Determining Your Role in Soil Mapping

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Determining Your Role in Soil Mapping

• The Promise of High Resolution Soil Maps
• Using High Resolution Soil Maps: Soil, Sensors, Solutions
• The Problem with High Resolution Soil Maps: What’s Different Now?
The Promise of High Resolution Soil Maps

- **Veris EC 32**
  - Clay% 38
  - CEC 31.5
  - OM% 4.4
  - **IOWA**: from a soil type mapped as a Webster silty clay loam.

- **Veris EC 25**
  - Clay% 34
  - CEC 21.2
  - OM% 3.5

- **Veris EC 15**
  - Clay% 16
  - CEC 12.4
  - OM% 2.0

- **Veris EC 8**
  - Clay% 8
  - CEC 7.4
  - OM% 2.4
  - **OHIO**: from a soil type mapped as a Mermill loam.

- **Veris EC 66**
  - Clay% 36
  - CEC 26.8
  - OM% 2.5

- **Veris EC 21**
  - Clay% 20
  - CEC 18.5
  - OM% 1.9
  - **KANSAS**: from a soil type mapped as a Sutphen clay loam.
The Promise of High Resolution Soil Maps

Mapping soil with crop data?

Yield maps and crop imagery show the effects of man, machines, and mother nature—and soil effects. But they are not soil maps.
“Precision ag has to get this right, or it’s better to not vary rates.”

The Promise of High Resolution Soil Maps
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Match corn population to soil productive potential
The Promise of High Resolution Soil Maps

Adjust soybean population to solve production challenges

Iron deficiency chlorosis: managed with a fusion of soil sensor maps

$35/ac benefit for variable seeding...
The Promise of High Resolution Soil Maps

Manage high N loss risk areas—less N loss, more yield

Understanding Nitrogen Loss

ONLY ABOUT 50% of applied nitrogen is absorbed by plants. Why?

INTO THE AIR

80% Up to 80% of applied urea N can be lost as ammonia-N (NH₃) to the air.
3% During nitrification and denitrification, up to 3% of applied nitrogen can be lost as nitrous oxide (N₂O).
20% During nitrification, up to 20% of applied nitrogen can be lost as nitrogen gas (N₂).

INTO THE WATER

25% Up to 25% of applied nitrogen can be lost to the water as nitrate (NO₃⁻).
The Promise of High Resolution Soil Maps
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Using High Resolution Soil Maps: Soil, Sensors, Solutions

Currently Available Soil Mapping Sensors
• Soil Electrical Conductivity (soil EC/EM)
• Optical
• Gamma
• Electrochemical Soil Measurements
• Topography

For each technology:
• The established science
• Most promising applications
Soil EC

• Soil Texture (and Salinity) by Electrical Conductivity
  – Measurement of soil’s ability to conduct electricity (in situ)
  – A way to measure differences in soil texture
    • The fine particles of clay make it more highly conductive than large soil grains such as silt and sand.
    • Not directly related to lab EC, unless soils are high saline

Soil Contact EC

Electromagnetic Induction (EM)
Jim Rhoades at the USDA-ARS Salinity Laboratory in California first used the technology in agriculture in 1977 to investigate near-surface agricultural features.

Fixed electrode soil electrical conductivity measuring was first developed in the 1920’s by Conrad Schlumberger in France and Frank Wenner in the United States for deep geophysical investigations.
Soil EC by electromagnetic induction (EM)

Swedish researchers circa 1945
*Photo courtesy of Rick Taylor, Dualem*

Jim Rhodes of USDA instrumental in pioneering ag research for EMI

Geonics EM38

TOPSOIL Mapper

Dualem D1-S
Extensive research conducted with Veris and EM devices conclude both are mapping soil EC, and the patterns from side-by-side mapping are virtually indistinguishable.

Google Veris, Geonics, Dualem + soil or EC or EM...Science-based companies with extensive independent research to back up technology
Soil EC matters because texture matters.

• Why it matters:
  – Soil Texture is directly correlated with major productivity factors:
    • Water-holding capacity
    • CEC (cation exchange capacity)
    • Rooting depth
    • Action of soil-applied herbicides

• Nematode activity
• Loss of mobile nutrients
• Subsoil characteristics
• Buffering capacity
Soil EC matters because texture matters.

**Solid applications for soil EC maps**

- Management zone soil sampling
- Calibrated to texture and/or CEC
- Variable-rate seeding layer
- Nitrogen scouting and management
- Improved irrigation management
- Yield map and crop imagery interpretation
- Sensor fusion with other soil sensor layers
Using soil EC...

Calibrating Soil EC to soil texture with laser diffraction

Variable sowing rates based on soil texture.
MZB... (now FieldReveal) commercialized advanced zone building in late 1990’s using multiple layers including EC.

Garden City (KS) Co-op: by the end of 2018 will have EC-mapped 100,000 acres in past 3 years.

Using soil EC...
Nick Emanuel: “By utilizing precise soil maps such as EC, we have the ability to place multiple sensors throughout the field to adjust our Variable Rate Irrigation applications, ensuring we are optimizing each soil zone’s own WHC throughout the field.”
Variable rate seeding in Argentina has significant potential due to highly variable soils. EC is being used extensively for seed scripts, perhaps over a million acres have been mapped.
Optical Soil Sensing

- Organic carbon/organic matter sensing by optical reflectance
  - A way to measure differences in organic carbon/matter
    - Darker soil typically has more OM than lighter soil, within a field.
    - Soil molecules with CH and OH bonds absorb light. This means soil appears darker when moist or has higher OM.
    - Do the dark areas on a bare soil image have more OM or more moisture?
    - Measuring 1-2” below the surface is crucial.

