The Graphical Representation of Soil Electrical Conductivity and Compression with Real-Time Sensing among Southern Illinois Soils

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Abstract

Soil sensing has grown to be one of the most influential factors of variable rate technology available to farmers today. Most information gained from sensors is coupled with GPS/GIS maps to further evaluate fertility recommendations. Sensors are engineered to test and help human understanding of various soil interactions which will assist with management decisions. However, most commercially available sensors are currently built to measure a single variable in the field. This project was a small step toward better understanding and establishing a measure of the relationship between soil electrical conductivity and soil compression. The primary objective of this effort was to create soil signatures for multiple types of soil and to simulate plow layers in a field. A soil sensor was engineered to graphically represent the relationship between these two factors. Due to the scope of the project, short-term deliverables are still somewhat unclear; however management practices can potentially be influenced with further development in the near future. Practical accomplishments in the short-term point to the need for further research, as real-time sensing with multiple variables can potentially prove to be beneficial for the agricultural industry.

Materials and Methods

The soil sensor was created using copper plating, which was insulated with rubber. The sensor was built in May of 2010 at UIUC. In order to measure electrical conductivity within a soil medium, a power source was needed to provide adequate amperage to flow between the platting. To simulate compression, a hydraulically driven piston was used to forcefully compact the soil. The two variables were controlled by a computer program, written in Matlab which collects, plots, and analyzes the data. Wet soil was used for the sensor’s calibration which had a significant exponential power to its curve, as was expected. A single soil sample has a fifteen second soil analysis, roughly 200 data points, and three graphs. (Force vs. Piston Height, Force vs. Compression Ratio, Resistance (Ohms) vs. Piston Height) Upon arrival at the Dixon Springs Agricultural Center, a diverse group of soil samples were obtained with a wide range of textures. Although the soils varied greatly in clay content, they appeared in the same relative location within the textural triangle. The samples were taken using a twelve inch probe and each sample had approximately twenty cores. Once the thirty-six samples were obtained from the seven locations, they were air-dried for five to seven days, ground, and screened. The constraints of the eleven week summer internship hindered the opportunity to locate additional and differing soil within the region. Removing water from the samples suggests that analysis is of the soil itself. Grinding the soil constituted a consistent bulk density between samples, while screening removed any foreign material. Samples needed to have weights of at least a kilogram to ensure a more distinct graphical analysis once run in the sensor. Soil texture was then determined for each sample, using the principles of Stoke’s Law and particle size. The soil samples varied in sand, silt, and clay content. Two sample locations were sampled knowing they have abnormally high levels of sodium and potassium, in order to compare and justify that the sensor was accurately measuring electrical conductivity.

Results and Discussion

The thirty-six soil samples had distinct sensor graphs (Force vs. Piston Height, Force vs. Compression Ratio, Resistance (Ohms) vs. Piston Height) associated with each location. The soil texture analysis was used to determine sand, silt, and clay content. (of which clay content directly affects electrical conductivity) Graphing the relationship between electrical conductivity and compression was very powerful because numeric values were assigned to the two variables. To date, with research done in current literature, no one has tested the idea of multi-variable analysis, to the best of our knowledge. However, creating graphs from the computer program (Matlab) only suggests theories on the interaction between electrical conductivity and compression. There must be more sampling and repetitions to scientifically prove that a certain soil texture reacts in such a way under a compression.

Conclusions

As previously stated, in order to scientifically represent soil electrical conductivity and compression, more development must be undertaken. Until more analysis is completed, many of the theories tested in this project will not be proven official until more examinations are finished.