Understanding in-field soil moisture variability and its effect on irrigation
Project No. 10-2019
Mary Love Tagert
Email: mltagert@abe.msstate.edu

Background and Objectives

There has been considerable research performed on using different methods and technologies to measure soil moisture, but much of this work has been done to estimate soil moisture in the near surface soil layer. It is important to consider soil moisture in the active rooting zone when making irrigation decisions, and granular matrix soil moisture sensors have been shown to conserve water and money while maintaining soybean yields because they can be used to schedule irrigation events based on crop water needs. However, questions still remain on the proper placement of sensors within a field and the density of sensors needed for making irrigation decisions. This project evaluates the spatio-temporal variability of rooting zone soil moisture over an approximate 18-hectare field using Watermark granular matrix soil moisture sensors placed at 12-, 24-, and 30-inch depths on a 55 x 55 m grid, resulting in 44 sampling points. The project is being carried out over three years at a pivot-irrigated site in Noxubee County growing primarily soybeans and corn, to evaluate rooting zone soil moisture variability over time under different climatic conditions. Because soils are commonly heterogeneous, and soil texture affects soil moisture, it is assumed that there will be some variability in soil moisture throughout the field. This project will determine the level of in-field variability of the rooting zone soil moisture of a soybean crop throughout the growing season and how this variability may affect yield, as well as the influence of soil texture and soybean vegetative characteristics on rooting zone soil moisture variability. The results of this project will help develop guidelines for sensor placement and density of sensors needed within a field. This project will increase the knowledge of North Mississippi producers on the use of sensors and thus increase the adoption of sensors for triggering irrigation applications in North Mississippi. The specific objectives are as follows:

1. Measure in-field spatial and temporal variability of soil moisture in the active rooting zone of soybeans using Watermark GMS sensors.
2. Evaluate the correlation of root zone soil moisture to soil texture and soybean vegetative variables.
3. Determine if the variability of in-field soil moisture is great enough to indicate a different irrigation schedule for different areas of the field.
4. Share project results with producers and stakeholder groups.

Report of Progress/Activity

1. Measure in-field spatial and temporal variability of soil moisture in the active rooting zone of soybeans using Watermark GMS sensors.

   On May 2, 2020, we installed soil moisture sensors at 12-, 24-, and 30- inch depths on a 55 x 55 meter grid, resulting in 44 soil sensor locations or grid points. The sensors at each point were connected to a data logger which was set to log measurements hourly. Corn was grown in Year Two as part of a soybean-corn rotation, and this is the reason for the additional sensor at 30 inches, to capture soil moisture in the active rooting zone of the crop. The data was downloaded weekly from the data loggers to analyze the soil moisture measurements.

2. Evaluate the correlation of root zone soil moisture to soil texture and soybean vegetative variables.

   Leaf Area Index (LAI) and plant height were measured weekly throughout the growing season at each grid point and sensor location, resulting in 12 measurement dates from May 16 to August 7, 2019. After analyzing the data, Year Two data shows that plant height has a higher correlation than LAI to soil tension, which is consistent with Year One results. However, the R^2

values are only 0.3122 and 0.1909 for plant height vs soil tension and LAI vs soil tension, respectively, in 2019.

3. Determine if the variability of in-field soil moisture is great enough to indicate a different irrigation schedule for different areas of the field.

   Objective Three is being met using the soybean data from 2018, or Year One of this project. Based on spatial analysis of the soil tension data, there are management zones that could be used if the producer were to switch to variable rate irrigation (VRI). Even without the switch to VRI, pivot speeds can be adjusted to apply water at different rates over different areas of the field. The field average measured yield was 59.2 bu/ac with grid-level yield ranging from 49.1 to 66.9 bu/ac. The DSSAT crop model results showed no variability across the field because of the homogeneity of the soil textures. The predicted field-level average soybean yield was 61 bu/ac based on the model simulations and taking into account the producer's management practices, including irrigation applications and actual rainfall that occurred during the 2018 growing season. Another set of simulations with actual 2018 recorded weather data and *no* irrigation events resulted in a slight decrease (0.33 bu/ac) in predicted yield compared to the base model runs. Given these results, the producer would have likely been more profitable in 2018 if he would *not* have irrigated. The results have recently been received from the soil testing lab with the soil moisture release curves. The data from the soil moisture release curves will allow us to convert measured soil tension in centibars to volumetric water content. Once soil tension measurements are converted, comparisons will be made in predicted and measured soil moisture in the rooting zone of the crops to ensure accuracy of the model predictions. The DSSAT model results will show if a different irrigation schedule is needed for different areas of the field and also the extent to which soil moisture variability affects yield. The application of the model in analyzing yield variability in this particular field can be further investigated by considering the use of long-term historical weather data. We can simulate soybean yield using 30 years of weather data and examine how soybean, with or without irrigation, performs in dry, normal, and wet years. The predicted yield in 2018 can be added to determine how well it fares against the ensemble set of simulations.

