor, but the data was not useful for analysis due to improper calibrations. Nematode samples were taken prior to planting and termination and were extracted using a modified Baerman's funnel method (a gravity-driven water extraction).

Results and Discussion

Cotton lint yields were affected by both variety (p <.0001) and irrigation regime (p <.0001) (Table 1). Genetic resistance to reniform nematodes increased lint yields by 436 kg ha^{-1} compared to the reniform-susceptible variety (mean = 1265 kg ha^{-1}). Trials with supplemental irrigation yielded 213 kg ha^{-1} more than rainfed trials (mean = 1376 kg ha^{-1}). Although nitrogen treatments alone didn't have any effect on yields, there was a variety by nitrogen rate interaction (p = 0.09). In PHY 443 W3FE (resistant), there was no difference between the middle two nitrogen treatments, 22 and 45 kg N ha^{-1}, but cotton lint yield increased with 67 kg N ha^{-1}. Within the susceptible variety, PHY 480 W3FE, there was no observable change in lint yields between nitrogen treatments (p > 0.05), implying that reniform nematode pressure was the limiting factor in this scenario. Remote plant heights, calculated from a DSM (Digital Surface Model), were highly correlated with direct plant measurements (R^2 = 0.93). Plant heights were affected by both irrigation regime (p <.0001), variety (p <.0001) (Table 1), and the interaction between irrigation regime and variety (p = 0.045). Irrigated trials produced cotton plants that were 3 cm taller than plants in rainfed trials. Similarly, resistant cotton plants were 3 cm taller than susceptible cotton. Susceptible plants were not affected by irrigation, but resistant plants with irrigation were 4 cm taller than resistant rainfed plants. Among the susceptible cotton, plant height was not influenced by irrigation regime, again implying that the limiting factor was not available water but reniform nematode pressure. Nitrogen rate did not affect plant height (p > 0.05). GRVI measured two weeks after N application was only affected by variety (p = 0.014) and nitrogen treatments (p = 0.01). Similar to the yield effect, the highest rate of nitrogen produced higher GRVI values when compared to the middle two treatments, and the resistant variety resulted in higher values than the susceptible variety. Nematode density was only affected by irrigation regime (p = 0.002) and variety (p <.0001) (Table 1). Irrigated trials had 32% more nematodes than rainfed trials, and the resistant variety had 54% less nematodes than the susceptible variety.

Table 1. Effects of genetic resistance and irrigation regime on cotton height, yield, and nematode density across locations (Wall and College Station, TX) in 2021.

Treatment	Yield (kg ha^{-1})	Height (cm)	Nematodes (200cc soil)
PHY 443 W3FE	1701 a	12 a	1870 b
PHY 480 W3FE	1265 b	9 b	4064 a
Irrigated	1590 A	12 A	3349 A
Rainfed	1376 B	9 B	2269 B

Means with the same letter and case are not statistically different (± = 0.1).

Summary

GRVI was affected by nitrogen rate and genetic resistance but was not affected by irrigation regime. These differences were observed as early as two weeks after nitrogen applications. Remote height measurements calculated using a digital surface model were reliable alternatives to physical height measurements. Plant height was a consistent indicator of reniform nematode severity and was not influenced by nitrogen rate. Genetic susceptibility to reniform nematode was consistently a more limiting factor to growth and yield than the abiotic stressors tested (deficit N and water). Preliminary findings suggest that fields with nematode pressure would benefit from the use of reniform nematode genetic resistance. Findings also imply that remote technology can be used to separate plant stress.

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