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VARIABLE RATE IRRIGATION 2010 FIELD RESULTS FOR CENTER PLAINS CONFERENCE

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BACKGROUND

Historically, the center pivot has been used by a farmer/operator to apply a selected depth of water uniformly across the entire field. Changes in technology have occurred that give growers the ability to apply differing amounts of water and products carried in the water to different zones along the pivot and sectors around the field (Perry 2005). This paper will discuss results from the summer of 2010 of a commercial center pivot equipped with the Valley Variable Rate Zone Control package. The paper will also review potential payback. It will close with a discussion of future needs for variable rate irrigation.

INTRODUCTION

Since the introduction of the center pivot in the mid-1950s, the mechanical move industry has continued to improve and develop products to better meet the needs of production agriculture. The overall goal has been to provide cost-effective, uniform irrigation across the field with a specific application depth .

With the introduction and acceptance of precision agriculture, suddenly more information has become available for a particular field and areas in the field, including yield, soil and gird sampled fertility maps. Farmers now have data indicating the variability across the field, which was already suspected but not proven. The challenge then became how to use this data and how to make changes that would impact different areas of the field.

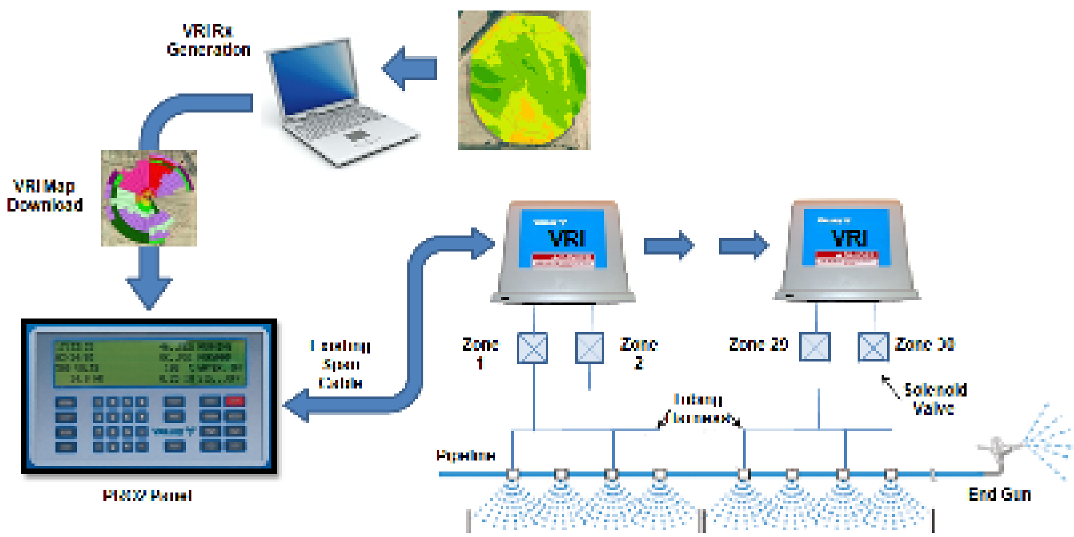
Fertilizer and chemical application equipment, as well as planters, have been equipped to make changes in rates or volumes across the field. Research into variable rate, or “site specific,” irrigation has been conducted at a number of locations across the United States by both Universities and USDA-ARS. These include, but are not limited to Universities of Georgia, Idaho, Nebraska and Texas A&M, and the USDA-ARS at Florence, SC, Ft. Collins, CO and Sidney, MT (King 2005, Marek 2004). The first commercial, marketed variable rate irrigation package was jointly developed by the University of Georgia, FarmScan and Hobbs and Holder (Hobbs & Holder 2006). These units have primarily been installed in the southeastern United States.

OBJECTIVE

The goal of this project was to demonstrate on a commercial field the viability of using a Valley Variable Rate Irrigation (VRI) Zone Control package to solve a farmer's challenges while maximizing returns from a center pivot irrigated field.

DISCUSSION

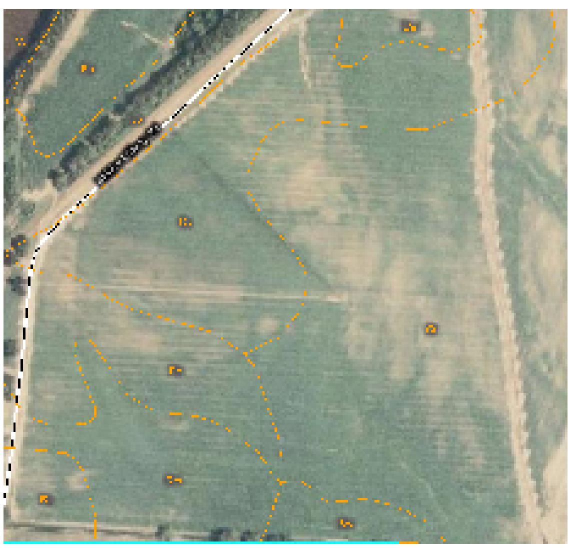
The VRI Zone Control package consists of a Valley Pro2 control panel, VRI tower boxes and a sprinkler control valve package. Information is sent between the control panel and the VRI tower boxes using a power line carrier (PLC) through the existing center pivot span cable. No additional control wires are required to use the product. Due to durability, reliability and experience, the sprinkler control valve used is the AquaMatic® brand, which has been used for more than thirty years on corner machines for sprinkler control. A tubing harness connects the AquaMatic valve to the solenoid on the VRI tower box. This hardware allows the center pivot to be broken into a maximum of thirty Pivot Zones. Below is a conceptual drawing of the Valley VRI Zone Control package components.



