Precision Farming Basics Manual – A Comprehensive Updated Textbook for Teaching and Extension Efforts

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Abstract. *Today precision agricultural technologies are limited by the lack of a workforce that is technology literate, creative, innovative, fully trained in their discipline, able to utilize and interpret information gained from information-age technologies to make smart management decisions, and have the capacity to convert locally collected information into practical solutions. As part of a grant entitled Precision Farming Workforce Development: Standards, Working Groups, and Experimental Learning Curricula funded through a USDA Higher Education Challenge Grants Program was to develop a Precision Farming Basics Manual. One goal of the manual is to equip those in or entering the workforce with the knowledge needed to make practical and knowledgeable decisions regarding the use and adoption of precision farming technologies. Each of the 15 chapters in the manual will contain: 1) learning objectives; 2) a descriptions of a real-world problem that the technology is designed to reduce; 3) a discussion of the technology, 4) student problems using the technology; and 5) experiential and team activities. In addition, a glossary of precision ag terms and an online video library will accompany the manual. Delivery of the manual will be made available through the American Society of Agronomy (ASA) on-line digital library. The overall goal of the Precision Farming Basics Manual will be to serve as an updated text for those teaching precision agriculture at the undergraduate level and the education of working professionals through extension efforts.*

Keywords. *Education, Undergraduate Education, Extension Education, Textbook, Precision Farming, Precision Agriculture, Site Specific Agriculture*

Introduction

Across the United States: 1) precision agricultural technologies are being rapidly adopted by farmers; 2) producers are increasing their reliance on information age technologies and agricultural industries are making strategic investments to take advantage of new economic opportunities; and 3) many farmers are purchasing precision technologies but are challenged with fully implementing variable rate treatments.

Today precision agricultural technologies are limited by the lack of a workforce that is technology literate, creative, innovative, fully trained in their discipline, able to utilize and interpret information gained from information-age technologies to make smart management decisions, and have the capacity to convert locally collected information into practical solutions.

The goal of this textbook is to equip those in or entering the workforce with the knowledge needed to make practical and knowledgeable decisions regarding the use and adoption of precision farming technologies.

Background

As part of a grant entitled Precision Farming Workforce Development: Standards, Working Groups, and Experimental Learning Curricula funded through a USDA Higher Education Challenge Grants Program (Clay et al., 2014) was to develop a Precision Farming Basics Manual.

The curricula of this manual will be based on meeting the desired student outcomes and it will integrate experiential learning techniques into all lesson plans. The textbook will be suitable for supplementing both traditional and distance classes. The proposed publication was based on a set of current Site-Specific Management Guidelines (Clay et al., 1999) developed in 1999. Technology has changed a great deal in 25 years. The Precision Farming Basics Manual will replace outdated technologies with current technologies and expand the student learning opportunities by including experiential exercises and problems with and without solutions. Each chapter in the manual tentatively titled, Precision Farming Basics, will contain: 1) learning objectives; 2) a descriptions of a real-world problem that the technology is designed to reduce; 3) a discussion of the technology, 4) student problems using the technology; and 5) experiential and team activities.

The proposed publication provides an updated textbook on the basics of precision agriculture targeted to a broader audience than publications currently in print.

Content of the Textbook

Each chapter of the textbook will contain: 1) learning objectives; 2) a descriptions of a real-world problem that the technology is designed to reduce; 3) a discussion of the technology, 4) student problems using the technology; and 5) experiential and team activities.

