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Field Evaluation of a Variable-Rate Aerial Application System

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Abstract. *Variable rate aerial application systems are becoming more readily available; however, aerial applicators typically only use the systems for constant rate application of materials, allowing the systems to compensate for upwind and downwind ground speed variations. Much of the resistance to variable rate application system adoption pertains to applicator's trust in the systems to turn on and off automatically as desired. If an application system operating in an automatic mode were to malfunction, the aerial applicator would be held liable for the misapplication. The objectives of this study were to evaluate a commercially available variable rate aerial application system under field conditions to demonstrate both the response and accuracy of the system to desired application rate inputs. This three year study involved planting oats, ryegrass and wheat in a 35 acre fallow field during the winter months to establish a uniform green backdrop by early spring. Binary prescription application maps were then generated and aerial applications of glyphosate were then made to this field using an Air Tractor 402B agricultural aircraft at 130 MPH with VeriRate variable rate aerial nozzles. Airborne multispectral imagery taken before and 14 days after the applications documented actual field deposition and efficacy of the glyphosate. The aerial imaging system was comprised of two high resolution cameras. One camera was outfitted with red, green, and blue filters while the other camera had been modified with a near-infrared filter. When compared to the prescription application map, these data provided application system response and accuracy information which showed that spray deposited,on average, within 20 feet of the target. The results of this study will be useful for quantifying and documenting the response and accuracy of a commercially available variable rate aerial application system so that aerial applicators can be more confident in their capabilities and the use of these systems can increase, taking advantage of all that variable-rate application technologies have to offer.*

Keywords. *Aerial Application, Precision Application, Remote Sensing, Variable-Rate Application.*

Introduction

Variable rate aerial application systems have been around for a little over a decade now, made possible by the rapid GPS technology advances in the mid-'90s. This technology opened up the possibility of applying pesticides, fertilizer and seed by air on an "as-needed" basis within a field.

These application systems are commercially available from several different companies. In addition to the normal types of spray equipment that typically are on an agricultural aircraft, they typically consist of a navigation system with a touchscreen display, lightbar, on-board computer to process inputs, flowmeter and a flow control valve. They can be used to provide constant rate or variable rate application or switched to bypass mode and operated manually. Most aerial applicators only use the constant rate capabilities of the system to compensate for upwind and downwind rate variations due to increasing or decreasing groundspeed.

In constant rate or variable rate mode, pilots can use the field boundaries to have the system automatically turn on and off the spray. When the pilot gets to the field, he would line up to make his first pass and open the spray handle as he enters the field. He would not have to touch the spray system again until exiting the field, at which time he would close the spray handle. A lightbar instructs the pilot where he needs to be for his spray swath and lets him know if and how much he's off of the spray line and by how much. During the spray job, a spray application log is created showing the field boundaries, spray zones, flight path and speed of the aircraft, and when the spray system was active during the job. With an installed height gauge, the aircraft's boom height above canopy also can be recorded. Currently, and perhaps justifiably, many aerial applicators are hesitant to use this automatic on/off feature because of the liability that comes along with it. If the system fails to turn off where it's supposed to, spray applications could be made outside of the field boundaries. Failure to turn on when needed would leave portions of the field unprotected. These scenarios could be disastrous.

Realizing that there was a great deal of uncertainty about how well these variable rate aerial application systems might perform in the real world, three years ago, we started conducting field studies to see how well they really worked. Specifically, we wanted to know how narrow the spray zones could be and how accurately the system could deliver the spray.

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Materials and Methods

For three consecutive years, a 35-acre research field was planted in a winter cover crop. This provided a nice green background for early spring of the following year. We created a binary on/off prescription map for the field (Figure 1) and sprayed glyphosate (32 oz./acre) over the field according to that prescription using our Air Tractor 402B equipped with a Satloc M3 IntelliStar system and 35 VeriRate nozzles (Figure 2). The airplane was flown at 130 mph with a spray swath of 65' and target application rate of 3 gallons per acre (GPA). The first year, we evaluated multiple 100- and 300-foot spray zones flying into the wind. The next year, we tested 50- and 100-foot spray zones into the wind. Earlier this year, we looked at 75-foot and 100-foot spray zones, applied both upwind and downwind. A Cessna 206 equipped with multispectral cameras was used to take aerial imagery immediately before and 14 days after the spray application. This allowed us to see exactly where the spray landed.

Figure 1. 35-acre ryegrass field with prescription application map overlay used for testing the system response of a variable rate aerial application system. The black boxes are 75' and 100' spray zones where 3 GPA of glyphosate solution were sprayed.

Figure 2. Air Tractor 402B equipped with a set of VeriRate variable rate aerial nozzles.The VeriRate nozzles are specially designed to apply a range of application rates using only changes in pressure without significantly impacting droplet spectra.

Results and Discussion

When overlaid with the prescription map, color infrared imagery, taken 14 days after treatment, showed excellent alignment between the targeted 100’ spray zones and where the spray actually deposited in the field (Figure 3). The average deviation from the intended spray boundary was approximately 20 feet, regardless of whether the plane was traveling upwind or downwind The variable-rate aerial application system, however, was unable to consistently apply product in the 75’ spray zones. Since the application system uses a wind driven pump to pressurize the system, it takes about one half second for the system to fully pressurize the boom and nozzles to initiate spray. Traveling approximately 200 ft./s, the 75’ zones do not allow the system enough time to develop the required pressure before the system gives the command to stop spraying. If the aircraft was equipped with a hydraulic pump, which provides more rapid pressurization, spray zones smaller than 100’ might be possible.