A prescription that is specific for the field is created with the VRI Prescription Software, which resides on an external computer. The prescription is then loaded into the Pro2 control panel. The VRI Prescription Software allows prescriptions to have up to 180 sectors around the field, each sector as small as two degrees.

In the spring of 2010, Valmont Irrigation began to review commercial field sites to validate the lab and field testing that had been done with the Valley VRI Zone Control package. A possible field was identified near Dyersburg, Tennessee, owned by Jimmy Moody; the center pivot was a Valley Model 8000 that was installed in 1997. The machine's configuration was a total length of 1,148 ft: five spans of 180 ft and one span of 185 ft with a 64 ft overhang. The flow rate was 800 gpm and pipeline coupler spacing was 108 in. The control panel was mechanical. The sprinklers were fixed-pad sprays with a medium groove pad and regulator. End pressure was 10 psi at the nozzle; the center pivot had pressure regulators. The drive train was high speed with 14.9x24 tires. The pump was a deep well turbine with a fixed-speed motor. Based on the manufacturer's data, it was determined that the flow rate should not drop below 450 gpm to maintain good efficiency and minimal pressure rise.

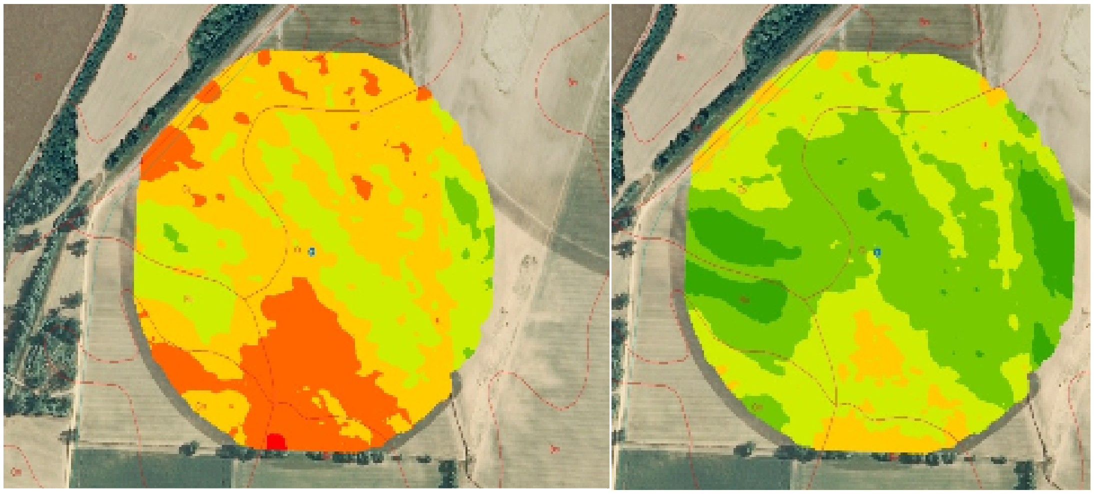
Mr. Moody described his challenges with this field. Parts of the field were either being overwatered or under watered, and uniform crop production was not being achieved across the field. His goal was to have more uniform crop production across the field. To accomplish, this he believed he needed to be able to adequately water the light soils without flooding the heavy soils. To evaluate the field to determine both the number of Pivot Zones needed along the pivot and sectors around the field, the NRCS soil maps (Figure 1) were reviewed; however, they did not seem to match the situation Mr. Moody had described.



Bw – Bowdre clay
CM – Commerce loam
CR – Crevasse loamy sand
CS – Crevasse sandy loam
Ro – Robinsonville fine sandy loam

Figure 1

Mr. Moody did not have a series of annual yield maps to average in order to help define the appropriate VRI package. Mr. Moody had done grid soil sampling, but, while this data was valuable and interesting, it did not help to lay out the VRI package. In a conversation with Dr. Earl Vories of USDA-ARS about VRI and how to determine the layout of Management Zones, it was suggested by Dr. Vories that apparent electrical conductivity (EC_a) of the soil profile be used (Vories 2008). EC_a is a sensor-based measurement that provides an indirect indicator of important soil physical and chemical properties. Dual EM was used to determine EC_a, as shown on the map below in Figure 2.



