Fluid JOURNAL
Official Journal of the Fluid Fertilizer Foundation
Late Spring 2009
Vol. 17, No. 3, Issue #65

Matt Wiebers, Dr. Matias Ruffo, and Dean Fairchild

GPS-Enabled Systems Monitor Spatial Variability And Yield Potential

Application rate controllers, used in conjunction with a yield monitor, are an effective way to generate local on-farm results.

There is a need for guidance on how farmers can use precision agriculture technologies to conduct on-farm research studies. Both farmers and dealers prefer to use local data to make management decisions, but they have lacked guidance on a practical approach to perform such studies with this technology.

Coupling the high degree of accuracy now possible with these systems and a compatible research protocol, farmers and dealers have access to a powerful set of tools to build local databases. The advances in the technology surrounding precision agriculture continue to grow and the cost of these systems is now within the budget of almost every farming operation.

Current technology

GPS. Many progressive farmers have purchased high-end GPS receivers for tractors and combines to use in auto-steering guidance. These GPS receivers have the capability of using differential correction from multiple sources such as RTK, WAAS, and Omnistar. The accuracy of each correction source is different, but all systems are now measuring accuracy in inches versus feet when GPS was introduced into agriculture. In addition, most of these new receivers are versatile enough to use either the US GPS system or the Russian GLONASS system. The accuracy of these systems allows farmers to know virtually every inch of their field.

Control/Logging. In the past, rate controllers and a logging computer were often separate boxes in the tractor cab. Figure 1 shows an AgLeader PF3000 monitor and Hiniker 8605 rate controller. In this example, the GPS latitude and longitude position is received by the AgLeader system. The corresponding application rate is determined from a prescription map loaded onto the data card. The AgLeader system transmits the desired (target) rate to the Hiniker rate controller via a serial cable. The rate controller recognizes the rate change and makes an adjustment to the rate. Simultaneously, the actual applied rate is being read by the rate controller and logged by the AgLeader system. This process repeats every couple of seconds.

Figure 1. AgLeader PF3000 and Hiniker 8605 rate controller.

This process works well, but it is subject to problems. These problems can include improper cables, loose connections, and damaged connectors or pins. Fortunately, the next generation of controllers such as the Raven Viper Pro, AgLeader Insight, Greenstar 2, Topcon X20, and AgCo Fieldstar have eliminated many of the challenges inherent in connecting different systems together. These integrated systems reduce cab clutter, use color touch screens, and have intuitive displays.

Current approaches

A review of available literature on the topic of on-farm research reveals an emphasis both on the design of the experiment and collection of calibrated yield data. However, there is little discussion about the importance of collecting the as-applied data. Experience tells us that even under ideal conditions the intended target rate and actual rate can vary significantly for several reasons such as:

- Speed of machine exceeds the capability of the applicator to achieve the target rate
- Rapid speed changes cause over- or under-application
- Uneven product flow from the machine
- Mechanical breakdown
- Accidental skip and overlap

Spatial variability. One of the most commonly used approaches to on-farm research is field-length strips. These strips are set up to compare a local farming practice against some new fertilizer product or method. In fields where soil type, drainage, and other yield-influencing factors are significant, this spatial variability alone can induce yield differences that can mask an anticipated response in the study. This can be a limitation of field length strip trials in on-farm research when variability is not managed by replications or by analyzing data within each strip.

Data analysis. At harvest, a farmer will look at the screen of his yield monitor to gauge the success of a new product or method. This often is the extent of the analysis with the conclusions based solely on the numbers computed by the yield monitor and not any additional statistical or economic analysis. Current mapping software is making this process easier, but data analysis is still viewed by many as a complex procedure.

Figure 2. Digital Othophoto.

