PERFORMANCE ASSESSMENT OF VARIABLE RATE FERTILIZER TECHNOLOGY

By J.P. Fulton, Department of Biosystems Engineering
Auburn University
M.W. Veal and S.A. Shearer, Department of Biosystems and Agricultural Engineering
University of Kentucky

Introduction

The development of spatial management tools such as the global positioning system (GPS) and geographic information systems (GIS) has allowed for agricultural resource management decisions to be made with greater detail and precision. This idea of site-specific management has been around for many years, but it is the tools developed in the 1980's and 1990's that have allowed this management method to grow in popularity. An important outcome of this method has been the opportunity to manage the variability within a tract of land at increasingly finer resolution when compared with the "field-average" approach of the past. However, site-specific management is currently limited by the ability of existing equipment to physically apply a management strategy within the confines of a management zone. Pneumatic and spinner disc applicators are two types of variable rate application (VRA) tools that are susceptible to a number of distribution control errors that compromises their ability to effectively apply a fertility regiment in relation to plant needs and existing localized soil conditions. Two common types of granular applicators are shown in Figure 1.

a) Truck-based pneumatic applicator

b) Spinner disc applicator.

Figure 1: Commercially-available applicators.

Field Research

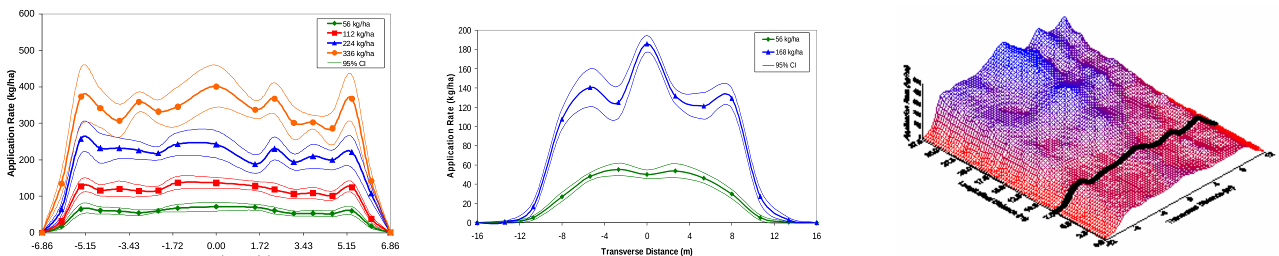
Research efforts at the University of Kentucky have attempted to quantify and identify application errors associated with spinner spreader and pneumatic fertilizer applicators. Among the problems addressed by this work is the variability across the application swath and delayed/sluggish rate changes as they affect distribution patterns. These distribution problems contribute to application errors within management zones, along field borders, or within environmentally sensitive regions of a field. To properly assess the distribution pattern, each applicator truck was driven across a test plot that consisted of an array of evenly-spaced catch pans. Figure 2 illustrates the field test set-up and the weighing of the collection pans. Following each applicator pass, the granular material from each pan was collected and weighed. A test regiment of fixed and variable-rate application passes was conducted for either applicator in an attempt to characterize system performance.

a) Collection Pan Array

b) Weighing collection pans.

Figure 2: Field evaluation of granular material distribution patterns.

Figure 3 illustrates how the distribution of material occurred across the boom of a pneumatic fertilizer applicator (3a) for four different application rates and a spinner disk applicator (3b) at two different application rates. The results for the both applicators indicate increased deviations from the desired pattern (even distributions for air-boom applicators, and Gaussian distributions for spinner disc applicators) at higher application rate. Further, figure 3b illustrates a shift in distribution pattern from the characteristic "M" pattern at low application rates to a "W" pattern at higher rates. Figure 3c not only depicts the non-uniform application rates across the boom, but also illustrates the sluggish systems response when changing from low to high application rates. The black line running across figure 3c indicates where the input command for a rate change occurred, however the actual change is gradual. Similar responses were also observed for the spinner disc applicators investigated.



a) Distribution for a pneumatic applicator

b) Distribution for a spinner disk applicator

c) Distribution for a pneumatic applicator during a low to high rate change

Figure 3: Field distribution patterns for pneumatic and spinner disk applicators.

Overall Applicator Performance

Once the applicator distribution was defined a spatial data model was developed within a GIS package to fully assess how well the actual application surface matched the prescription map. The "as-applied" file download from the applicator was used to generate the path and application rates as the truck traversed the field. At each GPS position contained within the "as-applied" file, a series of 13 polygons, normal to the direction of travel, was generated to represent how granual material was distributed across the spread width for that applicator. A grid of points was laid over the poloygon to aid the the analysis of overlapping passes. Using the coordinates of a single grid point, application rates polygons beneath the points were summed to determine the overall application rate for that location. Figure 4 illustrates the output of this model. At any point in these fields that a dot is visible (i.e., a color that differes from the background perscription color) the rate from the "as-applied" surface differed from the prescribed rate. Using a data from randomly selected sites within these fields the correlation (R^2) between this model generated ("as-applied") surface and actual field application was found to be as high as 0.77.

