Site-Specific Management Guidelines

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SSMG-7

Variable Rate Equipment—Technology for Weed Control

Summary

Sprayer controllers have been developed by agricultural equipment vendors to minimize variation of applied rates of chemicals within fields. The control systems that allow these devices to compensate for changes in vehicle speeds now also provide the potential to apply variable rates of pesticides according to preplanned maps. The types of sprayer systems and controllers capable of variable rate control are discussed here, along with their advantages and disadvantages. Communications between task computers used to store maps and these sprayer controllers are also discussed.

Are you considering the possibility of applying your weed control products at variable rates? Perhaps you apply preemergence herbicides for which recommended rates are based on organic matter. Furthermore you recognize large variability in organic matter within your field units. If so, variable rates may improve overall herbicide performance and reduce costs while reducing the risk of carryover damage to subsequent crops. Perhaps your farming operation has grown to the point that you are no longer completely familiar with all of the fields and local weed pressure areas within them. Do you have a need for more than one herbicide tank mix in your field? Perhaps you have other operators for your application equipment who are even less familiar with those fields than you are. Any of these may be reasons to consider the application of chemicals from a map-based sprayer system.

Most of us have practiced a form of variable rate application with a conventional sprayer. By conventional, I am referring to a system in which the chemical is tank-mixed with the carrier (water), and the nozzles and pressure regulating valve are calibrated to provide a desired volumetric application of mix at a certain vehicle speed. Any change in the boom pressure or vehicle speed from that of the calibration results in an application rate different from the planned rate. We have all used this to our advantage at times. For example, when observing an area of heavy weed infestation you might manually increase the pressure or reduce speed, thereby applying a higher (and somewhat unknown) rate of herbicide. Most precision application technologies rely on the use of a map of planned application rates, coupled with a GPS receiver, to determine the appropriate herbicide rate for a given area in the field.

If you have begun adopting some precision ag technologies, then you might have a yield monitor and a GPS receiver. Since the GPS receiver is necessary for map-based application of inputs you already may have one of the big items on hand. Two other components are required to conduct VR application of herbicides. First, some form of “Task Computer” will be required to provide a signal indicating the current target rate for the current location. Second, a system for physically changing the application rate to match the current target rate will be required. Let’s examine the technologies available for this part of the overall system first.

There are a number of different types of control systems on the market today that are adaptable to precision application. For the purposes of this discussion I will lump them into three categories. The first is flow-based control of a tank mix. The second is chemical injection based control, and the third is chemical injection control with carrier control. Incidentally, all of these systems evolved out of the desire to automatically match application rates to variations in ground speed. This eliminates much of the error in application that could occur if ground speeds change from the calibrated setup. The systems are effective at reducing this error. With the application rate managed by an electronic system, the ability to apply variable rates is a logical next step. This requires that the target application rate, or set point, be changeable according to the rate established for that location.

Flow-Based Control Systems

The flow based control of a tank mix is the simplest of the three types discussed here. These systems combine a flow meter, a ground speed sensor, and a controllable valve (servo valve), with an electronic controller to apply the desired rate of the tank mix. A microprocessor in the

