VARIABLE RATE TECHNIQUES AND EQUIPMENT FOR ON-FARM RESEARCH

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INTRODUCTION

A review of on-farm research publications suggests that the average age of these documents were written greater than 5 years ago, and often from an academic perspective. There is a need for guidance on how farmers can leverage current precision agriculture technologies and application equipment to conduct on-farm research studies. Coupling the high degree of accuracy now possible with these systems and a compatible protocol, farmers and dealers have a powerful set of tools to build local databases of information. Farmers prefer to see local data and results, but have lacked a practical approach and guidance to perform such studies.

Advances in the technology surrounding precision agriculture continue to grow at a steady pace. The use of RTK (real-time kinematic) GPS systems can provide repeatability down to just one inch. Rate controllers are becoming simpler to use with color touch screens, intuitive displays, and the reduction of cab clutter by using a single system to control steering, rate monitoring, and logging of the data. In addition, the cost of these systems is within the budgets for even small and medium sized farms. An unique on-farm research approach built with farmer input is outlined below.

CURRENT TECHNOLOGY

GPS - When the US Department of Defense turned off Selective Availability (SA) back in May 2000, there was a period of time where some precision ag users were complacent with no differential correction. As the technology has matured the need for high-end DGPS corrections has become a cornerstone of the current use in agriculture. Many farmers are purchasing RTK capable GPS receivers for tractors and combines to use in auto-steer and guidance. These new GPS receivers have the capability to use differential correction from multiple sources such as WAAS, Omnistar, and RTK. In addition, some of these receivers can be programmed to use either the US system, the Russian / Indian system (GLONASS), or both. The accuracy of these systems now allows farmers to know virtually every inch of their field.

RATE CONTROLLERS AND LOGGING SYSTEMS – In the past, rate controllers and the logging computer were often separate boxes in the tractor cab. The photo to the right shows an AgLeader PF3000 and Hiniker 8605 rate controller. In this setup, the GPS signal was received by the AgLeader system where the application rate was determined from a prescription map. The AgLeader

output the target rate to the Hiniker rate controller via a serial cable. The rate controller recognizes the rate change and makes adjustments to valves to increase or decrease the applied rate. Finally, the actual applied rate is read by the controller and sent back to the computer on the serial cable where it is logged by the AgLeader system to a removable data card. This process repeats every 1-2 seconds.

This process still works well, but with the number of cables and harnesses required it could occasionally have problems. The next generation of controllers such as the Raven Viper Pro, AgLeader Insight, Greenstar 2, Topcon X20, and AgCo GTA serve a dual purpose and eliminate some of the challenges inherent in connecting different systems together.

CHALLENGES OF ON-FARM RESEARCH

Depending on the type of dealer or famer, on-farm research can be met either with patience and due diligence, or it can be discarded at the first sign of trouble. It is important to recognize these personalities early in the relationship and be ready to act quickly if needed. Some of the more common characteristics of each are listed in the following table.

Table 1: Challenges and strengths with on-farm research

Dealer Challenges	**Dealer Strengths**
• Communication with the research team • Needs to be extremely efficient and cover the acres quickly • Employee turnover rate with applicators / operators • Keeping track of the as-applied map	• Often using the newest and most efficient technology • New equipment has less down time and great support from the manufacturer • Knows the equipment and applications systems very well • Has a support team for troubleshooting problems
Farmer Challenges	**Farmer Strengths**
• Memory fades of how the system works from season to season • Technical competency of hired help • Older systems, sometimes patched together • Often needs more technical support	• Attention to detail • Knowledge of the field • Openly communicates problems or issues with the application • Usually has smaller equipment which can confine the research to smaller areas

CURRENT APPROACHES

A review of literature on the topic of on-farm research publications reveals much discussion placed on the design of the experiment. Yield monitor data or weigh wagons are frequently suggested as a reliable source of data at harvest. However, not much is discussed about the importance of collecting the as-applied data. Even under ideal conditions the intended target rate and the actual rate can vary significantly for reasons such as the following

- Speed of machine exceeds the capability of the applicator
- Rapid speed changes
- Uneven product flow from the machine
- Mechanical breakdown
- Skips and overlaps

Spatial Variability

One of the most common approaches to on-farm research is a strip trial that runs the length of the entire field. These strips can be set up to test the farmer's normal practice against some new method. In fields where the length of the field is long (i.e. ½ mile rows), or where soil variability is significant, the spatial variability alone can induce significant yield differences that mask the nutrient response. One of the goals in research is to confine spatial variability by using small areas. This can be a limitation of field length strip trials in on-farm research when the average of the entire strip is compared against data from other strips in the field.

