Evaluating Various Soil Moisture Sensor Thresholds in Cotton in South Carolina

CLEMSON
PRECISION AGRICULTURE

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Introduction

Cotton growers in South Carolina suffer economic losses and reductions in crop yield due to untimely rainfall and drought stress in dry years. It is estimated that yield potential can be reduced between 54 and 82% among various crops due to drought stress (Saleem *et al*., 2016). Although growers can insure crops for unexpected losses, providing timely, supplemental, irrigation can stabilize year-to-year yields and improve producer economics.

Throughout the southeastern USA, cotton (*Gossypium hirsutum* L.) is an important commodity. In South Carolina, cotton contributed on average $150 million in 2017 to the economy on approximately 95,000 hectares from 2008-2018 (NASS, 2018). Cotton, an indeterminate crop, has the ability to compensate for stress better than other crops such as corn (*Zea mays* L.). However, reducing drought stress could lead to increases in yield and profit. In the event that soil moisture sensors are used for irrigation scheduling, knowing the appropriate sensor threshold value to utilize that not only maximizes profit, but also maximizes irrigation water use efficiency is essential for sustainable cotton production.

Objectives

- To determine a soil moisture sensor threshold in cotton that maximizes net returns above irrigation costs, and maximizes irrigation water use efficiency.
- To determine if soil moisture threshold values effect the rooting depth of cotton grown in a Wagram loamy sand.

Hypothesis

- A sensor threshold of 50% maximum allowable depletion maintained throughout the growing season will maximize net returns and irrigation water use efficiency in cotton.

Materials and Methods

Experimental Locations (2018):
- Blackville, SC – Overhead – Lateral Move Irrigation

Soil Type:
- Wagram loamy sand

Plot Dimensions:
- 32 rows – 60 m in length
- 4 Replications

Seeding Rate:
- 94,000 seed ha^{-1}

Variety:
- Deltapine 1538 B2XF

Treatments:
- Non-irrigated
- -15 kPa (25% MAD)
- -30 kPa (50% MAD)
- -60 kPa (75% MAD)

Sensors:
- Watermark 200SS
- Depths: 15, 30, and 60 cm
- Installed in 2nd Rep
- Checked M-W-F

Root Cores:
- Pulled at 5-leaf and at full bloom (0 to 76 cm)
- Within the row and row-middle
- WinRHIZO Pro – 2009 Software

Experimental Design:
- Randomized Complete Block Design

Data Analysis:
- Data subjected to analysis of variance (ANOVA)
- Means separated using Fisher's Protected LSD at $\alpha = 0.05$

Figure 1. Lateral-move overhead irrigation system.

Figure 2. Watermark 200SS sensors installed.