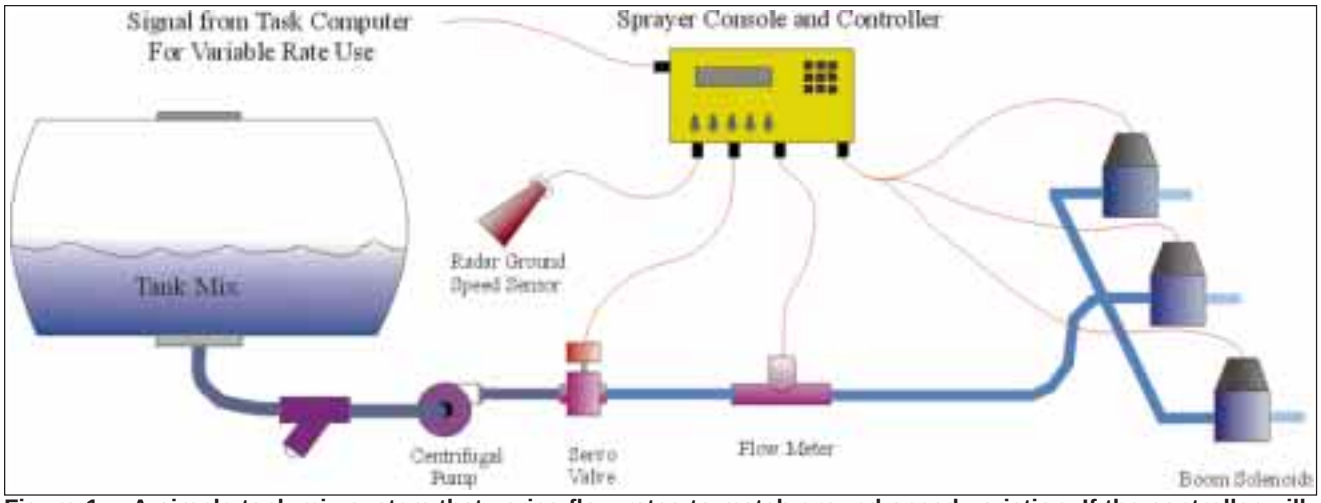

Figure 1. A simple tank mix system that varies flow rates to match ground speed variation. If the controller will accept an RS 232 input for a rate command from a task computer this system can do variable rate application.

console uses information regarding sprayer width and desired gallons per acre to calculate the appropriate flowrate for the current ground speed. The servo valve is then opened or closed until the flowmeter measurement matches the calculated flowrate. If a communication link can be established between this controller and a "map system," a variable rate application can be made. How the communication is accomplished will be discussed later. An illustration of the components comprising such a system is shown in **Figure 1**. Examples of commercial systems with flow-based control capability include Micro-Trak's 9000 series controller, Mid-Tech's 6100 series, Raven Industries SCS 440 or higher, and Dickey John's Land Manager and PCS systems. These systems have the advantage of being reasonably simple. They are also able to make rate changes across the boom as quickly as the control system can respond to a new rate command, which is generally quite fast.

As with any technology flow-based controllers also have limitations. The flow sensor and servo valve control the flow of tank mix by allowing greater or lesser pressure to be delivered to the spray nozzles. This can result in large changes in droplet size in the spray, and potential problems with drift. Some systems will warn you when the commanded flow rate is outside the best operating range for your nozzles. You can adjust the vehicle speed to get the flow rate back into an acceptable range. Also, an operator may have to deal with leftover mix and is exposed to the chemical during the mixing process. If you want a relatively simple system and can live with these limitations, this one should meet your needs while giving you the capability of applying variable rates of herbicides.

Direct Injection

An alternative approach to chemical application and control uses direct injection of the chemical into a stream of water. These systems utilize the controller and a chemical pump to manage the rate of chemical injection rather than the flow rate of a tank mix. The flow rate of the carrier (water) is usually constant, and the injection rate is varied to accommodate changes in ground speed or changes in the commanded rate. Again, if the controller has been designed, or modified, to accept an external command, the system can be used to do variable rate