(a) stretching vibration  
(b) bending vibration
Optical Soil Sensing

2002: Veris NIR spectroscopy
Over 300 wavelengths

Single wavelengths

Gaultney et al.,
1991

Funk et al.,
1991
Optical Soil Sensing

Veris EC-OM combo units

Precision Planting
Smart Firmer
Optical soil maps matter because organic matter matters.

- Soil Organic Matter
  - Mineralizing N, P, S
  - providing soil aggregation
  - increases nutrient exchange
  - retains moisture
  - reduces compaction
  - reduces surface crusting
  - Increases water infiltration
Optical soil maps matter because organic matter matters.

Solid applications for soil optical maps

- Calibrated to lab-analyzed organic matter
- Sensor fusion with other soil sensor layers
- Variable-rate seeding layer—with QC and calibration to OM
- Nitrogen scouting and management
- Increased understanding of productive potential
- Soil health indicator
Kevin Anderson, “We utilize the OM layer for nitrogen management inside of the Adapt-N model. We will also utilize the OM layer in our variable rate planting recs to check the EC numbers if they come back different than what we expect (muck soil for example)”.
Using the OM layer...central IL

Progressive Ag Services
Paul Schell and Matt Boudeman

“The Veris maps are showing us the base soil properties we have to work with. We’re using it for variable seeding and to vary nitrogen rates based on the Encirca N model.”
Matt Free, Marketing Director says, “we’re excited about the possibility of using the EC and OM data from our two iScans and Climate FieldView to improve our nitrogen management and variable seed populations.”
Other Sensors:

**Gamma:** soil emits gamma radiation based on radioactive decay. This is driven by soil mineralogy and relates to texture and other properties.

Other Sensors:

pH:

* Adamchuk et al., Veris’ exclusive license from Purdue University
* 2003: first unit sold
* Today: the only system in the world for mapping soil pH on-the-go.
Other Field Sensors:

Topography:
- GPS elevation—RTK best; LIDAR may be available
- If from GPS, QC review is a must
- Needs to be converted to slope, curvature, water flow models like TWI
- Powerful when fused with soil sensor data
Using multiple soil layers...

60 acre field in Dewitt County IL

Silty clay loam:
OM: 3%; Clay: 36%

Silt loam:
OM: 3%; Clay: 22%

Silty clay loam:
OM: 1.4%; Clay: 30%

Silt loam:
OM: 1.7%; Clay: 22%
Using multiple soil layers...

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Silt loam:
OM: 1.7%; Clay: 22%
Using multiple soil layers...

Erich Eller (northeast IN): Fixed Variables vs. Variable Variables
Using multiple soil layers...

Remi and Alex...France
Iron deficiency chlorosis (IDC) plagues high pH, poorly drained soils. Management: chelated iron and additional soybean seed.
So, why now? Soil sensors have been around precision ag for many years.

The sensors and maps are ready. So is the market.
Sensor maps used to be relative. They showed exactly where the soil changed but didn’t explain exactly what the change was.

Sensor maps are now typically calibrated to lab samples. Now the where and the what are both mapped precisely.
Because their meaning was vague, soil sensor maps required other layers and analysis.

New sensors and calibrations provide a much more comprehensive view of a field…

...providing the info needed for many decisions.
Where was precision ag’s focus?

- Custom-applied P, K, lime
- Grower not personally using the maps
- Inputs have an indirect relationship to soil physical properties
- Less sensitive inputs—rarely yield-limiting

*While precise soil maps help, this typically isn’t the killer app.*

Today’s precision focus...

- Grower-applied seed, nitrogen—and more
- Grower is personally using the maps
- Inputs have a direct relationship to soil physical properties
- Very sensitive inputs—yield-limiting

*Now, poor maps are revealed and precise soil maps are valued.*
Adoption of grower applied inputs was delayed by:

- Creating prescriptions was seen as a hassle
- Connectivity was limited
- Variable drives were only after-market
- Nitrogen was the ‘3rd rail’

The tech has come a long way...

- Software is intuitive and cloud-based
- API’s improve data connectivity
- Growers are more tech savvy
- Variable drives are from OEM and often standard
- Weather-based nitrogen models encourage improved N management
There likely were some exaggerated claims about what is being measured by the sensor signals. There is no FDA regulation on soil sensors.

Today, there is a large body of peer-reviewed scientific evidence about what sensors do and don’t do.

If claims are made today that aren’t supported by the scientific literature, be careful.
QC: Soil testing labs perform extensive QC tests on their processes using check samples and receive accreditation based on their accuracy.

Here’s why soil sensor map QC is so critical:

• These maps will drive prescriptions for the most yield-responsive inputs.
• Being wrong costs the grower money in year 1 and beyond.
• Being wrong is visible to the grower.
• Errors are compounded with model-based algorithms.

‘Check-sample’ transects

QC report on all Veris sensors developed since 2010
Summary...take home thoughts

• Soil sensing has come a long way.
• There is solid science behind most soil sensing technologies. Question unsubstantiated claims.
• The need for precise soil maps is strong and getting stronger, as precision ag moves to more variable seed and nitrogen applications.
• If you provide a soil map to your grower, he will know if it’s right.
• The soils of the world will likely be mapped precisely using soil sensors. What will your role be? Will you and your customers use soil maps you create, or from someone else?