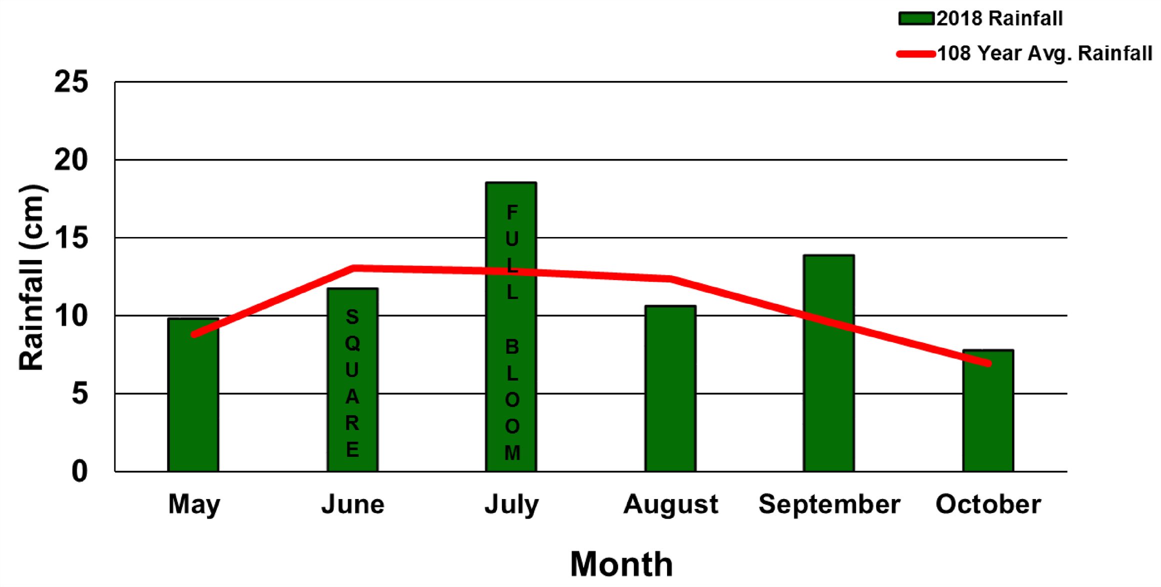

Figure 3. Rainfall in 2018 and Average Yearly Rainfall for Blackville, SC.

Treatment	6-22-18	7-3-18	7-9-18	7-12-18	8-22-18	Total Applied
Non-Irrigated	0.0 cm	0.0 cm	0.0 cm	0.0 cm	0.0 cm	0.0 cm
-15 kPa	1.91cm	1.9 cm	1.9 cm	2.5 cm	2.5 cm	10.8 cm
-30 kPa	0.0cm	0.0 cm	1.9 cm	2.5 cm	0.0 cm	4.5 cm
-60 kPa	0.0 cm	0.0 cm	0.0 cm	2.5 cm	2.5 cm	5.1 cm

Figure 4. Irrigation volumes and application dates for each sensor threshold value.

