Evaluation of the ability and the accuracy of different on-the-go soil sensor systems to estimate soil fertility status

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Introduction

One of the biggest innovations in agriculture is precision farming, which helps manage farm inputs like fertilizer, herbicides, and seeds by applying the right amount at the right location and time based on the landscape position and soil fertility status.

This study is a part of the precision agriculture field, which focuses on mobile soil sensors, which can be creatively employed to improve the creation of management zones for variable application of crop inputs and also obtain better information about fields with minimum cost by utilizing the "map-based" approach method.

Objectives

Our primary goals in this study are to :

- Evaluate the capacity of three commercial soil sensor systems to measure soil variables that are influential on crop production like soil moisture depth, organic matter, pH, **CEC**, soil texture, nitrogen levels, etc.
- Looking at the feasibility and economic sustainability of adopting a one-pass method to collect data .

Materials and Methods

The area under investigation is situated in Stillwater, Oklahoma. The experiments were carried out on six separate fields in three geographically distinct locations .

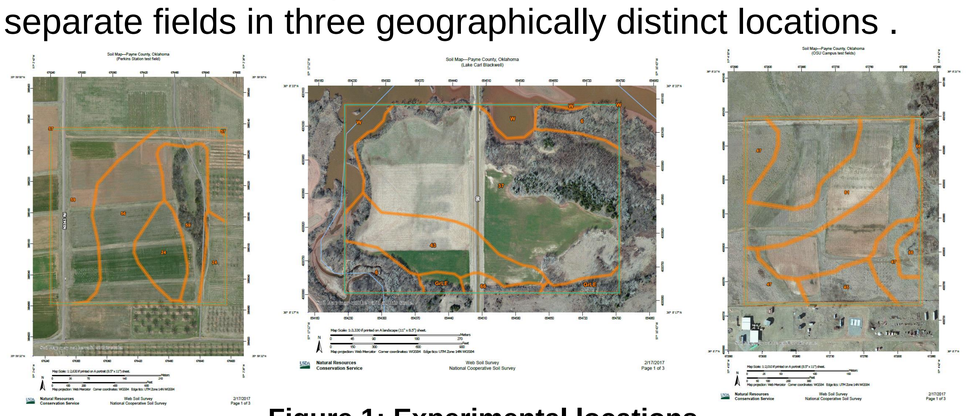

Figure 1: Experimental locations

Soil Types:

Lake C. Blackwell fenced:
Konawa Teller Complex
Port-Oscar complex (fine-silty)
Pulaski- Fine Sandy Loam

Lake C. Blackwell 10:
Port- Silt Loam
Pulaski- Fine Sandy loam
Masham Silty Clay loam
Grainola-Lucien Complex Fine & Loamy

N-40 OSU campus:
Kirkland, silt loam
Husta, Silt Loam – with Sodic horizon.
Perkins Station:
Konawa, Fine loamy
Teller, Fine sandy loam

In these experiments, 461 composite soil samples were collected (15 points in 40 ft), and 153 samples were analyzed. Original wet chemical analysis was performed on every third sample to provide insight into the accuracy of the sensors.

This project compared three commercially available soil sensing systems with laboratory analyzed soil samples taken from multiple field locations. The sensor systems evaluated are:

Sensor	Veris
Parameters Inferred or Estimated	Soil moisture, pH, CEC, organic matter
Sensing Method	Electrical conductivity via direct soil contact. Organic matter via optical detector. Retractable sampling probe for pH.

Veris system

Sensor	SoilOptix Technologies
Parameters Inferred or Estimated	Soil texture, moisture, organic matter, bulk density, nutrients
Sensing Method	Passive gamma-ray spectroscopy ^{232}Th, ^{40}K, ^{238}U, ^{137}Cs Total Count rate

SoilOptix Technologies system

Sensor	Geoprospectors-TopSoilMapper
Parameters Inferred or Estimated	Soil moisture, pH, CEC, organic matter, bulk density changes
Sensing Method	Non-contact Electrical conductivity measurement at three depths via electromagnetic induction

