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On-the-go Mapping of Soil Properties Using Ion-Selective Electrodes

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Outline

- Problem statement
- Ion-selective electrodes (pH, K^+, NO_3^-)
- Automated soil mapping system
- Soil pH field mapping
- Laboratory evaluation
- Summary

Problem Statement

- The sensing of soil variability is one of the most important steps in site-specific management
- Varying application rates is inappropriate without accurate soil maps
- Obtaining this descriptive information about a field is expensive using conventional methods
- There is a need to develop equipment for mapping chemical soil attributes on-the-go
- Offered technology must be reliable, rapid, simple, inexpensive, repeatable

Standard Chemical Soil Test

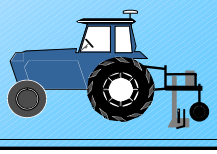
- Preparation (drying, crushing, sieving)
- Solution
  - 1:1 (Soil pH)
  - 1:2.5 (Nitrate-Nitrogen)
  - 1:10 (Potassium)
- Extraction
  - Water (Soil pH, Nitrate-Nitrogen)
  - Buffer Solution (Buffer pH)
  - Ammonia Acetate Solution (Potassium)
- Measurement
  - Ion-Selective Electrode (pH)
  - Atomic Absorption Spectroscopy (Potassium)
  - Cadmium Reduction Method (Nitrate-Nitrogen)

Direct Soil Measurement

- Preparation
  - Field conditions
- Solution
  - Naturally moist soil
- Extraction
  - Available ion activity
- Measurement
  - Ion-selective electrode

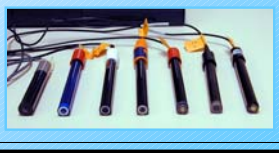
Hypothesis

Lower measurement accuracy is compensated by higher measurement density



Ion-Selective Electrodes

- Combination
- Flat Surface
- Gel-Filled
- Epoxy Body
- Glass (pH)
- PVC Membrane (K^+, NO_3^-)



Automated Soil pH Mapping Systems

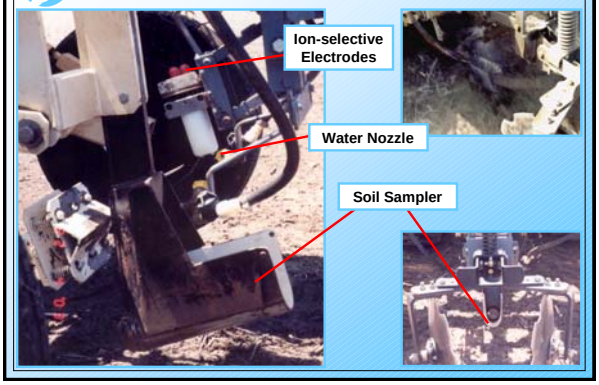
US Patent No. 6,356,830

Purdue University, 2000

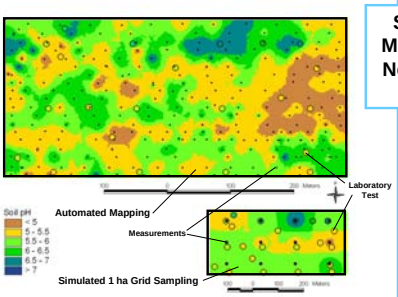
Automated Soil pH Mapping Systems

Veris Technologies, 2003

Soil Sampling Mechanism



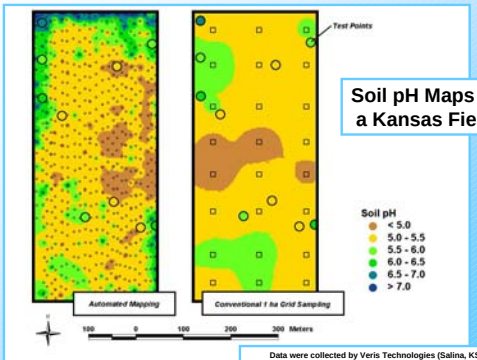
Soil pH Mapping



Soil pH Maps of a Nebraska Field

Data were collected by Veris Technologies (Salina, KS)

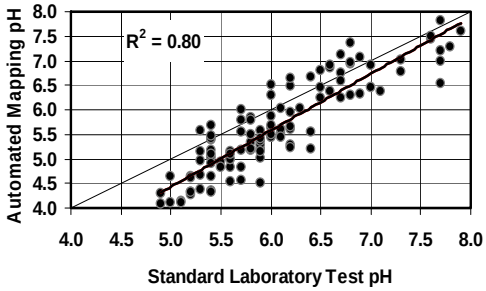
Soil pH Mapping



Soil pH Maps of a Kansas Field

Data were collected by Veris Technologies (Salina, KS)

Field Test (Soil pH Mapping)

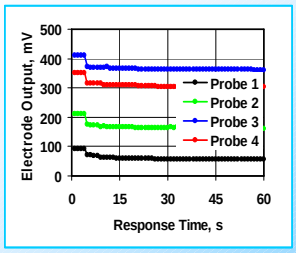


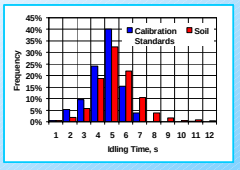
Laboratory Evaluation of Direct Soil Mapping