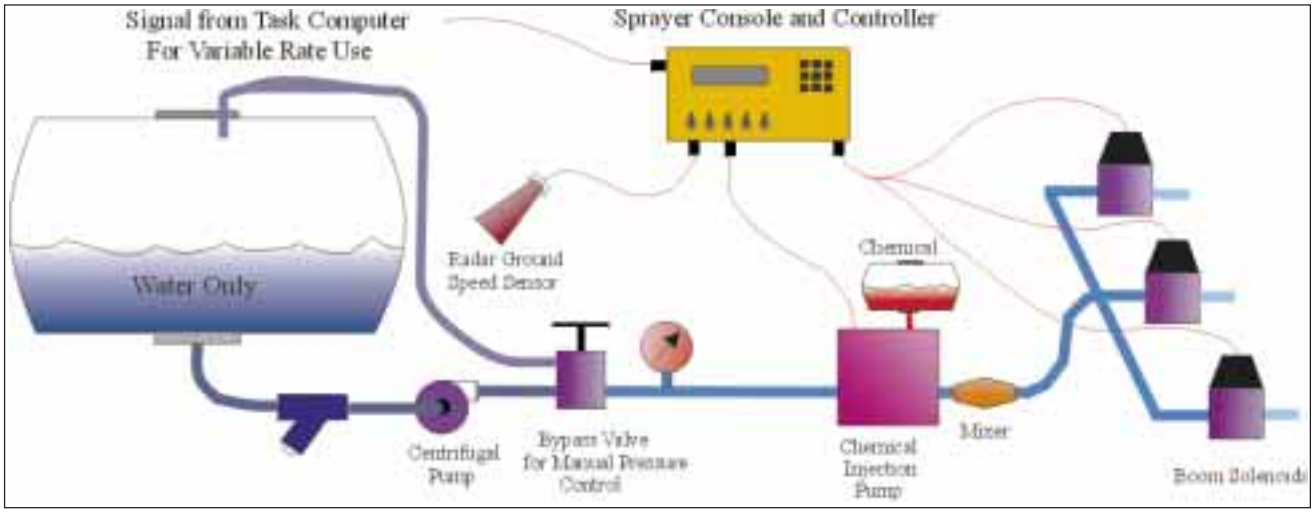

Figure 2. A direct chemical injection system. Water flow rate is set separately by adjusting pressure. If the controller will accept an RS 232 rate command, a task computer can be used to apply variable rates.

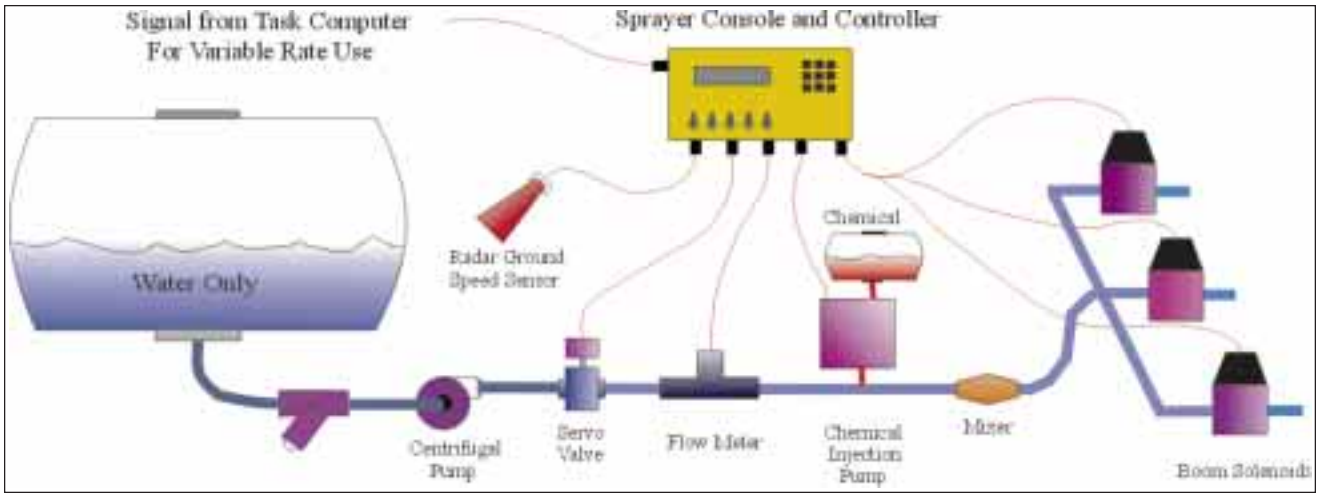

Figure 3. A chemical injection system with carrier control. The system increases or decreases both chemical flow rate and water flow rate to match ground speed variations. Controllers that accept external inputs of rate commands can do variable rate application.

application. The components of a system are shown in **Figure 2**. Chemical injection eliminates leftover tank mix and reduces chemical exposure risk. An additional advantage of this system is that the constant flow of carrier can be adjusted to operate the boom nozzles to provide droplets with a desirable size and distribution. The principle *disadvantage* for variable rate control is the long transport delay between the chemical injection pump and the discharge nozzles at the ends of the boom. The volume of this plumbing must be applied before the new rate reaches the nozzles. This can cause large delays in the rate change and "christmas tree" patterns of application as the new concentration of chemical works its way out through the boom. For example, a simulation of a farmer-owned broadcast sprayer conducted at South Dakota State University indicated that nearly 100 ft. of forward travel would occur before a newly commanded rate would find its way to the end nozzles of that sprayer. These limitations have lead to systems that use both carrier and injection control. Raven Industries, Micro-Trak, and Dickey John all have injection pump systems. All would also recommend that for variable rate applications they be used in conjunction with carrier control as described below.