The following is the working table of contents:

Precision Farming Basics – Table of Contents

1. **<u>Precision Agriculture Basics</u>**
    - Introduction
    - Value in Understanding and Managing Variability
    - Variability a function of Genetics X Soil/Landscape X Management X Weather
    - Examples of value realized
    - The Scope of Precision Agriculture: nexus of technology, agronomy, engineering, information management, economics
    - Nutrient Management – 4Rs

2. **Understanding and Identifying Variability**
    - Overview of things that cause variability: spatial vs temporal
    - Soils as they really are: continuum of change
        - Soil formation and change brought by anthropogenic influences
        - Landscape process and concepts/hydrology
    - Weather as a driver of variability
    - Management as driver of variability
        - Compaction
        - Enhanced erosion
        - Historic nutrients (manure, liming, equipment failure)
        - Historic cropping practices (rotations; memory effect)
    - Water Management
        - Irrigation
        - Drainage
    - Biotic and abiotic stresses
    - How plants respond to stresses
    - All stresses are manageable
    - Solutions to stress: Short term returns vs Long term sustainability
    - Develop PA Goals/Decisions to respond to variability

3. **Positioning Systems – GPS / GNSS**
    - Need for accurate location- referenceable location
    - What is GPS?
    - Overview of Satellite Ranging – The Basis for GPS Operation
    - Terminology and Description of GPS Operation
    - GPS Accuracy and Factors Affecting It, i.e. Effects of Satellite Geometry
    - Differential GPS (DGPS)
    - Sources of Real-Time DGPS
    - RTK Networks and CORS Networks
    - Introduction to GNSS Systems
    - GPS and DGPS Hardware
    - Levels of GPS Precision
    - What Accuracy is Needed
    - What GPS and DGPS Accuracy Terms Mean
    - GPS Testing and Benchmarking
    - Mobile device GPS
    - New GPS technology?

4. **Geographic Information Systems (GIS)**
    - Basics of a Geographic Information System
    - Strengths and weaknesses of different GIS systems
    - Characteristics of Maps
    - Different GIS Data Formats
    - Maps Scales
    - Map Projections
    - Coordinate Systems
    - GIS for Precision Farming
    - Farm Management Information Systems (FMIS)
    - Who Will Generate the Maps?: Private versus Professional Analysis
    - Data visualization (e.g., Lidar, Google Earth)

5. **Yield Monitoring and Mapping**
    - Basics Yield Monitor Components
        - Impact vs optical
    - Yield History, Calibration, Cleaning
    - Yield Data Collection
    - Yield Data Formats
    - Yield Mapping
    - Understanding Yield Data
    - Displaying Data/Mapping/Legends
    - Yield Monitoring of Specialty Crops
    - Yield Stability
    - Field Comparisons/On-Farm research
    - Protein sensing integration
6. **Soil Variability Measurement and Management**
    - Soil Properties for Crop Production
    - Methods of Soil Sampling and Analysis
    - Grid Sampling
    - Soil Type Sampling
    - Mapping Soil Properties
    - Selecting a Soil Sampling Program
    - Issues to Consider with Grid Soil Sampling
        - The importance of defining the purpose
        - Random vs targeted sampling
        - Estimating the sampling requirement
    - Management Zones
    - Quantifying Spatial Variability
    - Topography
7. **Pest Measurement and Management**
    - Weed assessment and control
    - Insect assessment and control
    - Disease assessment and control
8. **Remote Sensing for Agriculture**
    - Remote Sensing
    - How Objects Interact with Electromagnetic Energy
    - Spectral, Spatial, and Temporal Resolution
    - Aerial and Satellite Imagery
    - Remote Sensing Systems
    - Remote Sensing Systems – Measures of Performance
    - Remote Sensing Systems – Characteristics
    - Use of Remote Sensing Data
    - Sources of Satellite-Based Remote Sensing Data
    - Sources of Aircraft-Based Remote Sensing Data
    - UAV Technologies – The Future of Remote Sensing???
    - Detecting Insects, Weeds, and Diseases with Remote Sensing
    - Creating Management Zones with Remote Sensing
    - Product Comparisons
9. **Soil and Crop Sensing**
    - Electrical Conductivity
    - Active Optical Sensors