In addition, the aerial imagery also shows that the variable rate aerial application system was able to consistently turn on and off automatically as the plane flew over the field. The pilot merely had to open the spray valve to start the first pass and then close the spray valve at the end of the last pass. Usually, the pilot has to open and close the spray valve at the beginning and end of each spray pass. The beginning and end of each spray pass are normally the most dangerous areas in the field as trees, powerlines and fences are typically colocated with these areas. When the pilot can trust the system to perform as expected, he can then focus his attention on piloting the aircraft safely instead of concerning himself with the spray system. This aspect can greatly reduce stress and fatigue on the pilot, increasing the overall safety of the operation.

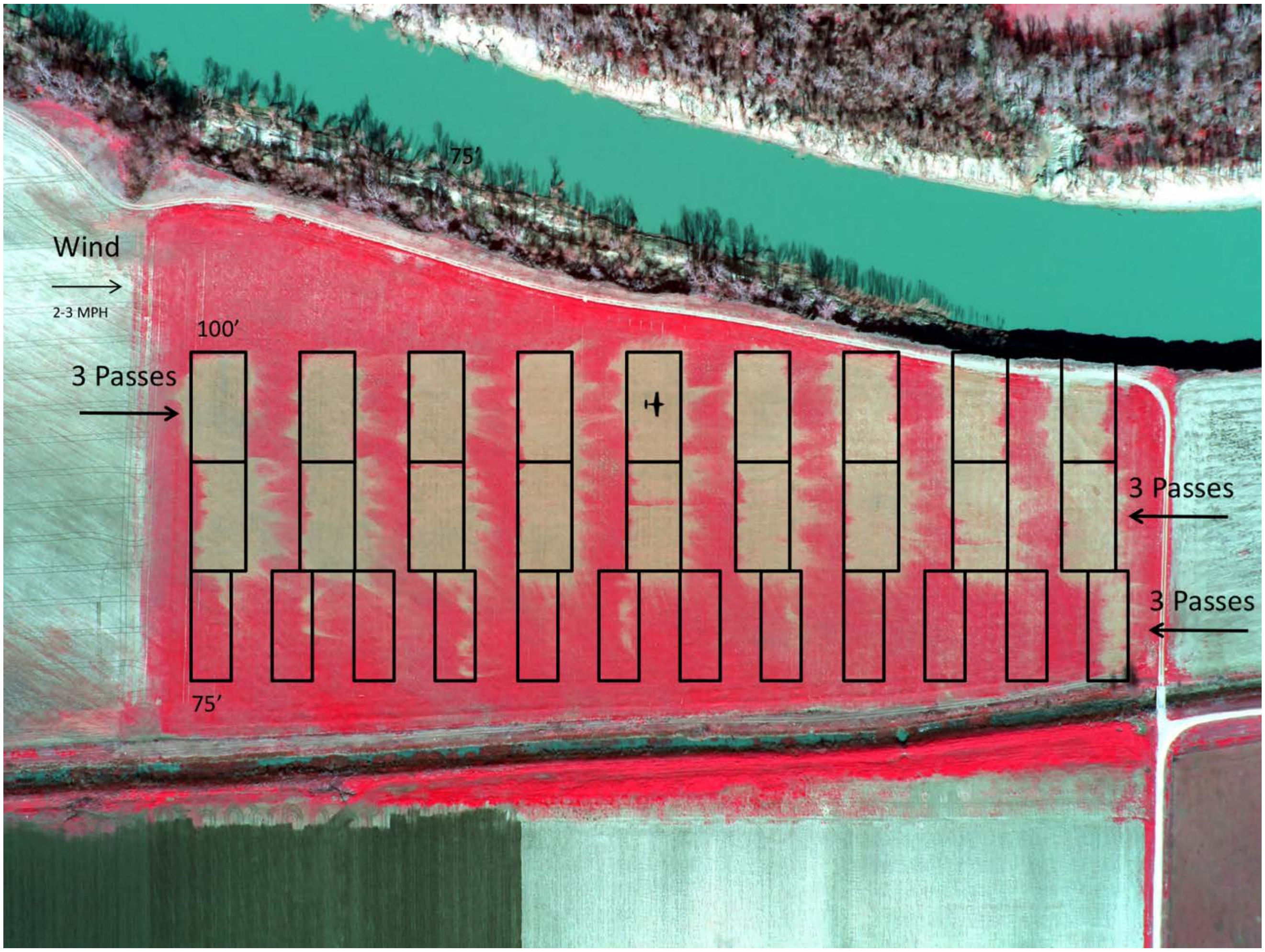

Figure 3. Color infrared imagery of a 35-acre ryegrass field with prescription application map overlay. Areas where glyphosate was sprayed appear beige.

Conclusions

Overall, the variable-rate aerial application system performed very well with the 100' spray zones. Average deviation from the target boundaries was approximately 20', regardless of whether the airplane was traveling upwind or downwind. The system was unable, however, to adequately commence and terminate sprays in the 75' spray zones. Pilot safety was increased by use of the automated system as the pilot could focus solely on flying the aircraft rather than having to additionally operate the spray system.

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