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Proper Implementation of Precision Agricultural Technologies for Conducting On-Farm Research

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Abstract
Precision agricultural technologies have provided farmers, practitioners and researchers the ability to conduct on-farm or field scale research to refine farm management, improve long term crop production decisions, and implement site-specific management strategies. The limitations of these technologies must be understood by those using them to conduct field scale research to gain useful knowledge from such investigations. Therefore, this paper will address how several precision agriculture technologies can be successfully used to conduct research at a field scale level. Discussions will include yield monitors, variable-rate, auto-swath technologies, guidance systems and GPS/GNSS correction services along with proper setup of machinery equipped with these technologies. The importance of selection, calibration, maintenance, and management will be covered and how these can impact results and thereby decisions made from utilizing these technologies for research purposes. Users must understand the limitations of these technologies. Performance expectations that exceed systematic capabilities may produce research data that are dubious at best. Understanding the limitations of precision agriculture technologies will provide useful knowledge for proper setup and analyses of investigations.

Disciplines
Agriculture | Bioresource and Agricultural Engineering

Proper Implementation of Precision Ag. Technologies for Conducting On-Farm Research

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Discussion Outline

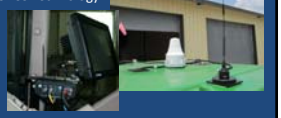
- Precision Ag Background
- Technology Limitations
  - GPS/GNSS sensors
  - Variable-Rate Technology (VRT)
    - Map-based application
    - On-the-go application
  - Automatic section control (ASC)
  - Yield Monitors
- On-Farm Research Considerations

Technology has advanced over the past 15-20 yrs, but to what limit?

Equipment and Controls

Equipment Size Continues to Increase

Advancement in GPS/GNSS Technology



On-the-Go Sensing

Individual Nozzle Control using Auto-Swath Technology

Image courtesy of Purdue University

History of Precision Ag

Data Collection | Steering Control & Variable-Rate | Implement Control

1992 — 1997 — 2002 — 2007

Current US Precision Ag. Trends

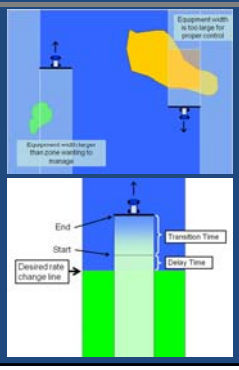
- *Machine Control*
  - Autoguidance and Lightbars
  - Auto-swath control
  - Strip tillage, fertilizing, and planting
  - Implement control on sloped fields
- *Demand for high-level GPS accuracy* (few inches - RTK)
- *Input Management*
  - Precise fertilizer and pesticide application
  - Variable-rate fertilizer, seeding, etc.
- *Solutions for information management*

Current emphasis on automating machine / implement control

Payback for Precision Ag Systems

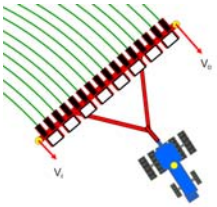
- Cash Methods
  - **Reduced pass-to-pass overlap** with guidance systems
  - **Reducing headland overlap** with automatic section control reduces input use.
  - **Improved crop yield** response from accurate input placement (fertilizer rate, seeding rate, etc.)
- Non-Cash Methods
  - Reduced operator fatigue
  - Better data and decision management
  - Identify yield limiting problems

Management Considerations



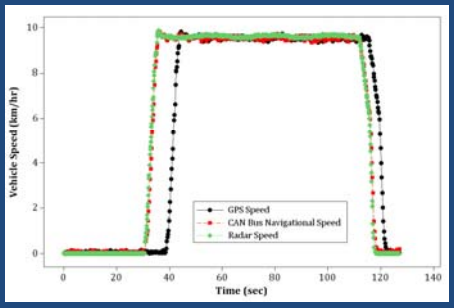
Management zone generation versus equipment size and control capabilities