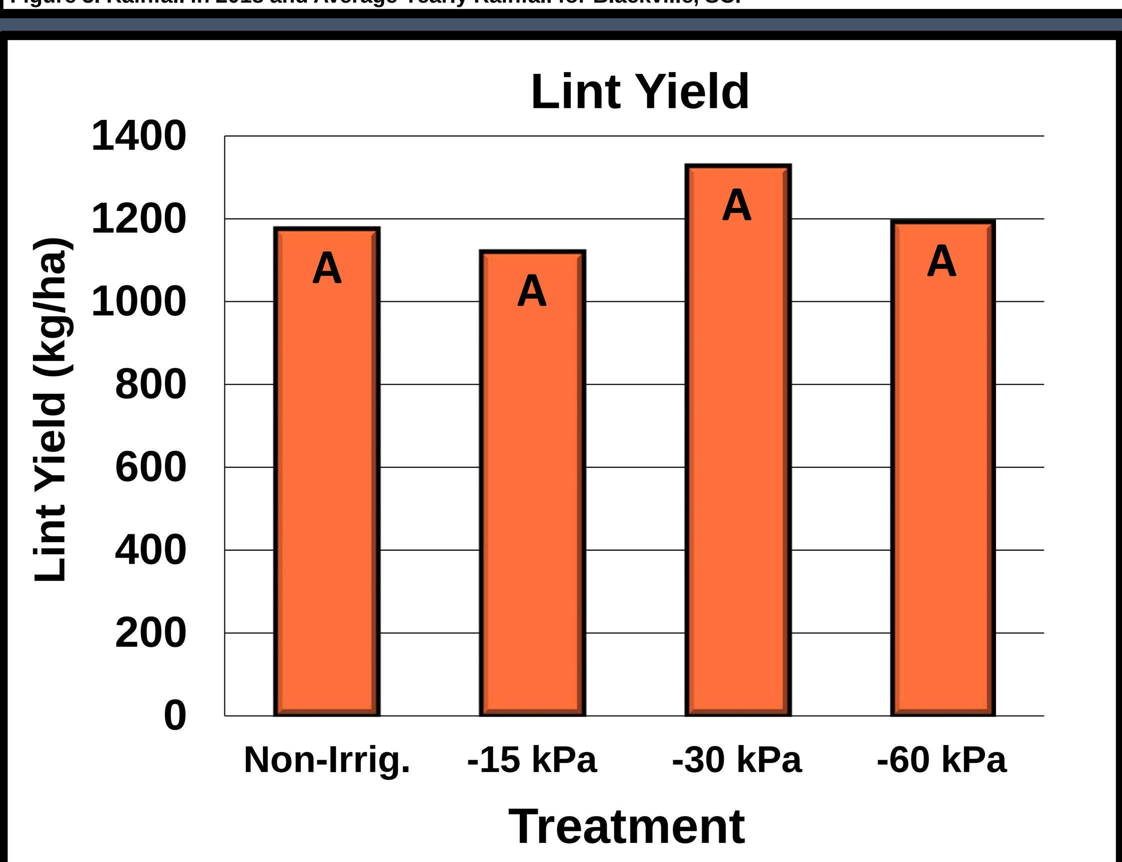

Figure 5. Lint yield as a function of soil moisture sensor threshold in 2018.

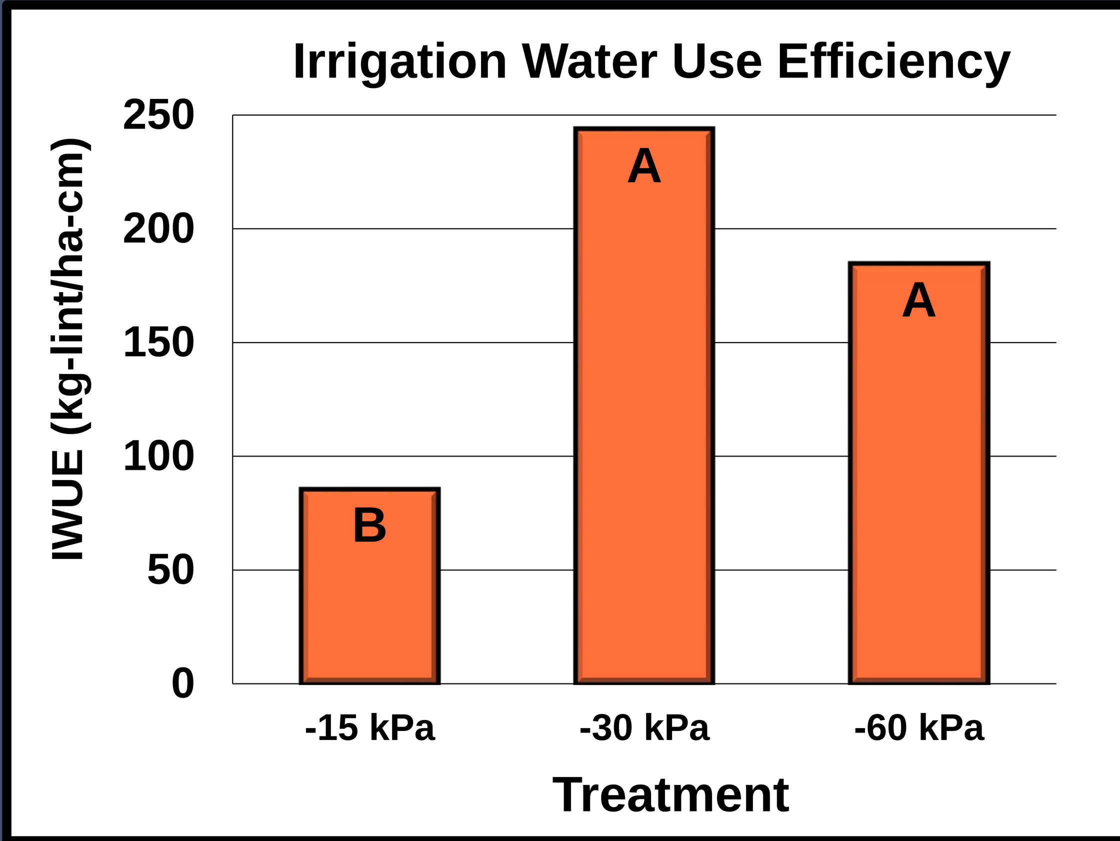

Figure 6. Irrigation water use efficiency as a function of soil moisture sensor threshold in 2018.