The spatial model was applied in several fields to determine the correlation between as-applied maps to prescription maps, it was found that spinner disk applicators have R^2 values ranging from 0.15 to 0.75 and pneumatic applicators range from 0.24 to 0.81. An R^2 value of one would represent a perfect match between the prescription and "as-applied" surfaces. Another factor that became apparent from this investigation is the responsibility of achieving accurate in-field product placement that resides with personnel that calibrate and operate the application equipment. This factor was determined to be more important than equipment selection, as an irresponsible operator always produces poor "as-applied" surface maps.

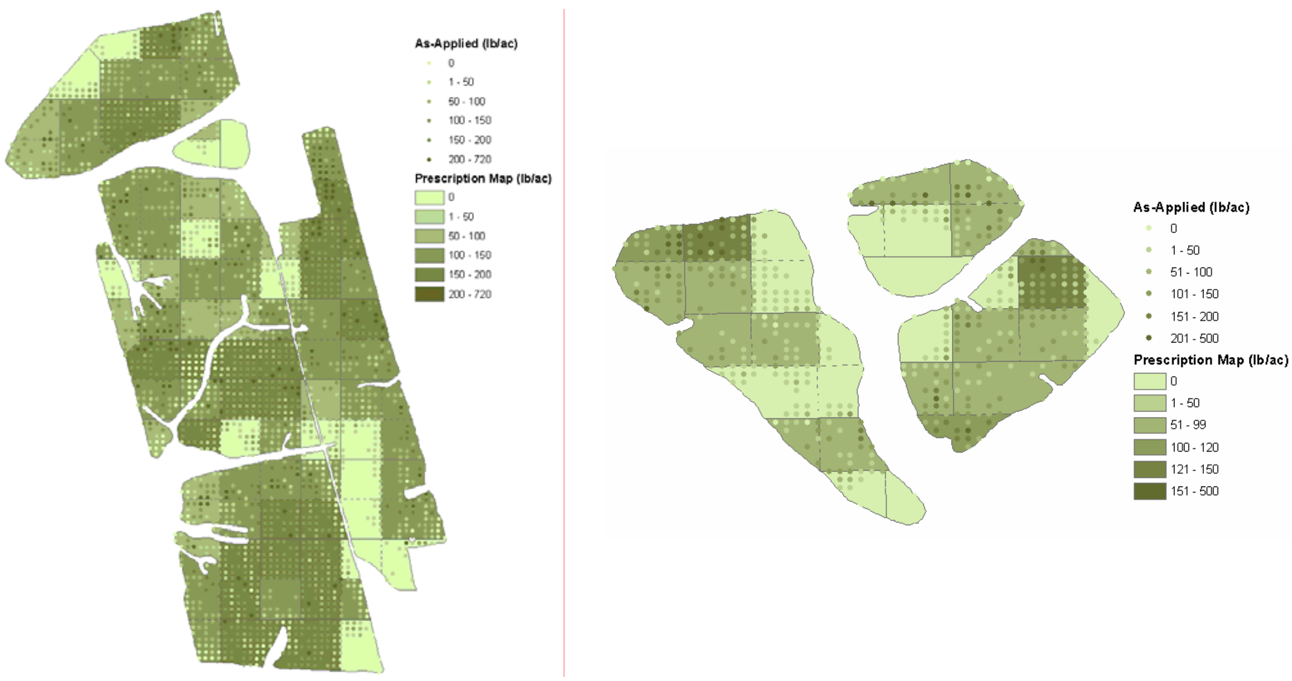


Figure 4: Spatial data model used to evaluate the as-applied rate to the prescribed rate.

Future Direction

Recent trends in the development of machinery and tools exploit the use of microcontrollers to enhance machine function by controlling functions on the machine with ever increasing resolution and precision. Fortunately, the same University of Kentucky researchers that studied the phenomena of fertilizer applicator discharge patterns have the ability to correct the problem through the utilization of low-cost microcontroller-based control networks. These economical and efficient control networks are the foundation of a new metering system to control the flow of granular material to individual distribution lines of a pneumatic applicator. The proposed metering system will consist of small metering devices that are operated independently of one another. By controlling the rotation of star metering wheels via a DC electric motors it will be possible to meter granular fertilizer with increased precision and accuracy. The result of this project will be an improved variable rate application (VRA) tool that will facilitate fertility management by the square meter as opposed to boom or spread width management in use today.

For More Information

John P. Fulton, Department of Biosystems Engineering, Auburn University
fultojp@auburn.edu (334)844-3541

Matt W. Veal, Department of Biosystems and Agricultural Engineering, University of Kentucky
matt.veal@uky.edu (859) 257-3000, extension 119

Scott A. Shearer, Department of Biosystems and Agricultural Engineering, University of Kentucky
shearer@bae.uky.edu (859) 257-3000, extension 218

Precision Agriculture for Kentucky http://www.bae.uky.edu/precag/