Curvilinear travel especially for larger equipment



RESULTS

GPS Dynamic Velocity Response

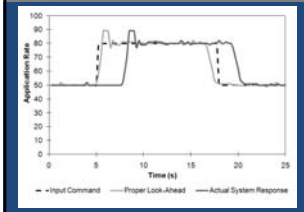


Quick acceleration can generate lag in GPS speed

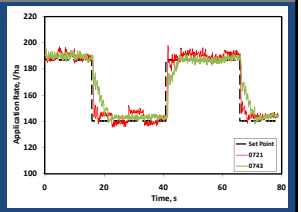
Single-base vs. Real-time Networks

- DOT CORS across the US have several mount point and correction format options.
- Popular among RTK adopters
- Iowa DOT CORS
  - Static accuracy (2DRMS)
    - CMR+ (single-base): 3.02-cm horizontal; 4.27-cm vertical
    - iMAX (network solution): 3.68-cm horizontal; 7.14-cm vertical
  - 24-hour RTK fix
    - CMR+ 99.8%
    - iMAX 98.5%
- Satellite commonality between rover and base station(s) critical for maintaining RTK fix solutions at rover.
- GPS vs. GNSS

Variable-rate Controller Response



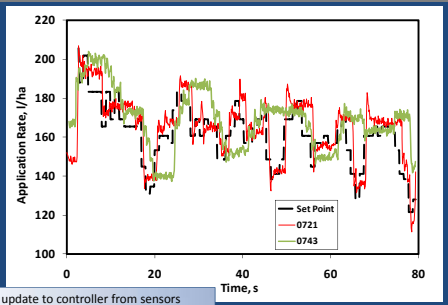
Look-ahead feature



Controller Setup (valve control number)

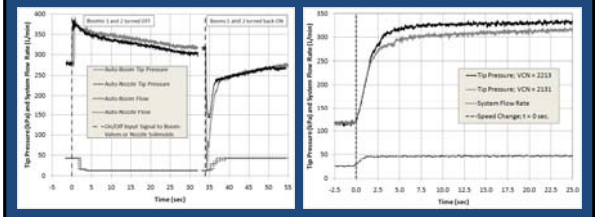
- Response varies for increasing vs. decreasing rates
- Time require to make rate change
- Setup impacts performance

On-the-Go Sensor Based Controller



- 1-Hz update to controller from sensors
- Controller unable to accurately respond
- Note the differences in controller settings

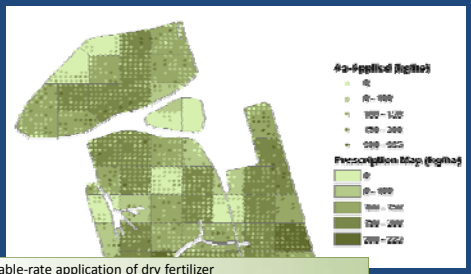
Auto-Swath on Sprayers



- System flow rate (feedback to controller) does no respond to nozzle response
- Controller setting impacts response

Sprayer Off-Rate Errors

Variable-Rate Technology



- Variable-rate application of dry fertilizer
- 1-acre grids
- 5-sec increasing and 8-sec decreasing rate-change response
- Off-rate error typically unknown to operator and farm manager.

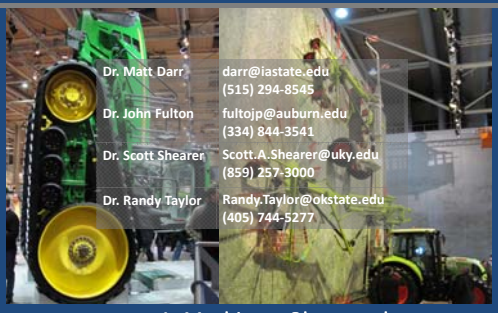
Yield Monitors

- Slope impacts mass flow measurements (12%)
- Time delays for material movement through harvester exist
- Quick acceleration impacts mass flow / volume estimates.

Considerations for PA Research

- Realistic expectations
  - Misperceptions can lead to incorrect decisions
  - Plot work versus field-scale work
- TLC for technology
  - Requires proper setup, calibration and implementation
  - Periodic system checks
- RTK data source (reliability and accuracy)
- Management zones
  - Size and shape
  - Control resolution of equipment
- Avoid stopping or quick acceleration within plots
- PA technologies can be powerful tools
  - Limitations and operational constraints must be understood.

Questions



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