

Variable-rate fertilizer application allows crop producers to apply different rates of fertilizer at each location across fields. The technology needed to accomplish variable-rate fertilization includes an in-cab computer and software with a field zone application map, fertilizer equipment capable of changing rates during operation and the Global Positioning System (GPS). The fertilizer rate at specific locations within fields is based on the geo-referenced field zone map on the in-cab computer. The system includes a vehicle-mounted GPS unit to monitor field locations, allowing the computer to change the application rate between zones. Electronic communication between the in-cab computer and the rate controller on the application machine functions to change the fertilizer rate across the field.

Field Management Zones and Application Maps

Crop fields can be divided into management zones to allow producers to use different production techniques based on the unique conditions in each area of fields. Fertilizer application maps are prepared from zone maps to indicate the amount of fertilizer needed for crop production in each zone and used for variable-rate fertilization. Producers use management zones to assign a unique crop yield goal to each zone in fields. Variable-rate fertilization equipment is capable of changing application rates during field operation. Variable-rate fertilization uses GPS integrated with a computer in the tractor cab to change rates in each field management zone.

The number of zones in each field primarily is determined by variability within fields, with more uniform field conditions requiring fewer zones. Zone soil sampling determines the residual available plant nutrients, and this information is used with crop yield goals to select the rate of fertilizer to apply in each management zone.

Zone maps are made using a geographic information systems (GIS) computer program capable of combining

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Variable-rate Fertilization for Field Crops

Equipment Requirements

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field variability information to delineate field areas based on productivity levels. Several factors contribute to field variability, including topography, soil physical and chemical properties, cropping history, historical cropping patterns and field uses. A regional project in North Dakota, Montana and Minnesota concluded that a variety of factors can be used to develop zones, but topography, remotely sensed images of previous years' vegetative growth and historical crop yield data revealed the highest correlation to crop productivity.

Major farm equipment companies and several GIS companies market computer programs capable of combining the various layers of information to make field zone maps. Crop consultants or agricultural computer consultants are available to prepare zone maps for a per-acre fee.

Web-based zone map developing tools are available and allow users to develop field management zones online. ZoneMap (<http://zonemap.umac.org/>) is a zone mapping tool available for use without charge and is designed to develop both management zone maps and fertilizer application maps for the northern Plains region of the United States. ZoneMap allows users to build zone maps from historical vegetative growth patterns and upload and incorporate their own geo-referenced field information to help delineate field variability to develop management zones.

Both zone and application maps are digital computer files with unique digital formats. Users need to be mindful of the file format required by their in-cab controller and export and save the files in the appropriate format from the GIS program. Although zone maps are usable for more than one fertilizer application, refining zone boundaries annually is important to incorporate additional field variability knowledge gained from each year's crop yield and soil test analysis data.

Variable-rate Application Equipment

Since different equipment is needed for variable-rate application, depending on the type of fertilizer and the method of application, this publication describes the variable-rate liquid, gaseous or granular fertilization equipment in separate sections. However, since GPS use is common to all methods of variable-rate fertilization of field crops, an initial section outlines GPS equipment and in-cab controllers.

GPS Antenna and Receiver

Variable-rate fertilization relies on GPS to maintain constant equipment positions, allowing the in-cab computer to signal rate changes as the equipment moves from one field management zone to the next. Since fertilizer application equipment is normally wider than the horizontal error of even uncorrected GPS signals, any GPS signal accuracy usable for vehicle guidance is acceptable for variable-rate fertilization.

If the GPS receiver antenna is not mounted directly on the fertilizer applicator, the in-cab controller needs to be programmed to account for the separation distance between the GPS antenna and applicator to ensure the fertilizer rate is changed at the correct location as equipment moves into a new management zone.

Computer/Controller

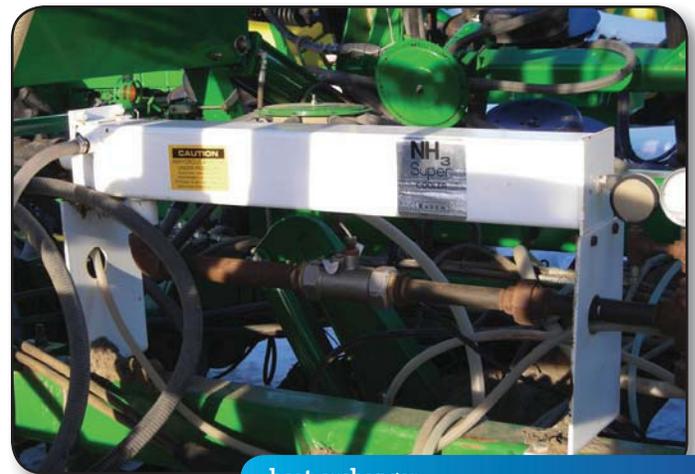
The central component of variable-rate application equipment is the computer/controller normally mounted in the vehicle cab. The controller performs several functions, including: 1) operating a software program to display the fertilizer application map, 2) recording the GPS signal to recognize the vehicle real-time position on the map, 3) communicating signals with the rate control device to alter the fertilizer rate, 4) monitoring vehicle speed and 5) recording the fertilizer application map.

Unfortunately, many older electronic monitors are not capable of performing variable-rate fertilization, requiring producers interested in variable-rate fertilization to purchase new controllers. Several functions are important when choosing a controller, including the ability to control and vary various products simultaneously, compatibility with other brands, compatible digital data formats, ease of interaction, the ability to record and save fertilizer application maps, and capabilities to perform other functions besides variable rate application. Other controller functions include operating spinner fertilizer spreaders, variable-rate and boom-section control on sprayers, and vehicle guidance systems.

