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Overview of Variable-Rate Technology

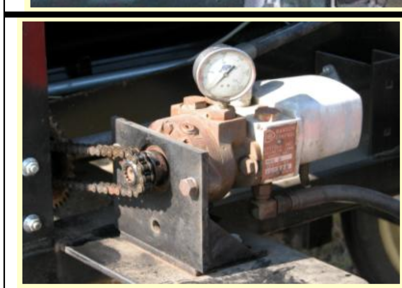
Introduction
Agricultural technologies using the global positioning system (GPS) and geographic information systems (GIS) have started to change how farmers are managing cropland. With these tools and the desire to manage existing field variability, variable-rate technology (VRT) has evolved. VRT describes any technology that enables the variable application of inputs. Therefore, VRT mounted on equipment permits input application rates to be varied across fields in an attempt to site-specifically manage field variability. This type of strategy can reduce input usage and environmental impacts along with increasing efficiency and providing economic benefits.

Figure 1. Example of a planter equipped with VRT.

How does the technology work?
Variable-rate technology combines a variable-rate (VR) control system with application equipment to apply inputs at a precise time and/or location to achieve site-specific application rates of inputs (Figure 1). A complement of components, such as a DGPS receiver, computer, and VRA software and controller are integrated to make VRT work (Table 1).

Three different approaches exist to implement VRT: **map-based**, **sensor-based**, and **manual**. In the **map-based** approach, a prescription map (Figures 2 and 3) is generated based on soil analyses or other information and then used by the VRT to control the desired application rate within each zone. The **sensor-based** approach is not discussed within this publication since it is new and under-development by most companies. However, this type of system utilizes sensors to assess crop or field conditions to provide real-time VRA of inputs. **Manual** control can also be used to vary the application rates with the operator responsible for changing the rates on the controller during operation.

Table 1. A VRT system includes the use of a computer loaded with the appropriate field application software, a controller, a DGPS receiver, and a control mechanism (i.e. hydraulic valve and motor) for the metering mechanism. A typical setup for a spinner spreader equipped with VRT is shown.

Example	Component	Description
	Computer	A laptop, PDA, or other computer systems is used (some equipment manufacturers produce their own such as John Deere). This component serves two purposes: 1) ability to run the application control software and 2) serves as the user interface.
	Controller	Processes and controls the application rate. Can be a separate system from the software and control mechanism. It uses the set point rate from the software and ensures the control mechanism (motor or actuator) is putting out the appropriate rate. It uses feedback from a ground speed radar (GSR) or other speed sensor to compensate for speed variations while also using a speed or position feedback from the control mechanism to ensure it is turning at the appropriate speed or positioned correctly.
	Software	Provides the ability to view prescription maps, determine the desired application rate based on field position, and logging. It reads the uploaded prescription map and communicates the desired application rates to the controller.
	DGPS Receiver	Provides position information which is used by the control software to adjust rates based on prescription map. It provides the ability to spatially log the actual rates applied for the generation of as-applied maps. A GPS receiver with differential correction (WAAS, Starfire, OmniStar, RTK, etc.) is recommended.
	Hydraulic Motor and Valve	Component which controls the meter unit. Can be a motor, linear actuator, or another control device. Shown is a hydraulic motor which uses a hydraulic control valve to adjust the flow rate to the motor thereby controlling the motor speed.
	Control and/or Metering Mechanism	The component which directly controls the feed rate. Examples of metering mechanisms would be an apron chain, seed disk, or liquid injection system.

Map-Based Approach

The map-based approach to VRA is popular since soil testing analyses and other information can be used to easily develop the prescription maps. Prescription maps can also be developed using additional information such as yield maps, historical management, soil texture or type, remote sensing (aerial or satellite), soil electrical conductivity, and terrain features (elevation, slope, etc). These maps can be generated using agricultural GIS software packages and can be either **grid-** or **zone-based** (Figures 2 or 3, respectively).

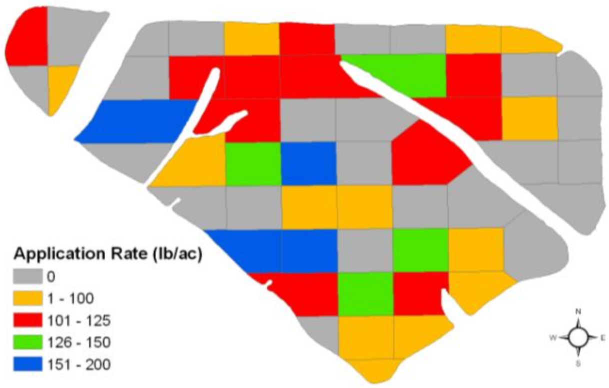


Figure 2. An example of a grid-based prescription map.

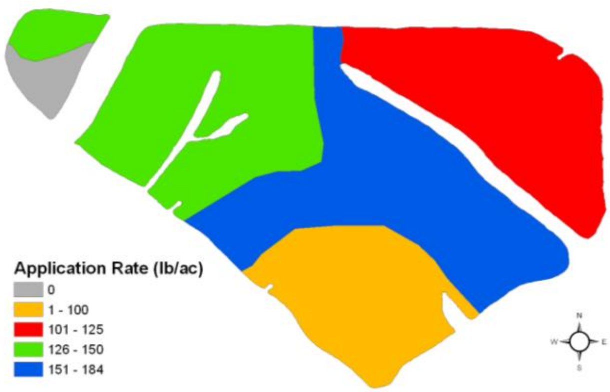


Figure 3. An example of a zone-based prescription map.

Uses of VRT

VRT continues to rapidly develop which coincides with advancements in electronic controls and communication. Application of VRT in crop production can include:

- Fertilizer (Macro and Micro nutrients) and Lime
- Pesticides (herbicide, insecticides, and fungicides)
- Manure (Litter)
- Seeding
- Tillage (vary depth based on level of compaction)
- Irrigation

Benefits

Variable-rate technology can provide several benefits:

Economics

- Increased input efficiency - apply only what is needed
- Could reduce overall amount of inputs used
- Improved in-field equipment efficiency
- Improved crop yields through optimal use of inputs

Environmental

- Minimize over-application of inputs thereby reducing the risk of pesticide and fertilizer runoff or leaching into water sources,
- Reduce application in environmentally sensitive areas

Considerations for Adoption

- Machinery can become more complex reducing reliability and increasing user frustration
- VRA requires good equipment management – calibration and proper maintenance
- VRA requires good knowledge of machinery
- Need to determine how to develop prescription maps
  - Assess field variability (i.e. soil variability through intensive soil sampling) using either grids or management zones
  - Generate prescription maps
  - Who will perform these activities? Producer, consultant, Co-Op?
- Need to define overall goal for using VRT (i.e. reduce costs, increase yields, improve environmental stewardship, etc.)

Additional Information

Also see ACES Timely Information Sheets:

- Introduction to Prescription Maps for Variable-Rate Application (January 2009)
- Calibrating Equipment with Variable-Rate Technology (January 2009)
- Overview of Automatic Section Control Technology (July 2008)
- Precision Soil Sampling for Alabama Farmers (January 2007)

Disclaimer

The mention of trade names and commercial products is for informational purposes and does not necessarily imply endorsement by the Alabama Cooperative Extension System.

Prepared by

John Fulton, *Assistant Professor and Extension Specialist*, Christian Brodbeck, *Research Engineer*, Biosystems Engineering Department, Auburn University and Amy Winstead, *Regional Extension Agent*, Shannon Norwood, *Multi-County Extension Agent*, Alabama Cooperative Extension System.