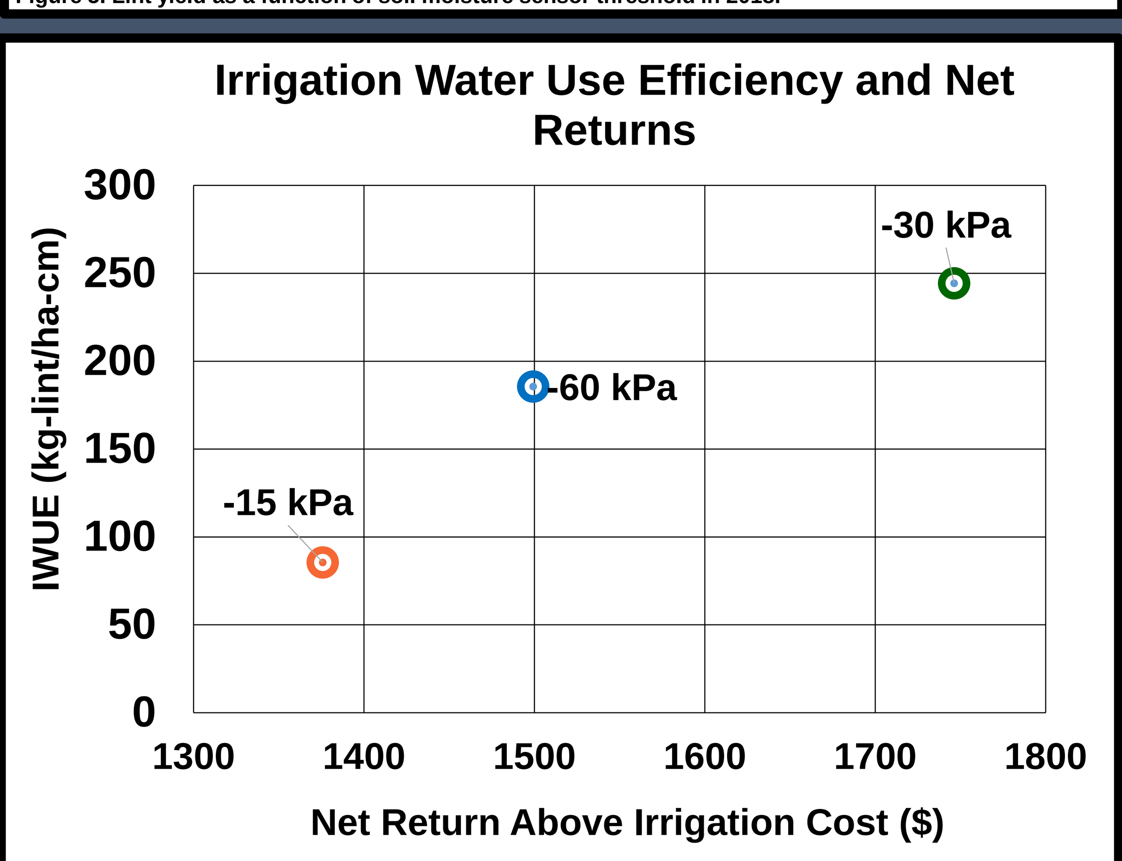

Figure 7. Sensor threshold by IWUE and Net Return Above Irrigation Cost in 2018.

Figure 8. Cotton root image from 5-leaf.

Figure 9. Cotton root image from full bloom.

