Cotton Yield, Fiber Quality, Water Use Efficiency, and Spectral Reflectance Responses to Irrigation and Tillage Management in the Texas Rolling Plains

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Abstract

A field study was conducted in 2012 and 2013 at Chillicothe, TX, to investigate the lint yield, water use efficiency (WUE), and spectral reflectance responses of cotton under different irrigation and tillage treatments. A split-split plot design with three replications was used with irrigation as the main plot (dryland, 45% evapotranspiration replacement, 90% evapotranspiration replacement, and irrigation based on a remote sensing method developed by researchers in the current study), tillage (conventional and no-till) as the sub plot, and varieties (PHY499, DP1044, PHY375 , and FM9170) as the sub-sub plot. lint yield, WUE, and fiber quality were significantly affected by irrigation and irrigation-by-variety interaction. Increasing irrigation level resulted in a linear increase in lint yield and WUE. The irrigation-by-variety interaction showed that the 90% evapotranspiration (ET) replacement treatment involving PHY375 produced the greatest lint yield and WUE. Tillage did not significantly affect lint yield, WUE, and fiber quality. Increasing irrigation resulted in a linear increase in fiber length and strength, and a linear decrease in fiber micronaire.

Objectives

The objectives of this study were to 1) comapre lint yield, WUE, and fiber quality of four cotton varieties under different irrigation and tillage management practices and 2) investigate the spectral reflectance response of cotton under different irrigation levels in the semi-arid Texas Rolling Plains.

Materials & Methods

Site Description and Experimental Design

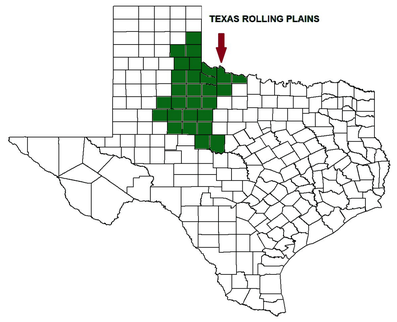
- The study was conducted in 2012 and 2013 at the Texas A&M AgriLife Research Station at Chillicothe, TX (34º15'N and 99º30'W; 431 m above mean sea level).
- The experimental design was a split-split design with three replications. Each main plot was 23 m long and 16 rows wide.
- Main plots consisted of four irrigation treatments (dryland, 45% ET, 90% ET, and irrigation based on a remote sensing method), subplots consisted of two tillage systems (No tillage and Conventional tillage), and sub-subplots consisted of 4 cotton varieties (FM9170, DP1044, PHY375, and PHY499). The daily crop water demand was calculated as follows;

$ET_c = k_c \times ET_0$

Data Collection and Statistical Analysis

- Multispectral scene reflectance was recorded using a portable 16 channel spectroradiometer (CropScan, Rochester, MN) at 2 m above the surface.
- Reflectance measurements were taken on cloud-free days within 2 hours around local solar noon time on harvest rows throughout the growing season.
- Two vegetation indices were calculated using the reflectance data. The normalized difference vegetation index (NDVI) as NDVI = (NIR – RED)/(NIR + RED) and the normalized difference water index (NDWI) as NDWI = (NIR – SWIR)/ (NIR+SWIR) where NIR is the reflectance at the wavelength of 810 nm, RED is the reflectance at the wavelength of 665 nm, and SWIR is the reflectance of shortwave infrared at the wavelength of 1160 nm.

- At physiological maturity, the two center rows were machine harvested and subsamples were collected for obtaining ginning and fiber quality data.
- Analysis of variance was performed using the PROC GLIMMIX in SAS.



Results & Discussion

Field Overview

Dryland Cotton

45% ET

90% ET

- Replacing 90% ET produced the highest linet yield and WUE (Table 1).
- Tillage did not significantly affect lint yield or WUE (Table 1).
- Among varieties, PHY375 produced higher lint yield. (Table 1).

Table 1. Lint yield and water use efficiency (WUE) of four cotton varieties as affected by irrigation and tillage across 2012 and 2013.