4. Share project results with producers and stakeholder groups.
   - Multiple presentations and posters have been created to present the preliminary findings of this project and will be listed in the End Products section.

All data is still preliminary, and no final conclusions have been made.

Impacts and Benefits to Mississippi Soybean Producers

Once this project is completed, it should result in major benefits on Mississippi soybean producers, particularly in Northeast MS. This project will help producers have a better understanding of how sensors can be utilized under pivots and in the hilly terrain of Northeast MS. Also, this project encourages the use of soil moisture sensors and should increase adoption of sensors in this region of the state, helping producers be more profitable through more efficient water use for irrigation.

End Products–Completed or Forthcoming

Completed Oral Presentations:

1. Blade Hodges: Factors Affecting In-Field Soil Moisture; Mississippi Water Resources Conference; April 3, 2019.
2. Blade Hodges: Three Minute Thesis competition; Mississippi State University; November 14, 2019.

3. Mary Love Tagert: Using Soil Moisture Sensors to Understand In-Field Soil Moisture Variability; ASABE Annual International Meeting; July 9, 2019.

Future Oral Presentations:

1. Mary Love Tagert and Blade Hodges will give an oral presentation at the 2020 ASABE conference in Omaha, Nebraska in July 2020.
2. Mary Love Tagert will give an oral presentation at the 6th Decennial National Irrigation Symposium in San Antonio, Texas in November 2020.
3. Mary Love Tagert has been invited to participate as a speaker for the Vertical Track on "Agriculture" as part of the IEEE World Forum on the Internet of Things 2020 panel discussion on the use of soil moisture sensors. This was scheduled for April 5-9 in New Orleans, LA but has been postponed due to COVID-19.

Completed Poster Presentations:

1. Blade Hodges: Evaluating In-Field Soil Moisture Variability with Sensors; Mississippi Academy of Sciences Summer Symposium; Mississippi State University; July 2019.
2. Blade Hodges: Evaluating In Field Soil Moisture Variability and Factors Affecting It; Northeast Mississippi Producer Advisory Council in Verona, MS; February 20, 2020.
3. Blade Hodges: Evaluating In Field Soil Moisture Variability and Factors Affecting It; Mid-South Farm and Gin Show, Memphis, TN; February 27-28, 2020.

