Interaction of Irrigation and Soil Effects on Cotton Yield

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Introduction

- Irrigated agriculture accounts for ~80% of the U.S. consumptive water use
- Soil variability reduces the effectiveness of conventional irrigation management
- Benefits of variable-rate application of agrochemicals, seeds, and nutrients masked by applying inappropriate amounts of water
- Testing dense grid of soil sampling locations expensive, but mobile apparent soil electrical conductivity (EC_a) widely used to map soil variability
- Center pivot irrigation systems equipped with variable rate irrigation (VRI) capability have been shown to perform dependably
- Soil properties will impact the optimal irrigation strategy for a given location, but information will need to be supplemented for in-season adjustment
- U.S. Department of Agriculture's Agricultural Research Service (ARS) patented Irrigation Scheduling Supervisory Control And Data Acquisition (ISSCADA) system with integrated sensor network subsystems to detect crop water needs and provide spatially variable recommendations for watering rates

Objective

The goal of this research is to develop ways to utilize variable rate irrigation to improve crop production. The specific objective of the work in this report is to better understand the impact of variable soil texture, as estimated by EC_a, on the irrigation response of cotton.

Methods

- Field study at the University of Missouri Fisher Delta Research Center Marsh Farm at Portageville (36.41° N, 89.70° W) during 2016 and 2017
- Soil mapping units: Tiptonville silt loam (Oxyaquic Argiudolls), majority of the field; Reelfoot loam and sandy loam (Aquic Argiudolls) (Fig. 1).

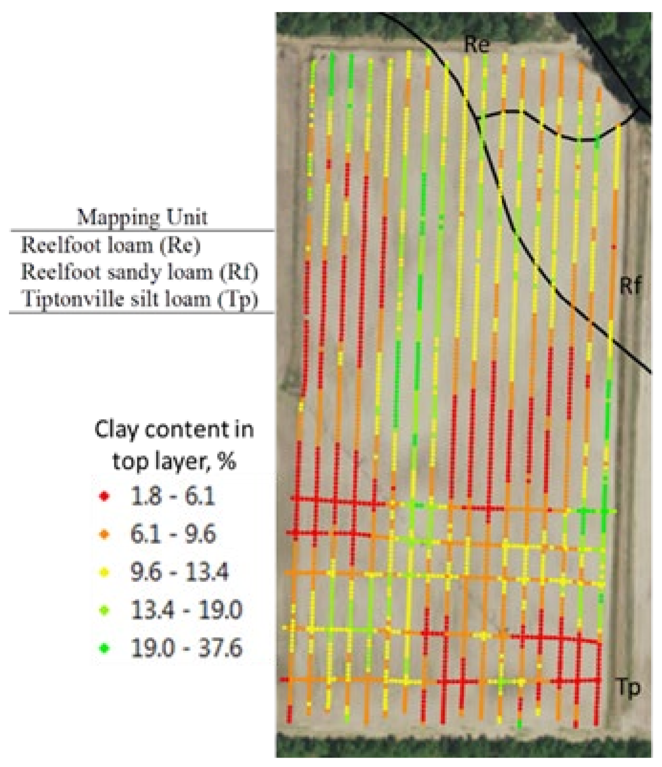

Figure 1. Study field with mapping units and clay content quintiles from EC_a transects

- Field contains areas of high sand content too small to show up in soils map
- EC_a data collected using Veris MSP3 system on a 1-s interval and 10-m transects
- Sand, silt, and clay fractions obtained from laboratory analysis from 8 calibration locations chosen to cover the range in mobile EC_a values
- Veris EC_a data were related to measured soil properties using linear regression

- Study field irrigated using a 160 m Valley 6000 center pivot irrigation system with a Valley Zone Control VRI system
- System included seven independently controlled water management zones
- Three irrigation management treatments: ISSCADA system, uniform irrigation based on Arkansas Irrigation Scheduler (AIS), and rainfed production (Fig. 2)
  - ➢ four replications in 2016, each comprising an arc of 45°
  - ➢ five replications in 2017, each comprising an arc of 36°