Geoprospectors system

Results

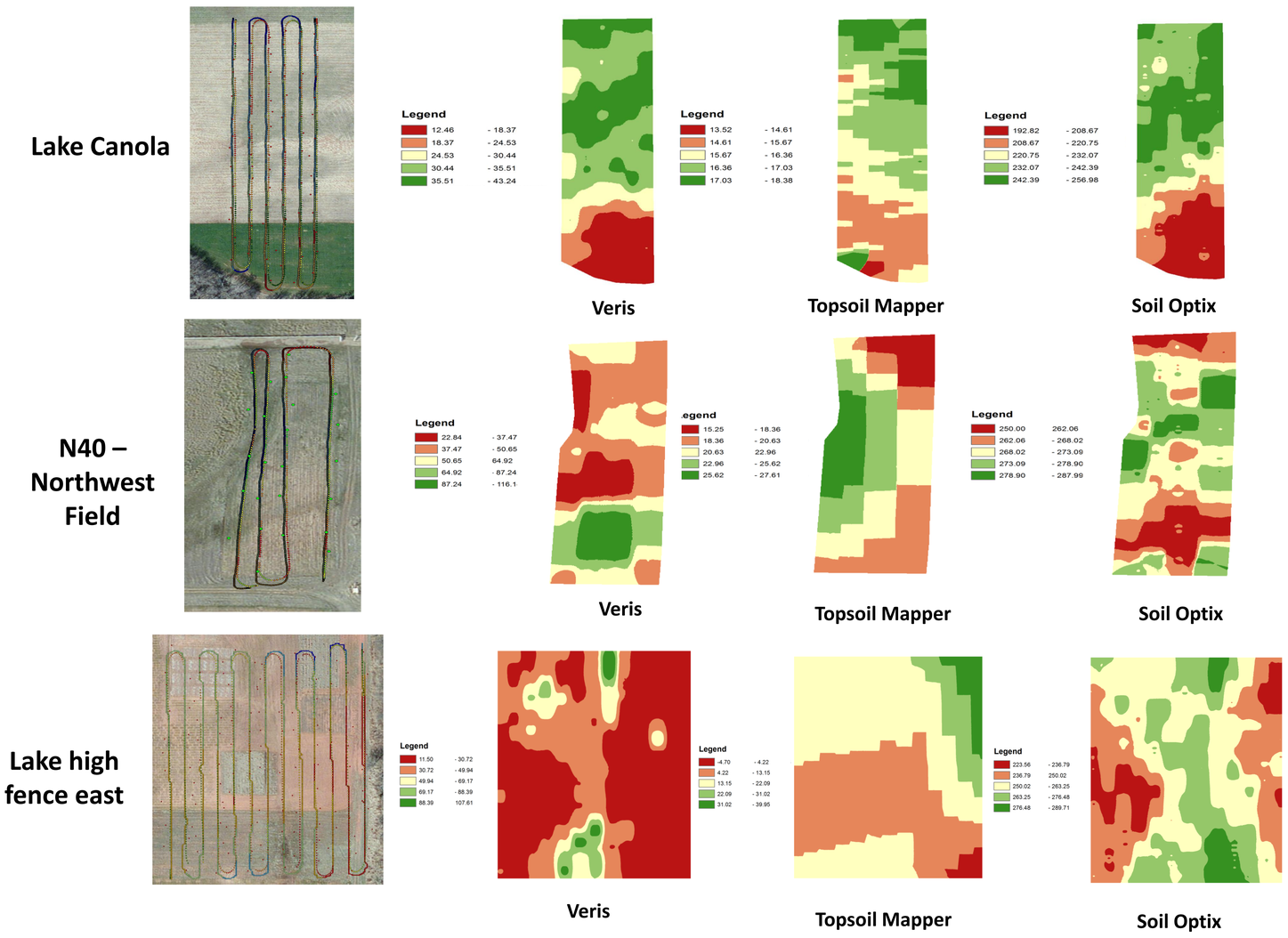

Figure 2: EC Mapes generated based on 3 different soil sensor (Veris, TSM and SoilOptix) in three locations geographically distinct

Sensor	moisture	pH	lab EC	organic matter	clay content	texture
Veris	Y	X	Y	LC	X	Y
SoilOptix Technologies	LC	Y	LC	Y	LC	LC
Geoprospectors -- TopSoilMapper	Y	N	LC	Y	N	N

KEY:
Y= relationship exists
N= no relationship
X= not measured or analyzed
LC = local calibration required

Table 1 : Remotely Sensed Soil Parameter Correlation with Laboratory Data

Discussion

- Each of the three mobile soil sensing systems that were tested by OSU had differences in terms of accuracy, ease of operation, robustness and type of soil parameters sense.
- The repeatability of results depend to the environmental conditions. So, natural spatial and temporal variability in soil parameters makes on-the-go sensing a challenge.
- The physical operating environment (undulating motion, vibration, dust, moisture, chemicals, EMI, etc.) adds to the sensing difficulties.
- The addition of soil sensors to planting and tillage equipment to adopt a one-pass method to collect data is challenging because of the environmental factors and will be an area of continuing effort.
- The project is still in progress, and we are integrating it into other projects . Also, we are looking at the evaluation of the number of local samples needed to calibrate the sensors.