Graphics/Tables

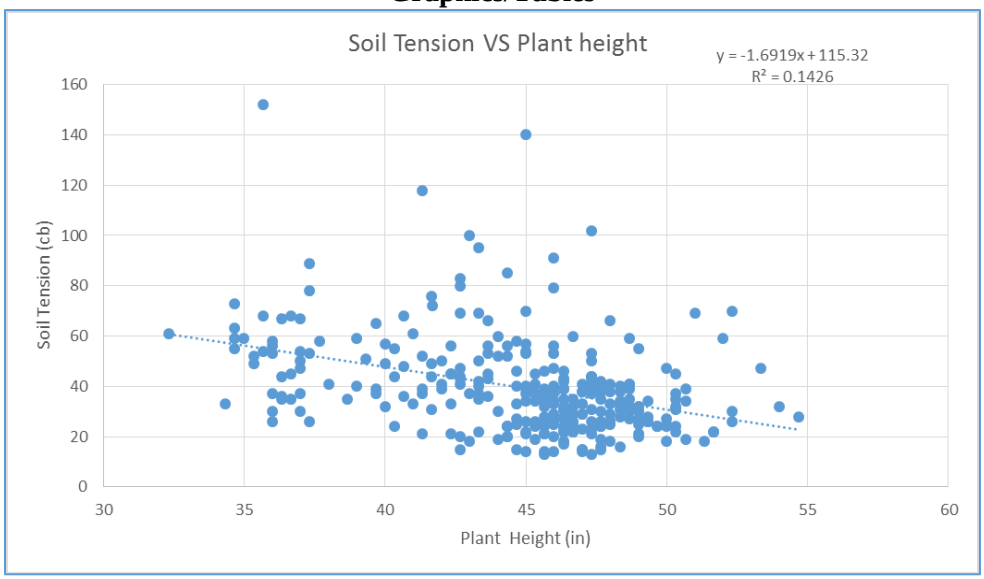

Figure 1. Soil tension vs plant height for 2018 soybean growing season.

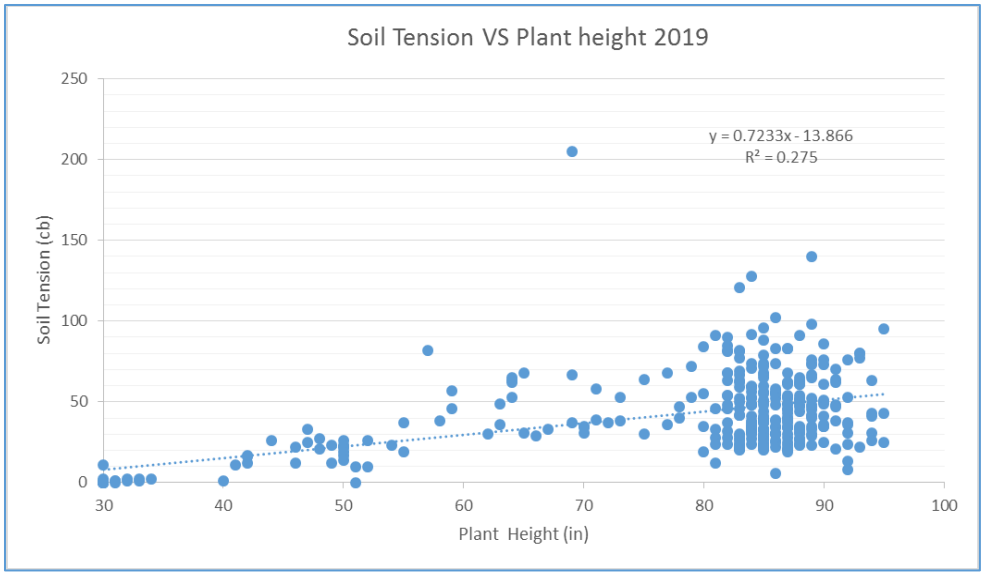

Figure 2. 2019 Soil tension vs plant height for 2019 corn growing season.