Data Analysis

When farmers conduct on-farm research, they will frequently look at the screen of their yield monitor closely at harvest for validation. The yield monitor averages loads overall from each strip and the farmer is given a yield for each. This is frequently where the farmer makes a decision on which treatment was the winner. The data is unloaded onto the farm computer back in the office, but often there is no other analysis. Seldom is the as-applied layer overlaid on the yield monitor data and analyzed statistically to the point where real conclusions can be made about the different treatments. Current mapping software is making this easier, but it is still an office computer solution and not a combine solution.

A UNIQUE APPROACH

In 2003, Mosaic partnered with the Crop Physiology Laboratory at the University of Illinois to study nitrogen rates on corn. During the development of this approach, both the university and Mosaic worked balance a scientific approach with the capabilities of current technologies and commercial application equipment. This study was confined to Illinois at first and then expanded to include fields from Iowa, Minnesota, Nebraska, and Indiana. The research methodology pushed the limit of the capabilities of the equipment at the time and created a very significant amount of statistically sound yield response data.

METHODOLOGY

In the following sections are a brief summary of each step used in the process.

Equipment Selection Criteria
The application of fertilizer can be done by the farmer or by the dealer. The decision often depends on local farming customs, the acreage of the farm, and the form of fertilizer being used For example, farmers in Illinois who side-dress ammonia will manage their own equipment and application. A farmer in Iowa who is applying urea can often have it applied affordably by his dealer. In either case it is important to have a discussion with involved parties to determine the type equipment in use and their competency in knowing how to load a prescription-based application.

Field Selection Criteria
For a nitrogen rate study, it is important to limit other contributions of N to the field. A discussion with the farmer can identify fields that have applications of N already. In addition, the farmer can also provide field history and advise portions of the field with other yield limiting issues such as pH, salinity, and drainage. If available, a GPS soil test can be used to look at other nutrient deficiencies that could limit yield. When possible, a single hybrid or variety should be used to limit the yield differences due to different genetics. If a Bt refuge will be used in the field, talk with the farmer about where this will be placed and avoid research in the refuge.

Identification of Zones
This research approach uses blocks or "stamps". The stamp placement is determined by evaluating available spatial layers. A bare soil image (Figure 1) can show differences in soil type and drainage. Other layers of importance are prior yield maps (Figure 3), which can show locations of headlands, end-rows, drainage, and access roads which should be avoided. A yield map often contains elevation data which can create a topography map showing the water drainage for the field. Other data layers can include satellite imagery, digital soil maps, and tile drainage maps. The location of the stamps should be targeted to provide an even sampling from low, medium, and high performing areas in the field.

Research Design and Layout
The map layers serve as guidance to placement of the research stamps. These stamps are not full length field strips, but rather they are a small cluster of cells. Each cell is approximately 300 feet long and twice the width of the applicator, typically 0.5-1.0 acre. The length is adequate to allow a rate controller sufficient time to change from one rate to the next, and still provide adequate data for analysis. Using a distance that is twice the applicator width accommodates for at least one full pass through each cell (Figure 5). Often the actual A-B line of the applicator does not match perfectly with the alignment of the stamp. Using a cell that is twice the width of the applicator reduces the chance that a rate may not get applied correctly (Figure 6). An ArcView GIS extension is used to streamline the process of quickly developing the stamps and outputting a shapefile prescription. The stamps are strategically placed in the field, positioned using the layers mentioned in step 3. There are two stamps in low yielding zones, two in average yielding zones, and two in above average yielding zones. The decision to use 6 stamps limited the economic loss to the farmer due to yield reduction, while providing enough data to generate yield response information.

Collection of As-applied Data

It is not unusual for some parts of research fields to not receive the target rate of fertilizer prescribed. 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 key element in validating the amount of product applied to an area. When a GPS prescription file is used to control the rate, the software records the as-applied data automatically. The difference between the target rate and the actual rate is used when assessing the yield response when analyzing the harvest data.

In-Season Considerations

In-season data collection, such as NDVI aerial photography, can help identify yield-limiting events that have occurred. The imagery is not used to make in-season management decisions, but rather to help explain unusual yield responses when analyzing the data after harvest. For example, the imagery can 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 fungicide or insecticide, it should be applied to all of the research areas evenly to eliminate it as a source of potential variability.

Harvest

At the start of each harvest season, there are minor adjustments that need to be made to the combine in order to get all of its systems working properly. Large farming operations may actually trade for a new combine every year. As a result, it is a good idea to delay harvest of the research fields until at least a week into the harvest season. A calibration load just prior to harvesting the research can provide assurance that the yield monitor is working correctly. A correctly calibrated yield monitor should be within 1-2% of the scale weight when harvesting corn. Large farms can have multiple combines. In these cases, it is best to use a single combine and yield monitor when harvesting research fields to eliminate variability from different monitoring systems.