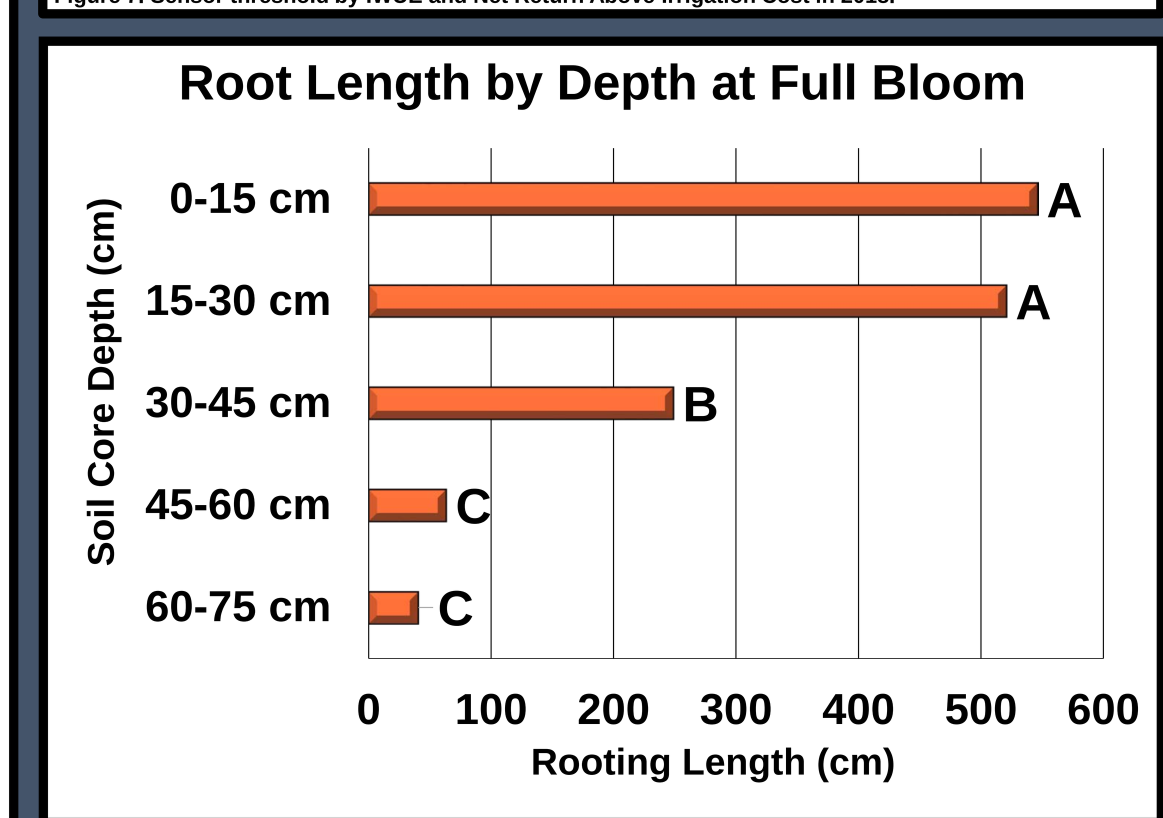

Figure 10. Root length by depth at full bloom in 2018.