Equipment for Variable-rate Application of Anhydrous Ammonia

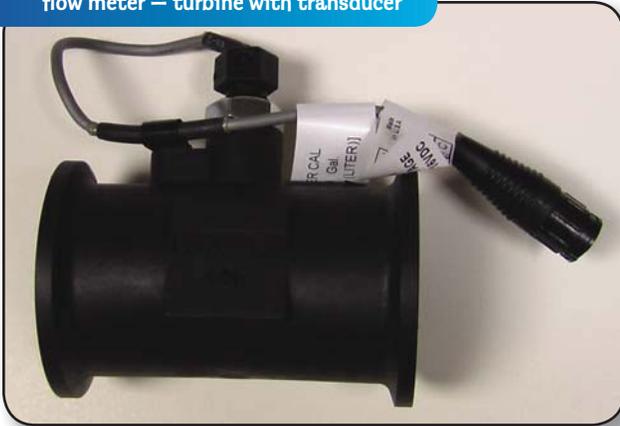
Applying variable-rate anhydrous ammonia requires an in-cab controller, GPS receiver, thermal transfer unit, flow meter and flow control valve.

The **thermal transfer unit**, also called an anhydrous ammonia cold-flow unit, functions to keep the anhydrous ammonia in a liquid state, which makes measuring it and controlling the flow rate more accurate. As anhydrous ammonia is released from the nurse tank, it becomes a vapor. The thermal transfer unit cools the vapor so it changes back to a liquid. This is accomplished by releasing a small amount of gaseous anhydrous ammonia into a heat exchanger close to the liquid anhydrous chamber. Since anhydrous ammonia vaporizes at minus 28 degrees Fahrenheit, it is an excellent refrigerant and functions to cool the anhydrous ammonia to keep it in a liquid form. The small amount of vaporized anhydrous ammonia used in the thermal transfer unit is injected continuously into the soil through one of the injection knives.



heat exchanger

flow meter — turbine with transducer



The **flow meter** is installed inline after the material leaves the thermal transfer unit to measure the amount of liquid ammonia that is flowing to the soil injection knives. An electrical connection from the flow meter is used to signal the constant flow rate to the in-cab controller. The flow rate is information required to change and control the rate for variable-rate application. Several kinds of flow meters are available for use with variable-rate equipment.

The **flow control valve** is a ball-type valve installed inline after the flow control meter with an electrical connection to the controller, which is similar to the connection to the flow meter. The controller functions with the flow control valve to vary the anhydrous ammonia flow to the injectors. Constant communication among the controller, flow control meter and flow control valve are required to maintain the desired application rate.

flow control valve



Variability among injectors can be minimized by keeping the anhydrous ammonia in liquid form and using high-quality distribution manifold and equal-length hoses to each injector. If hoses are not equal in length, the injectors closest to the distribution manifold will receive more anhydrous ammonia than the injectors farther from the manifold. Another problem can occur when operating on side hills. If one end of the applicator is higher than the other, the low end may receive more anhydrous ammonia than the higher end because of the effects of gravity.

Equipment for Variable-rate Application of Dry Fertilizer

Granular dry fertilizer can be applied in a separate operation with fan or air spreaders or in conjunction with planting using seeding equipment. Each of these options uses an in-cab controller, GPS receiver and a variable-rate option to adjust the application rate.

Fan-type fertilizer spreaders use a variable-rate electric or hydraulic motor to adjust the speed of the feeding apron or conveyor belt.



fan-type fertilizer applicator

Air-type fertilizer spreaders use a variable-rate electric or hydraulic motor to adjust the speed of the feeding screw conveyor.



air-type fertilizer applicator

The **variable-speed hydraulic or electric motor** changes the fertilizer application rate by adjusting the metering system, which is a screw conveyor, metering chain or conveyor belt. These units need to be calibrated for specific fertilizer blends because nitrogen, phosphorus and potash have different densities and flow rates.

variable rate motor, control valve and rate controller



Air Seeders and Planters

Fertilizer equipment for seeding equipment is similar to equipment installed on separate fertilizer applicators. The benefit of fertilizing equipment mounted on seeding equipment is everything can be done in one pass across the field. This often will save time and money. The disadvantage is fertilizer must be delivered to the field at a busy time of year. This sometimes can slow the seeding operation because fertilizer must be added to the fertilizer tanks on the seeder or ammonia tanks must be hauled to the field and connected behind the seeder. An ammonia tank behind the seeder may require an operator to make larger turns at the end of the field. This may slow the operation and be undesirable for the operator.

variable rate transmission on air seeder



The use of ammonia at seeding time usually will require placing the ammonia at least 3 inches from the seed row. Usually the ammonia will need to be placed below and to the side of the seed row to obtain this distance.

Getting Started

The easiest way to begin variable-rate fertilization with field crop production is to hire a commercial fertilizer applicator equipped with this technology. Most commercial applicators add a fee for variable-rate application; however, the total cost for small acreages likely will be less than purchasing equipment.

Producers also could retrofit granular fertilizer spreaders or anhydrous ammonia applicators to get started in variable-rate fertilization. This will involve adding a variable-rate electric or hydraulic motor to vary the speed of the conveyor belt and a rate controller in the tractor cab.

Modifying an anhydrous ammonia applicator to accomplish variable-rate fertilization involves adding a heat exchanger on the applicator to maintain the anhydrous ammonia in liquid form, a flow control valve, a flow control meter and a rate controller in the tractor cab.

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