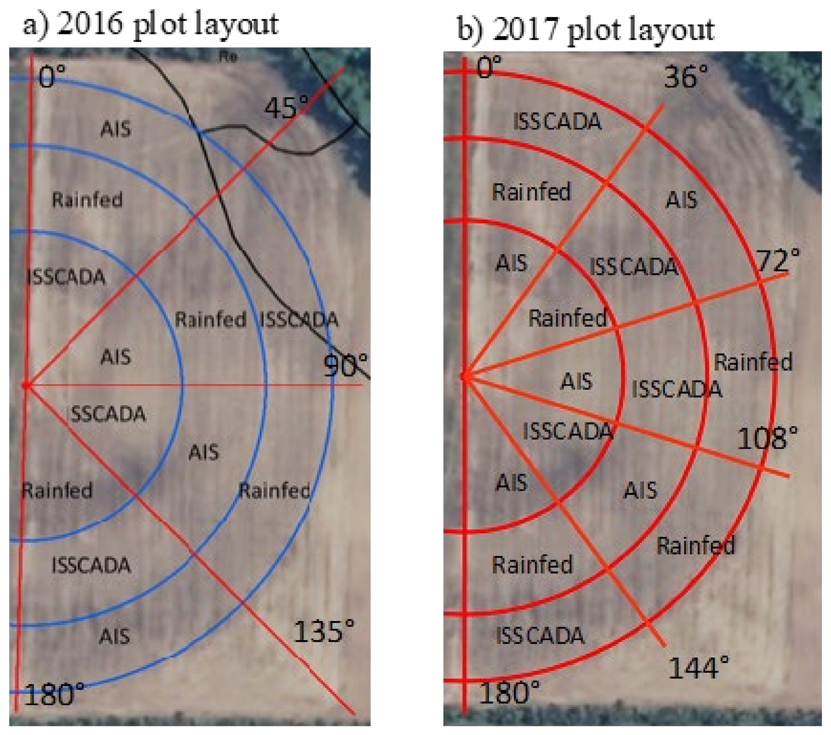

Figure 2. Plot layouts for a) 2016 and b) 2017

- Crop harvested with a Case IH 2155 4-row cotton spindle picker equipped with an Ag Leader Insight yield monitor system with sensors for every row
- 7-m buffer placed on each side of each plot to account for overspray from adjacent nozzles and yield in those areas was not used in analyses
- To investigate relationship between irrigation treatment response and soil, yield data points within 2.0 m of an EC_a point averaged to provide an estimated yield associated with estimated clay content
- Spatial data analyses were conducted with GeoDa 1.12 using spatial error model

Results

- Roughly three fourths of field in Tiptonville silt loam mapping unit, but clay content much more variable
  - ➢ estimated clay content 2% - 38%; mean 9.8%, median 9.4%
- Areas of very low clay/high sand content
  - ➢ >40% of points contained less than 10% estimated clay
  - ➢ <20% of points contained more than 20% estimated clay
- Total rainfall through the irrigation period (planting through 17 August) was similar both years (Table 1), but the timing differed, thus more irrigations in 2017
- ISSCADA-managed plots irrigated independently from each other - some cases with same total seasonal application but different timing of the applications

Table 1. Water applications to field

Water application	ISSCADA	AIS	Rainfed
2016			
Planting	23 May		
Total rainfall (mm)	321		
Number of irrigations	1.25*	2	0
Total irrigation application (mm)	24*	38	0
Total water applied (mm)	345	359	321
2017			
Planting	15 May		
Total rainfall (mm)	309		
Number of irrigations	3.8*	6	0
Total irrigation application (mm)	65*	112	0
Total water applied (mm)	374	421	309

* Value is average of all replications

- Soil variability reflected in the yield maps for both growing seasons
- Some differences likely due to different randomization of irrigation treatments
- Yield data points associated with EC_a data points, Fig. 3 a) and b), with just over 1,000 points each year, were included in subsequent analyses
- No apparent bias regarding the location of treatments - average clay content not significantly different among the water management treatments

Figure 3. Seed cotton yield quintiles for yield associated with EC_a points for a) 2016 and b) 2017

- No significant differences observed among water management treatments in either year (Table 2)
- When clay content included as covariate, very strong relationship ($p < 0.001$)
- Slopes approximately the same both years (55 and 52 kg seed cotton ha^{-1} increase per 1% clay content in 2016 and 2017, respectively)

Table 2. Seed cotton yield with and without clay covariate

Irrigation treatment	Seed cotton yield (kg ha^{-1})	
	Yield only	With covariate*
2016		
ISSCADA**	3246 a	3182 a
AIS***	2965 a	2929 a
Rainfed	2748 a	2706 a
Clay content, %	---	55.2
2017		
ISSCADA	2782 a	2759 a
AIS	2960 a	2959 a
Rainfed	2447 a	2436 a
Clay content, %	---	52.0

* mean values at the median clay content of 9.4%
** USDA-ARS Irrigation Scheduling Supervisory Control And Data Acquisition system
*** Arkansas Irrigation Scheduler

- The ability to rapidly collect spatially dense EC_a data sets, which can usually provide accurate estimates of soil texture, is essential to this type of research
  - ➢ The mobile EC_a survey resulted in 5,465 data points within the study field and adjoining 5 ha field over the course of a few hours
  - ➢ By strategically selecting the locations of calibration samples, accurate estimates of clay content were derived
  - ➢ Manually collecting and analyzing even 1% of points would be extremely expensive and the resulting dataset would be insufficiently dense for these kinds of analyses

Conclusions

This study addressed the impact of variable soil texture on cotton response to irrigation. While a more extensive dataset will be needed to thoroughly investigate the interactions, some qualitative observations were clear:

- A strong effect of clay content on cotton yield was observed in both seasons, even without significant differences among the water management treatments
- Under conditions of high soil variability, properly conducting studies and using appropriate methods for analyzing the results are essential
- Spatially dense soil texture data accurately estimated from mobile EC_a surveys is important for enabling advances in VRI and other precision agriculture practices

Acknowledgements

We acknowledge the support of Valmont Industries and Jake LaRue in this research, and the contributions of Andrea Jones. Mention of trade names or commercial products in this paper is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the United States Department of Agriculture.