	Lint yield (kg ha^{-1})	WUE (kg ha^{-1} mm^{-1})
Irrigation	P > *F* = <0.0001	P > *F* = 0.018
Dryland	490D§	1.67B
45% ET	1148C	2.32A
RS	1462B	2.19AB
90% ET	1764A	2.54A
Tillage	P > *F* = <0.799	P > *F* = 0.570
No till	1219	2.19
Conv. till	1213	2.17
Variety	P > *F* = <0.053	P > *F* = 0.173
PHY499	1179B	2.12
DP1044	1223A	2.19
PHY375	1233A	2.20
FM9170	1229A	2.20

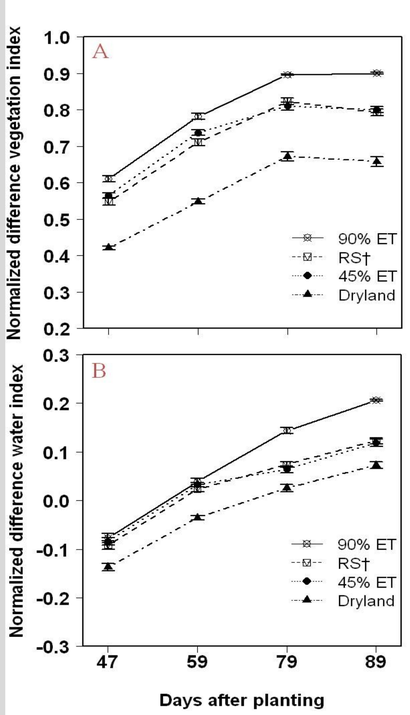


Figure 1. Normalized Difference Vegetation Index (A) and Normalized Difference Water Index (B) measured during the growing season. Error bars represent the standard error of the mean. †RS is remote sensing-based irrigation

- The normalized difference vegetation index (NDVI) and normalized difference water index (NDWI) were measured during the growing seasons (Fig. 1).
- NDVI peaked around 79 days after planting (DOY 222) (Fig. 1a).
- For NDWI, there were no significant differences in NDWI early in the growing seasons (Fig 1b).
- Unlike NDVI, NDWI increased during the growing season until DOY 232 (Fig. 1b).

- Figure 2a-c illustrates fiber length, strength, and micronaire response to total water.
- Increasing total water linearly increased fiber length and strength for all varieties (Fig. 2a and b).
- For fiber micronaire, all varieties showed a linear decrease as total water increased (Fig. 2c).
- Among varieties, FM9170 had the highest fiber length increases while DP1044 had the lowest increases in response to increasing total water application (Fig. 2a).
- FM9170 showed the greatest fiber strength increase as a result of increased water level (Fig.2b).

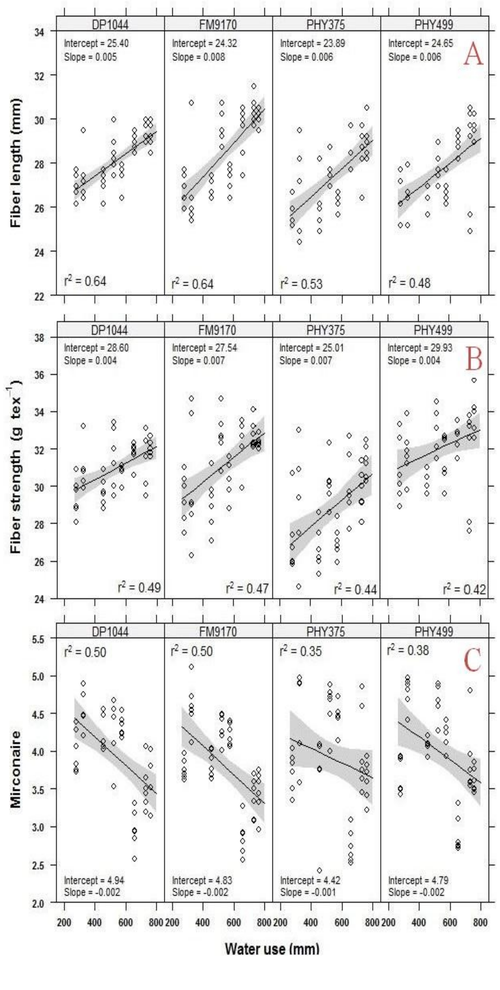


Figure 2. Fiber length (A), strength (B), and micronaire (C) of four cotton varieties in response to water use (irrigation + precipitation) described by ordinary least squares regression in 2012 and 2013 growing seasons. Shaded areas are 95% of confidence intervals.

Summary & Conclusions

- Results from this field study showed that lint yield, WUE, and fiber quality were affected by irrigation amounts and variety characteristics in the semi-arid Texas Rolling Plains.
- The highest lint yield (1764 kg ha^{-1}) and WUE (2.54 kg lint ha^{-1} mm^{-1}) was obtained for the 90% ET irrigation treatment.
- Among varieties, PHY375 performed better at higher irrigation levels while PHY499 performed better at low irrigation levels.
- No significant benefit from the minimum tillage treatment was observed in the current study.
- NDWI performed better compared to NDVI as no saturation problems were observed in NDWI values during the peak growing season.

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