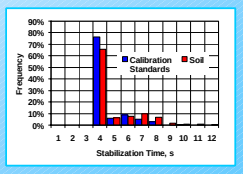
- Stability
- Calibration
- Repeatability
- Accuracy
- Reliability

- Crete Silt Loam
- Wymore Silty Clay Loam
- Brocksburg Sandy Loam
- Hall Silt Loam
- Thurman-Anselmo Fine Sandy Loam

Electrode Stability

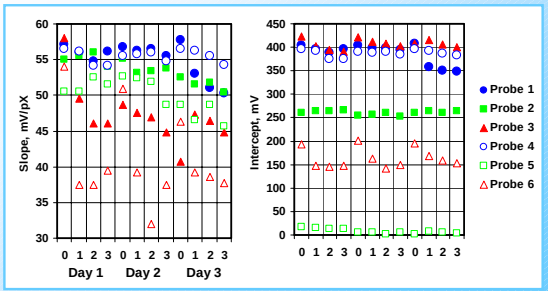






It takes approximately 10-15 s to obtain a relatively stable reading

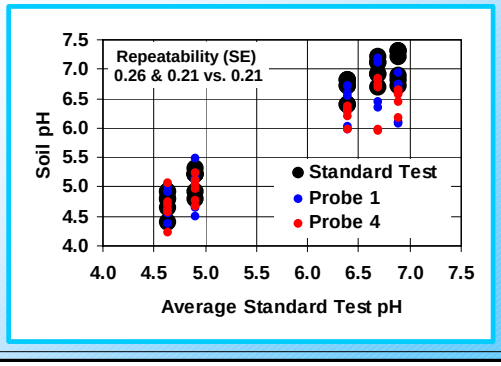
Electrode Calibration



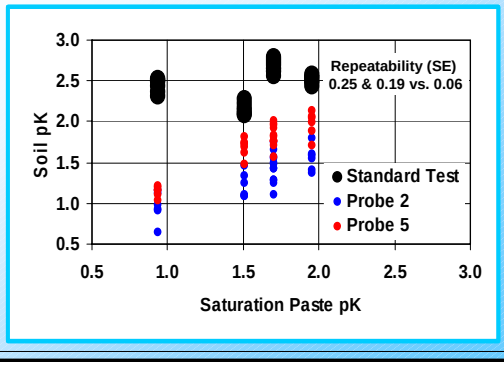
Electrode (Nernst) Slope

Intercept (Standard Potential)

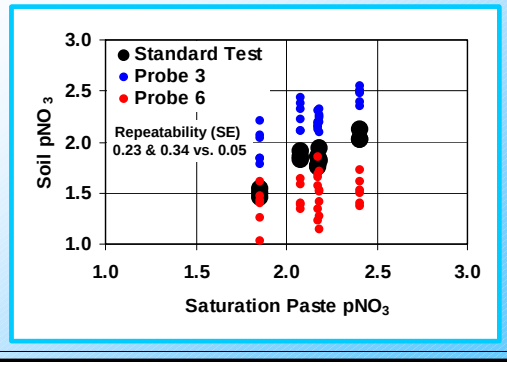
Soil pH (DSM vs. Standard Test)



Potassium (DSM vs. Atomic Absorption Spectroscopy)



Nitrate (DSM vs. Cadmium Reduction)



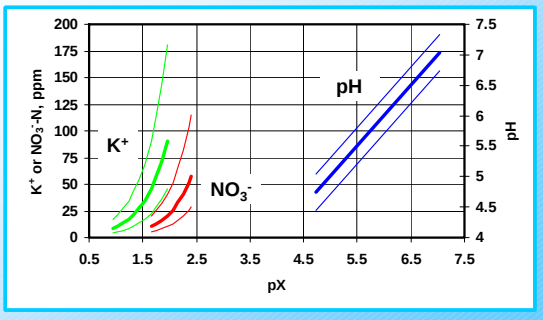
Electrode Accuracy

	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5	Probe 6
	pH	pK	pNO_3	pH	pK	pNO_3
	Brand 1			Brand 2		
Individual R^2	0.89	0.40	0.30	0.93	0.67	0.03
Daily Mean R^2	0.96	0.61	0.60	0.97	0.83	0.08
Mean R^2	0.98	0.89	0.89	0.99	0.95	0.56

Reference:

Average Standard Test for pH
Saturation Paste and Atomic Absorption Spectroscopy for pK
Saturation Paste and Cadmium Reduction for pNO_3

Distinguishing between Levels of Soil Properties



Summary

- Direct soil measurements of H^+, K^+ and NO_3^- have root mean squared errors less than 0.3 pX (pH, pK, pNO_3)
- Automated soil pH mapping is a promising alternative to conventional sampling and analysis methods due to increased sampling density
- Estimating exchangeable potassium content or buffer pH requires additional information about soils tested
- Automated mapping of residual nitrates in topsoil may be feasible only if a substantial field variation exists

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