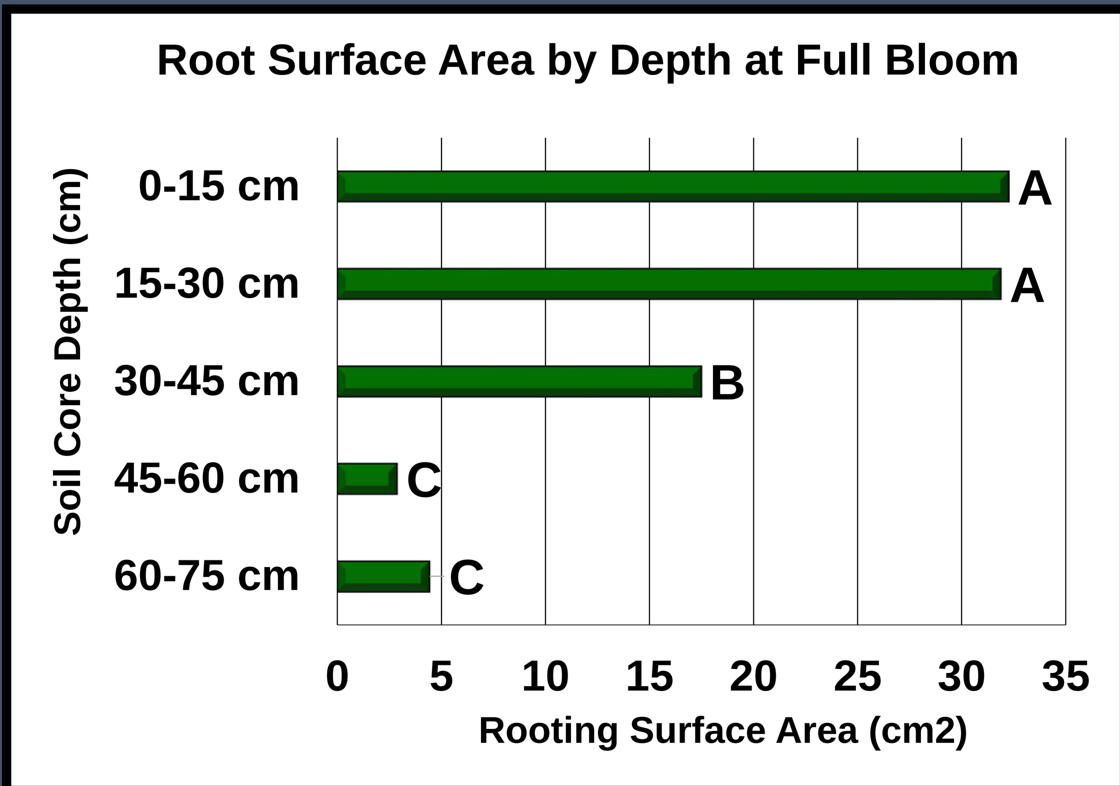

Figure 11. Root surface area by depth at full bloom in 2018.

Results and Discussion

- Rainfall exceeded the 108 year average in four out of six growing season months in 2018 (Figure 3).
- No differences in plant growth measurements (plant height, total plant nodes, nodes above white flower, or nodes above cracked boll) were observed at first bloom or first cracked boll regardless of irrigation treatment (Data not shown).
- Soil moisture sensor threshold values (irrigation treatments) did not have a significant effect on cotton lint yield in 2018, which is likely due to the frequent rainfall that occurred (Figure 5).
- Irrigation water use efficiency (IWUE) was significantly lower where a soil moisture sensor threshold value of -15 kPa was utilized compared to both -30 and -60 kPa (Figure 6).
- Overall, the -30 kPa soil moisture sensor threshold value provided the greatest net return above irrigation cost in addition to maximizing IWUE in 2018 (Figure 7).
- No differences in root length, surface area, or root diameter as a function of irrigation treatment/soil moisture sensor threshold value were observed (Data not shown).
- Cotton root length and root surface area varied significantly at different depths within the soil profile (Figure 10 and 11).

Conclusions

- Watermark 200SS soil moisture sensors appear to be an effective irrigation scheduling tool in cotton in South Carolina.
- In 2018, a weighted average threshold of -30 kPa resulted in the greatest IWUE and net returns above irrigation cost, which agrees with the hypothesis.
- Soil moisture sensor threshold did not impact cotton root length or surface area among soil cores.
- In 2018, majority of the cotton roots were within the top 45 cm of the soil profile which may suggest the depth at which soil moisture should be measured and maintained.
- Additional data collected in years with varying degrees of rainfall are needed to develop soil moisture sensor threshold recommendations.

Future Research

- Continue to evaluate irrigation scheduling using soil moisture sensors and to determine the optimum sensor thresholds to use in South Carolina.

Literature Cited

[NASS] National Agricultural Statistics Service. 2018. South Carolina Statistics. [USDA] United States Dept. of Agric. Washington, D.C. www.nass.usda.gov/Statistics_by_State/South_Carolina (accessed 12-1-18).

Saleem, M.F., M.A.S. Raza, S. Ahmad, I.H. Khan, and A.M. Shahid. 2016. Understanding and mitigating the impacts of drought stress in cotton-a review. Pak. J. Agri. Sci. Vol. 53(3)1-15. www.pakjas.com.pk (accessed 12-1-18).