Precision Agriculture and Precision Agriculture and Sensor Systems Team

- Development of Proximal Soil and Plant Sensing Systems
- Geospatial Data Processing and Management
- Practical Implementation of Precision Agriculture

“Precision agriculture is a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production.”

National Research Council, 1997

- La agricultura de precisión es un concepto agronómico de gestión de parcelas agrícolas, basado en la existencia de variabilidad en campo.

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- Precision farming or precision agriculture is a farming management concept based on observing and responding to intra-field variations. Today, precision agriculture is about whole farm management with the goal of optimizing returns on inputs while preserving resources.

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Goal

Object

System Approach

System Approach Implementation

• Conservation tillage
• Machinery use logistics and tracking
• RTK-level auto-guidance
• Automatic section control
• Yield mapping
• Soil electrical conductivity mapping
• Remote sensing (aerial/satellite)
• Soil sampling and analysis
• Band fertilizer placement
• Variable rate nitrogen management
• Variable rate P and K management
• Variable rate seeding

Machinery Tracking

Real-Time Equipment Monitoring
Planting with VRT Seeding and Individual Unit Control

Variable Rate Technology

Application Quality Control

Georeferenced Soil Sampling

Sampling depth – 0-30 cm and 30-60 cm
Sampling Study

Prediction Quality
Root-Mean-Square-Error

IDWKriging Tile
PointDiagonalZ pattern

P2O5 Variability
(mg/kg)
< 75
76 - 100
101 - 125
126 - 150
151 - 175
176 - 200
> 200

Field 1 - P2O5
Z-pattern
Diagonal
Point

Simulation Study

Simulation Study Results

Soil EC and Field Elevation Mapping

Soil Sampling Strategies

Precision Agriculture Adoption
Cons of Precision Agriculture

Source of Profitability

Profitability = Increased Revenue – Additional Cost

- Inputs Saving
- Yield Gain
- Yield Quality Improvement
- Environmental Control
- Record Keeping

- Capital Investment
- Time Investment
- Potential Risk
- Insufficient Knowledge

Why Variable Rate Technology?

- It is obvious that skipping, overlapping or placing agricultural outputs outside the cropping area should be avoided
- 4R nutrient stewardship
  - Right fertilizer source
  - Right rate
  - Right time
  - Right place

Return on Investment

- System Changes > $50/ha/year
- Quality Control and Logistics $20-100/ha/year
- Variable Rate Technologies < $50/ha/year

Source of Savings

Tillage

- No-till if possible
- Strip-till to localize main soil treatments
- Spot tillage of compacted areas
- Variable depth tillage in response to the depth of a hard pan
Seeding
• Change rate to account for differences in water availability
• Change depth to optimize emergence
• Change the hybrid in response to local environments

Water
• Field landscaping and drainage
• Control water table
• Optimized irrigation scheduling
• Variable rate irrigation

Liming
• More lime is needed for low pH soil
• No lime should be applied to neutral or alkaline soil
• It takes extra lime to raze pH in soils with high buffering capacity

Nitrogen
• Apply when it is needed
• Account for all possible credits (predictive)
  – Potential for mineralization
  – Yield history
  – Residual N
• In season management (reactive)
  – Feed the crop under N stress
  – Do NOT feed the crop under a different type of stress

Potash and Phosphate
• Band placement
• Relevance to past management
• Historic crop removal
• Mapping local needs

Organic Fertilizers
• Avoid environmentally risky areas
• Nutrient balance in certain cases
• Improved logistics
Herbicides

- Change the rate according to the quantity of weeds
- Change the product according to the species
- Change the rate according to soil carbon

Site-Specific Crop Management

- Sensing in Precision Agriculture

  - Remote
    - Satellite
    - Aircraft
    - UAV
  - Proximal
    - On-the-go
    - On-the-spot
    - Profiling

- Sensing
  - In-season imagery
  - Real-time sensors
  - Off-season imagery
  - Sensor-based mapping

Data transfer

Tillage & seeding

Crop harvesting

Fertilization

GIS

Plant protection

Ancillary data

Storage medium

Prescription maps

Sensing in Precision Agriculture
Sensor Fusion

Data Integration

Site Specific Calibration

Spatial Data Clustering

Multiple Input Data Layers

Crop Canopy Sensing

Lab data

Topography

Sensor Fusion

Soil EC

Soil pH

Soil Reflectance

Data Integration

Sensing data

GNSS

Yield data

Imagery

Lab data

Farmer experience

Machine

Rule

Technology

Site Specific Calibration

$OF = \sqrt[5]{S_{opt} \cdot D_{opt-pH} \cdot D_{opt-EC} \cdot H_{cr-pH} \cdot H_{cr-EC}}$

- S-optimality
- D-optimality (soil pH)
- D-optimality (soil EC)
- H-criteria (soil pH)
- H-criteria (soil EC)

Spatial Data Clustering

Multiple Input Data Layers

Crop Canopy Sensing

Shallow EC

Deep EC

Elevation

Partitioned Field

GPS

Thermal sensor

Ultrasonic sensor

Optical reflectance sensors
Aerial Imagery

Wireless Sensor Networks

Map of Real-Time Water Stress Impact Assessment

Soil Profiling Sensors

On-the-Spot Analyzer

MIR Spectroscopy

In situ Microscopy

Diffuse Reflectance Variable Filter Array Mid-Infrared (MIR) spectroscopy - 2780-5096 nm or 5500-10800 nm
The Smart Tractor Concept

- Match tractor operation with local conditions according to operator-defined rules or direct operator input
- Use of internal or external sensors to replicate appropriate operation settings

Stage Control
Variable Rate Liquid Cattle Manure Management

- Allowed environmentally safe discharge of additional 30% (150 m³) of liquid manure in this 11.1-ha alfalfa field

Proportional Control
Variable Rate Liquid Cattle Manure Management

- Allowed environmentally safe discharge of additional 20% (80 m³) of liquid manure in this 12.4-ha corn field

Map-Based Control
Variable Rate Liquid Cattle Manure Management

Variable Depth Planting

- Planting Depth Control
- Soil Water Content Sensing
There is no such a situation where precision agriculture does not work. There are many instances where promoted solutions are not appropriate for solving a given set of problems, or are not executed correctly.

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