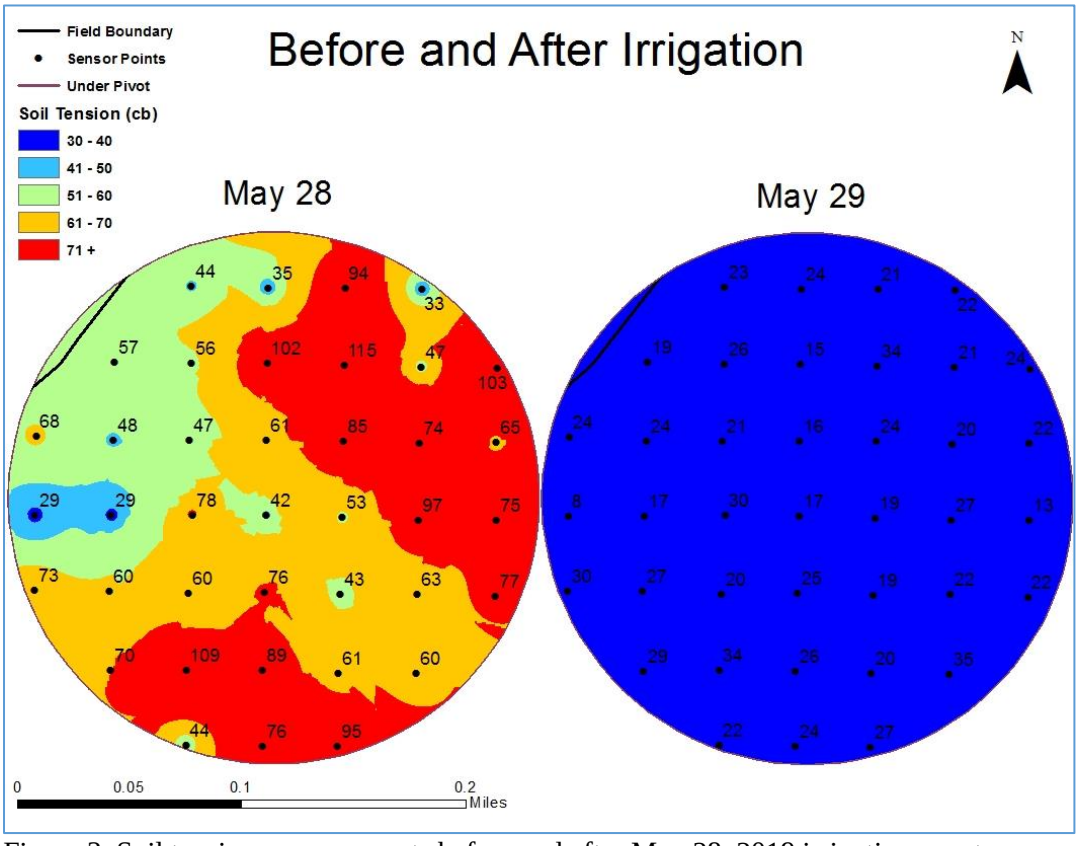

Figure 3. Soil tension measurements before and after May 28, 2019 irrigation event.

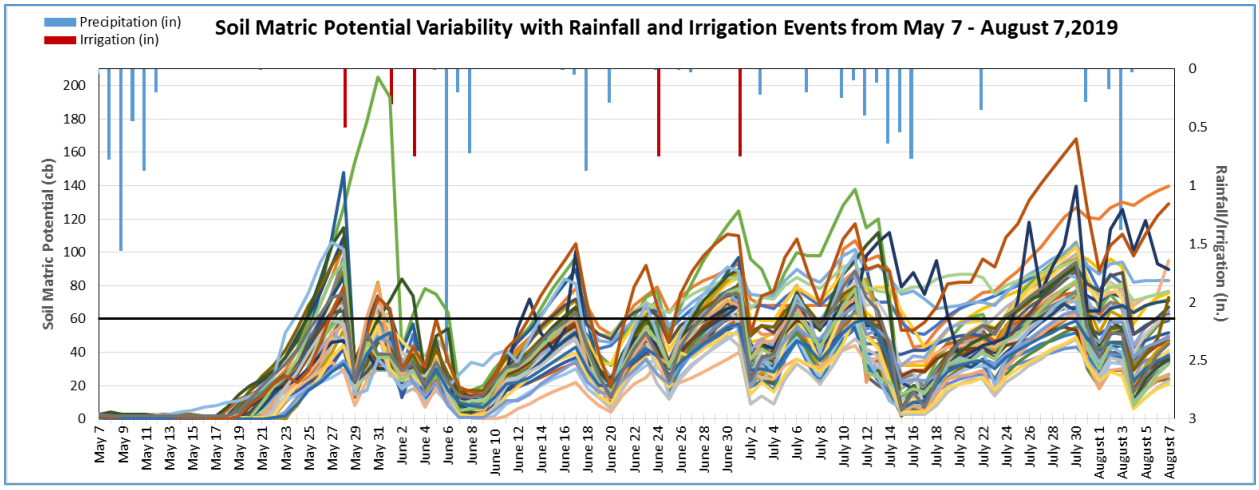

Figure 4. Weighted soil water tension (cb) in the active rooting zone at each point from May 7 to August 7 with rainfall and irrigation events.