Data Analysis

The raw yield monitor data from the memory card is the preferred source of data. The mapping software can be set up with filters and methods that may accidentally screen out usable data. The raw yield monitor data is downloaded, processed, and cleaned. It is then overlaid on the as-applied map layer from earlier in the season. The yield data points are discarded where there is a significant difference between the target fertilizer rate and the actual applied rate. The remaining yield data is summarized and the response function for each stamp can be modeled as shown in Figure 11.

CONCLUSIONS

GPS and rate controller technology used in conjunction with a yield monitor is a very good way to generate local on-farm results for both dealers and farmers. The placement of small stamps or clusters of research provides a new way to minimize both spatial variability and potential yield loss. This research approach can be easily adopted using current commercial software and equipment. It can rapidly scale-up to include many fields. The data gathered from these research fields can be used to statistically evaluate new products and help quantify value to producers—by developing a local database.

APPENDIX OF LAYERS


Figure 1 – Digital Othophoto


Figure 2 – Digital soil map

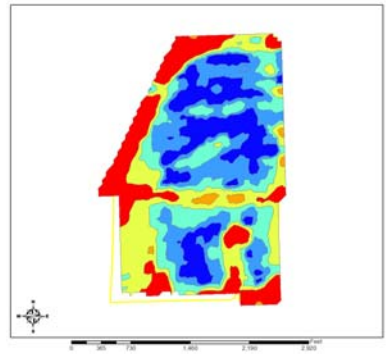
Figure 3 – GPS yield map

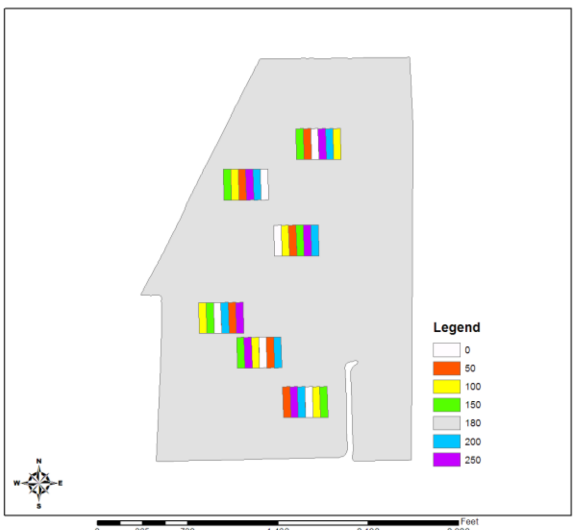

Figure 4 – Stamp placement

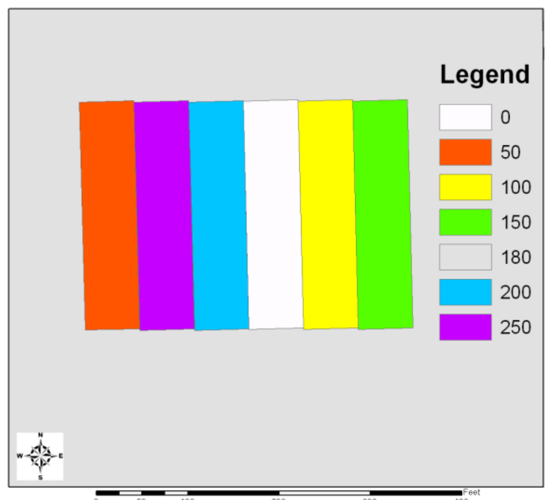

Figure 5 – Typical stamp

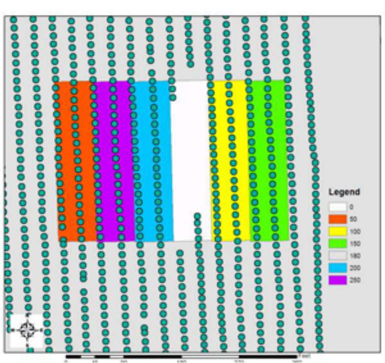
Figure 6 – Overlay of as-applied

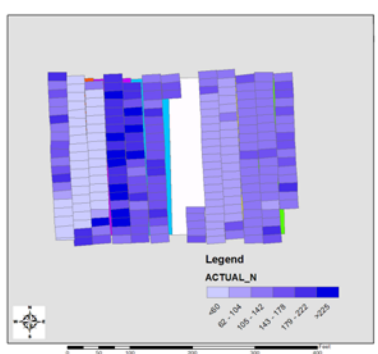

Figure 7 – As-applied polygons

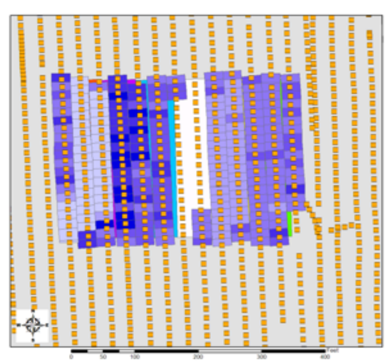
Figure 8 – Yield data overlay

EXAMPLE OF COMPLETED ANALYSIS

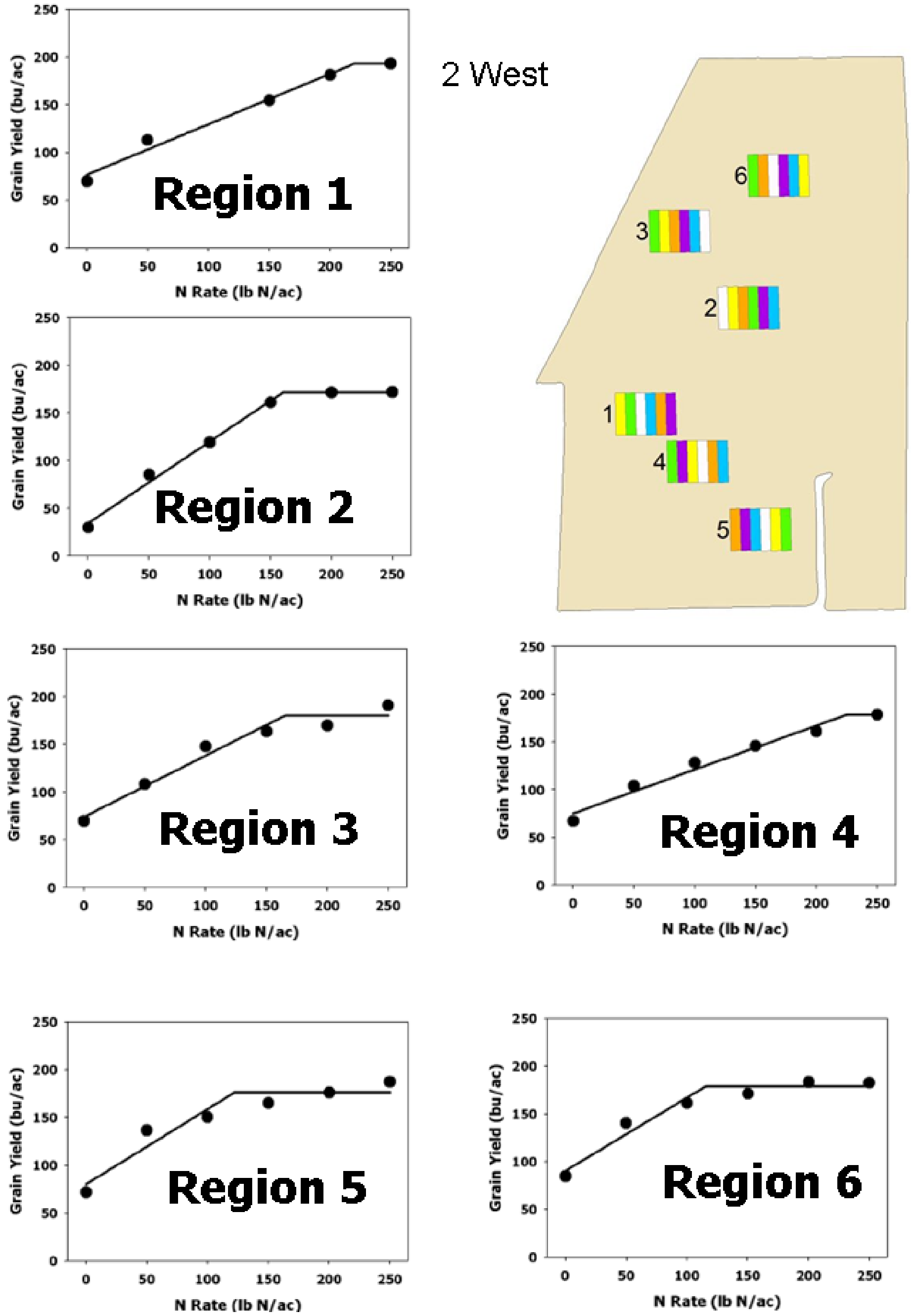

Figure 11 – Response functions at each site