- Proximal Sensing
- pH Mapping
- Ultrasonic Sensors
- Machine Vision

10. <u>Electronics and Control Systems</u>

- Application Control Systems
  - Liquid
  - Dry
  - Implement
  - Direct Chemical Injection
  - Other (NH3 and Manure)
- Spray Boom and Nozzle Control – Liquid and Dry Products - Automatic Boom Leveling and Section Control
- ISOBUS / CAN Communication
- Wireless Applications in Agriculture
- Telemetry
- Product Comparisons
- GPS-Aided Guidance
- GPS Auto Guidance Systems
- Implement Steering
- Equipment Control, i.e. Planter Downforce and Precision Placement

11. <u>Variable Rate Application</u>

- Seed, Pesticides, and Fertilizers
- Options for Implementing Variable-Rate Application (VRA)
- Comparison of Map and Sensor-Based Variable-Rate Application
- Components of all Variable-Rate Applicators
- Technologies for Variable-Rate Applications
- Individual row and section control
- Multi-hybrid planting
- Examples of Commercial Sensor-Based and Map-Based Variable-Rate Application Systems
- Liquid Chemical Application – Sensor-Based
- Issues to Consider with Variable-Rate Application
- Variable Rate Irrigation
- Future Applications of Variable Rate Technologies
- Needs for Further Development of Spatially-Variable Control

12. <u>Precision Agriculture Data Management</u>

- Collecting and processing data
  - Soil surveys
  - Historical aerial photos
  - Soil sampling
  - Weeds and other pests
  - Soil Sensors – i.e. Electrical conductivity,
  - Yield monitors
- Mobile Apps
- Data Mining
- Data Compatibility
- Data Interpretation and Correlation
- Big Data – Its Implications, include High Level Description of Data Science Tools
- Data Ownership

13. <u>On-farm trials</u>

- How to do set up
- Equipment considerations: calibration and implementation
- Narrow the objective
- Analyzing/interpreting the data
- Aggregating with other trials (within farm and across farms)

14. <u>Environmental Implications of Precision Agriculture</u>

- Nutrient Management – 4Rs
- Eutrophication
- Leaching
- Hypoxia
- Soil Erosion
- Nitrous oxide
- Cover Crops – Precision Residue Managment
- Water Management
    - Irrigation
    - Drain Tile Systems
    - Supply
- Weeds – Invasive and Herbicide Resistant Species

15. <u>Economics of Precision Agriculture</u>

- Using the Precision Agriculture Approach – Maximizing Farm Profitability
- Estimating Precision Farming Benefits
- Case Studies
- Using yield and soil maps to create fertilizer application maps,
- Grid vs management zone sampling,
- Creating variable rate plant population maps
- Opportunities for On-Farm Variety Performance Testing Using GPS-Enabled Technologies
- Making Drainage Decisions
- Managing Long-Term Soil Fertility
- Increasing Cost Effectiveness of Weed Control

Appendix A (Chapter 16) – Glossary of Precision Agriculture Terms

Appendix B (Chapter 17) – Videos / Multimedia of Precision Ag Technologies

Conclusion or Summary

Delivery of the manual will be made available through the American Society of Agronomy (ASA) on-line digital library. The expected completion date of the textbook is by the end of 2016.

After the Precision Farming Basics manual, as well as another publication, fifteen lessons/year will be tested in precision farming classes at the University of Nebraska, Oklahoma State University, and Colorado State University in years 2 and 3. Each university will test 5 different curricula each year, which results in 30 lessons tested in years 2 and 3. For each lesson, the students will complete pre and post assessments, and they will identify the strengths and weakness of the new curricula. Students enrolled at the University of Missouri and South Dakota State University represent a traditional curricula control group. These students will follow common protocols and will complete the identical pre and post assessments. Statistical comparison between changes in student outcomes in the non-experimental controls and experiential lessons will be conducted. Based on this analysis the curricula will be revised and research papers prepared.

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Chapter 15 – Economics of Precision Ag – Terry Griffin – Kansas State University

Appendix A (Chapter 16) – Glossary of Precision Agriculture Terms – Kent Shannon

Appendix B (Chapter 17) – Videos / Multimedia of Precision Ag Technologies – Brian Arnall – Oklahoma State University

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