Direct Chemical Injection with Carrier Control

Chemical injection with carrier control requires that the control system change both the chemical injection rate and the water carrier rate to respond to speed or application rate changes. One control loop manages the injection pump while a second controller operates a servo valve to provide a matching flow of water. A perfect system of this type would deliver a mix of constant concentration just as if it were coming from a premixed tank. The system can have many of the advantages of both of the earlier systems. Direct injection of chemical means that there is no leftover mix to worry about, and the operator is not exposed to chemicals in the process of tank mixing. Changeover from one rate to another occurs as quickly as both chemical and carrier controllers can make the change, which is generally very fast. Disadvantages include a more complex system with higher initial cost, and the problem of pushing varying amounts of liquid through the spray nozzles as rates change, with the resulting changes in droplet and spray characteristics. Available systems that fit into this category include, but are not limited to, the Raven SCS 700 series, the Mid-Tech TASC 6300 system, or the Micro-Trak TNi1740. If you do a lot of spraying and wish to avoid the hazards of tank mixing, these systems will give you a great deal of control over your spraying operations and offer the capability of applying variable rates of herbicides from a pre-planned map.

A few specific control systems have been mentioned here. However, this is an area of rapid change, and new models with advanced features debut regularly. I suggest searching the world wide web using the manufacturer's name as a keyword as a means of locating product descriptions and specifications. Most systems will fit into one of the categories described here. At the time of this writing there are some useful sites, such as www.horvick.com/news/news.html and www.precisionag.com/prodnew.html that provide information regarding various spray systems and their specifications. However, web based resources change rapidly and a search will undoubtedly turn up new information that may help in selecting an appropriate system for your farming practices.

Putting it All Together

The discussion so far has centered around how the different controller and plumbing systems achieve a given rate of application. The other part of implementing variable rate, or site-specific, weed control concerns how we store and communicate commanded rates to these sprayer systems. In simple terms, this requires a "task computer" and a communications link. The task computer holds the map of rates that you have planned. This map would most likely have been developed on your desktop computer with a mapping program. That program must save the application map in a form understandable to your task computer. Note that the task computer could actually be a conventional notebook computer running the desktop software, but the industry is moving towards more rugged

devices with fewer moving parts. Examples of these include Raven's AMS198 and John Deere's Green Star system. The Ag Leader PF3000 system combines this task computer concept into the yield monitor console so that the unit can serve both purposes. Other systems are undoubtedly available, these are only examples. The map is typically loaded into the task computer on a PCMCIA card that uses no moving parts. Current practice also includes connecting the GPS receiver to the computer. The software running on the task computer then determines the current rate command based on the coordinates it receives from the GPS receiver and sends the rate for that management zone to the sprayer controller.

How the chemical rate information is passed from the task computer to the sprayer is another issue. Current practice in most cases is to use the RS 232 Serial Interface to connect the task computer to the sprayer controller. This standard interface is able to send strings of characters and numbers from a task computer that the receiving device can use, *if they are in exactly the right format.* A properly formatted message might begin, for example, with a specific character to signify a chemical rate and be followed by a specific number of digits that represent the actual rate to the controller. These messages are currently specific to each controller manufacturer. Raven, Micro-Trak, and Dickey John allow direct connection of an RS 232 cable for this purpose. Mid-Tech uses a DataLink communications managing module between the task computer and their sprayer controller. In each case it is necessary for your task computer software to be fully aware of the format of the rate message required by the device with which it is communicating. Companies generally make this format available to anyone who needs it, including mapping software developers. If your mapping program has 'drivers' for your brand of sprayer system, communication between the software and sprayer should not be a problem. 'Drivers' are small computer files or programs that tell your software the specific ways to deliver information to another specific device. If drivers are not available, it will require more work and some understanding of your software and serial communications to make the two devices function together. This communications link is usually used in both directions as the sprayer controller sends the current measured application rate back to the task computer which records this information as a part of a map record. If you are discouraged by the complexity of an overall system for use in variable rate weed control you may wish to read the guideline entitled *Standardization and Precision Agriculture—The Promised Land* (SSMG-8). There is hope on the horizon for the complex systems of precision agriculture.

Whatever your level of technology usage today, it is valuable to stay informed with regard to the changes occurring in production agriculture. Not all new technologies offer clear and large economic benefits to all producers. However, being familiar with the technology will allow you to decide which pieces of the precision puzzle may be used to help you survive and thrive in a competitive world. ■

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