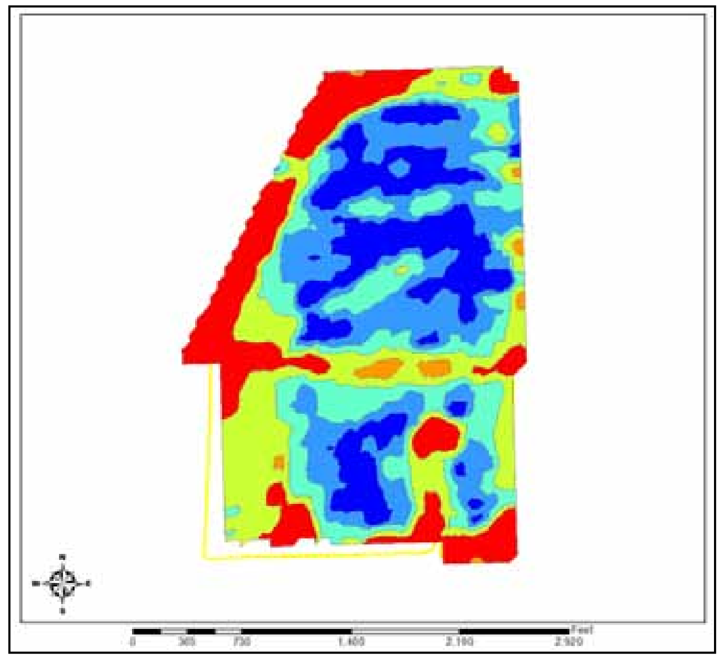

Figure 3. GPS yield map.

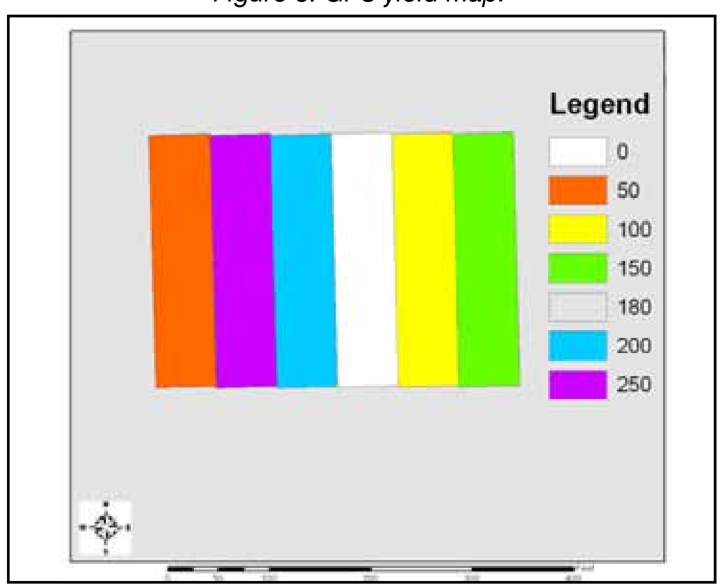

Figure 4. Typical stamp.

A unique approach

Beginning in 2003, Mosaic partnered with the Crop Physiology Laboratory at the University of Illinois to study the spatial variability of corn response to nitrogen (N). During the development of this approach, both the university and Mosaic balanced a scientific approach with the capabilities of current precision agriculture technologies and commercial application equipment. This N rate study was adopted to work in situations across the corn growing regions of the Midwest including Illinois, Iowa, Indiana, Minnesota, and Nebraska. The research methodology pushed the limits of the equipment and technology, and created a significant amount of yield response data.

Methodology

Equipment selection. Nitrogen fertilizer application can be accomplished by the farmer or dealer, depending on local farming customs, farm acreage, application timing, and form of fertilizer used. For example, farmers in Illinois who sidedress ammonia will usually manage their own equipment and application. By comparison, a farmer in Minnesota who is applying urea often will have it applied by his dealer. In every case, when conducting on-farm research it is important to have a discussion with involved parties to determine the capabilities of the equipment and the training and competency level of the people who will be making the application.

Field selection. For a N rate study, it is important to restrict other additions of N to the field beyond the experiment. A quick discussion with the farmer can identify fields that have applications of N from other sources, and also provide field history and other yield limiting problems such as pH and drainage. GPS soil tests can be used to review other possible nutrient deficiencies. A final consideration is to limit the research field to a single hybrid or variety in an effort to

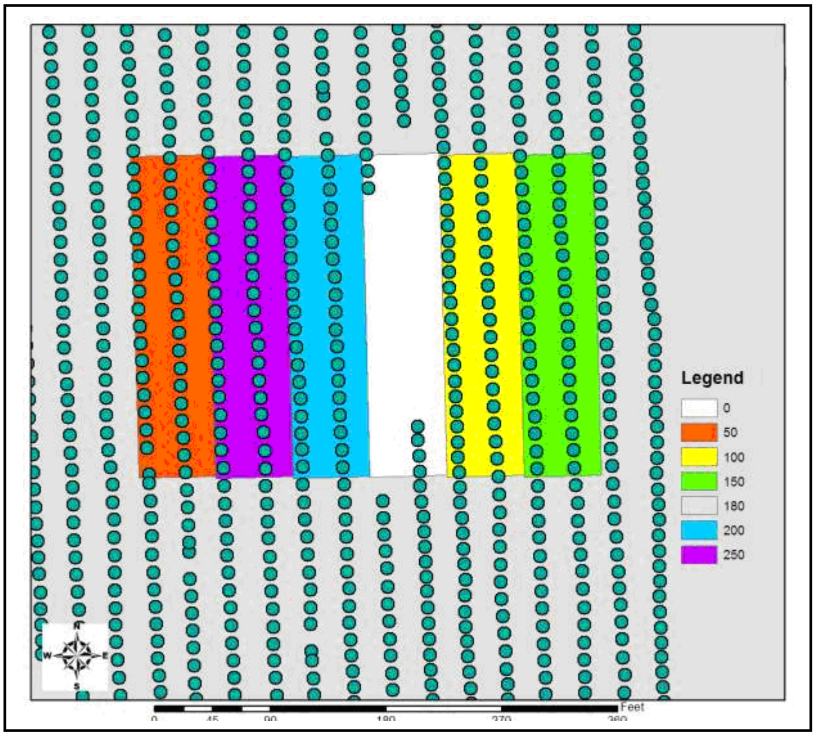

Figure 5. Overlay of as-applied.

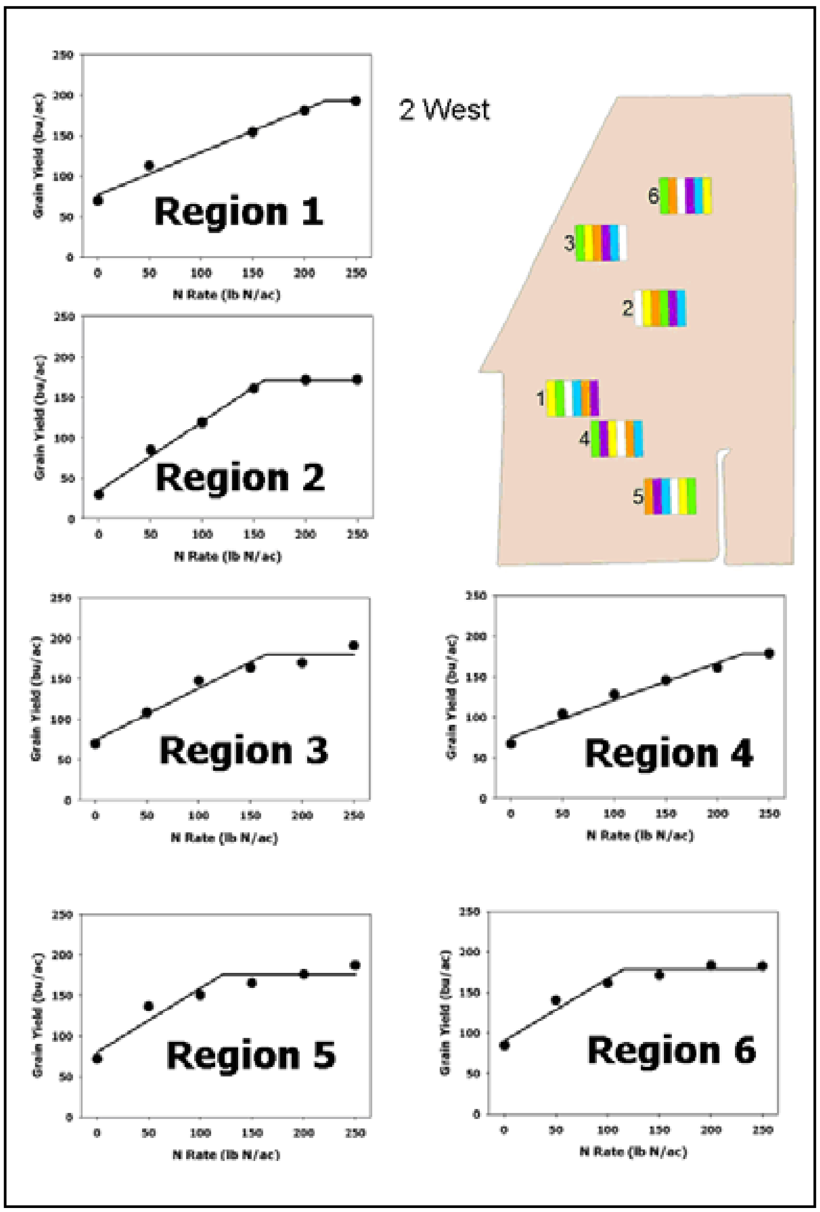

Figure 6. Response functions at each site.

limit yield differences due to different genetics.

Identification of zones. A bare soil image (Figure 2) can show differences in soil type and drainage. A prior yield map (Figure 3), can show yield and traffic patterns, locations of headlands, end rows, irrigation systems, and also provides elevation data used to create a topographic map. In-season satellite and aerial images, digital soil maps, GPS soil tests, and tile drainage maps can further delineate management zones.

Research design/layout. This research approach uses blocks or "stamps." The stamp placement is determined by evaluating the available spatial layers. The location of the research should be targeted **to provide an even representation from low, medium, and high-performing areas in the field. These stamps are assigned to areas approximately 300 feet long and twice the width of the applicator, with each typically half to one acre in size. The length needs to be adequate to allow the rate controller sufficient time to change from the previous rate and provide a sufficient amount of data points. Selecting a stamp width twice the applicator boom width provides a measure of assurance in case the chosen A-B line of the application equipment does not match up with the intended alignment of the stamp (Figures 4 and 5). The decision to use six stamps in this experiment protocol limited the economic loss to the farmer due to yield reduction in the N-omission areas while providing a statistical amount of data points to develop the yield response function.

As-applied data. The actual applied rate of fertilizer can vary from the intended rate of fertilizer prescribed. As mentioned above, this can be due to equipment limitations such as driving too fast for the desired rate, rapid changes in speed or direction, skips, overlaps, machine breakdown, and product flow issues. For these reasons the as-applied map is a vital element in validating the amount of product applied. The difference between the target rate and the actual rate can be used after harvest as a means to select the yield data points matching the desired fertilizer rate.

In-season considerations. In-season aerial photography can identify yield-limiting events that have occurred which are beyond the control of the farmer. The imagery can be an important link used to explain unusual crop responses when analyzing the yield data. The imagery can be used to identify weed pressure, storm damage from hail or wind, and drought or flood effects. If an in-season crop protection product is needed such as a fungicide, herbicide, or insecticide, it should be applied to all of the research stamps evenly to eliminate it as a source of variability.

Harvest. At the start of each harvest season there are routine adjustments and maintenance for the combine. While making these initial adjustments, it is a good idea to harvest other non-research fields. Calibration loads should be conducted when harvesting the research to assure that the yield monitor is recording within 1 to 2 percent of the true yield. In the case where multiple combines are in use, it is best to use a single combine when harvesting on-farm research to simplify the analysis of data and eliminate potential variability from different monitoring systems.

Data analysis. The unprocessed yield monitor data taken directly from the card are preferred. If the yield data are first processed by the farmer's mapping program or a yield mapping service, it is possible to unintentionally filter out important data. Once the yield monitor data have been downloaded, processed, and cleaned, they are merged with the N as-applied map. At that time, yield data points can be discarded where there is a significant discrepancy between the target fertilizer rate and the actual applied rate. The remaining yield data are summarized and the response function for each stamp can be modeled as shown in Figure 6.

Conclusion

While the previous example is only one of several different protocols that can be used with precision agriculture technologies, it demonstrates the importance in providing education and guidance to farmers and dealers to successfully evaluate new products in the future.

Wiebers is agronomy research lead, Dr. Ruffo is global data analyst, and Fairchild is assistant vice president of Agronomy with The Mosaic Company, Plymouth, MN.