Deep EC_a Figure 2 Shallow EC_a

This data seemed to match Mr. Moody's perception of the field's characteristics. The decision was thus made to use this information as a starting point to help define the VRI Zone Control package. Rice was the crop for the 2010 growing season. Based on the shallow root system of rice, it was decided to use the shallow EC_a information to both define the VRI Zone Control hardware and to develop the initial prescription.

A decision was made to maintain the same area in the zones in order to simplify management decisions and to make it easier to determine the impact on the hydraulics, as each Pivot Zone along the center pivot would have the same flow rate. The center pivot was split into ten Pivot Zones with the length of the Pivot Zones and number of sprinklers as:

Zone 1 – 363 feet – 40 sprinklers
Zone 2 – 150 feet – 17 sprinklers
Zone 3 – 115 feet – 13 sprinklers
Zone 4 – 97 feet – 11 sprinklers
Zone 5 - 86 feet – 10 sprinklers
Zone 6 – 78 feet – 9 sprinklers
Zone 7 – 71 feet – 8 sprinklers
Zone 8 – 66 feet – 7 sprinklers
Zone 9 – 62 feet – 7 sprinklers
Zone 10 – 59 feet – 7 sprinklers

Each Pivot Zone along the center pivot represents 9 ½ acres and had a flow of 80 gpm. The sectors around the field were in four-degree increments, which totaled 900 Management Zones, or "blocks." Figure 3 below illustrates the initial prescription used.

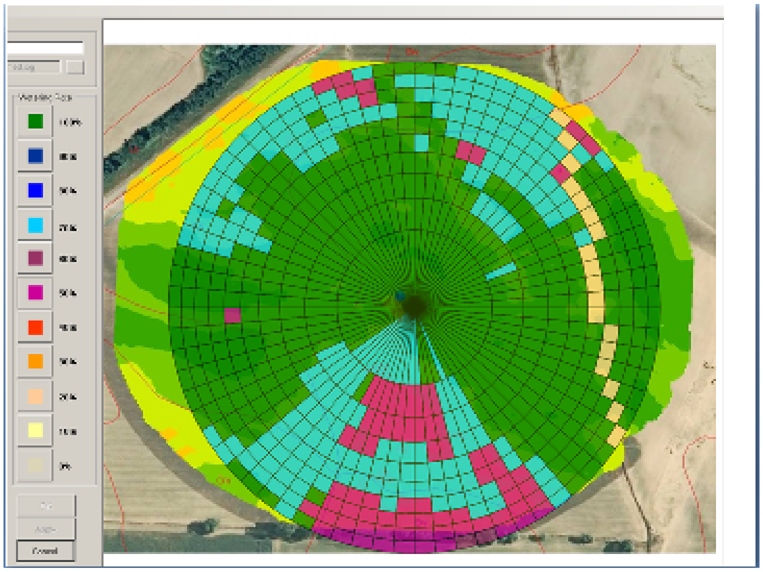


Figure 3

The VRI Zone Control hardware was installed along with a new sprinkler package, pressure regulators and sprinkler control valves. One AquaMatic valve was used for each hose drop. Once the hardware was installed and the VRI software was uploaded to the Pro2 control panel, the constants for the VRI Zone Control were entered and the prescription uploaded. The pivot was then run to test the package. During the growing season, base application depths ranged from 0.25 in to 0.45 in. A significant portion of the nitrogen for the rice crop was applied through the center pivot with an Inject-O-Meter pump. The nitrogen was liquid with an analysis of either 32-0-0-0 or 28-0-0-5. The VRI Zone Control package was used as the heavier soils had much better fertility than the lighter textured areas, so the nitrogen application amounts were cut back based on the EM map. Since the injector pump was a fixed speed, a separate prescription was created to compensate as much as possible for the fixed pump. The goal was to reduce nitrogen as in the areas that received less irrigation.

One area of particular interest was how to validate the performance of the VRI Zone Control during the growing season, while not just waiting for the yield results. The VRI Zone Control package “pulses,” or cycles, the valves off and on, which then turns the sprinklers off and on to achieve the desired change to the base application depth. The problem was approached in three ways:

- Visual observation of the Pivot Zones and Management Zones
- Soil moisture monitoring in one of the areas with the light textured soils where the prescription always called for 100% of the base application depth, and in heavy soils area where the base depth was reduced by up to 40%. For example, if the base application depth was 1.00 in, then an area of 40% reduction would only apply 0.60 in
- Aerial imagery– infrared and color spectrum

One of the first observations was the cycle time was too long when a Pivot Zone was operating in an area where there was to be a reduction in the application depth. It was observed the drive unit was moving so far during a pulse that sufficient overlap of the sprinkler package in the direction of travel was not being achieved. To correct this, the cycle time was changed in the constants – something easily done at the control panel.

The soil moisture data was tracked remotely; it looked for drying trends in the area where the prescription called for a reduced application depth. Below is an example of the data sets for a sample time period (Figure 4).

Figure 4

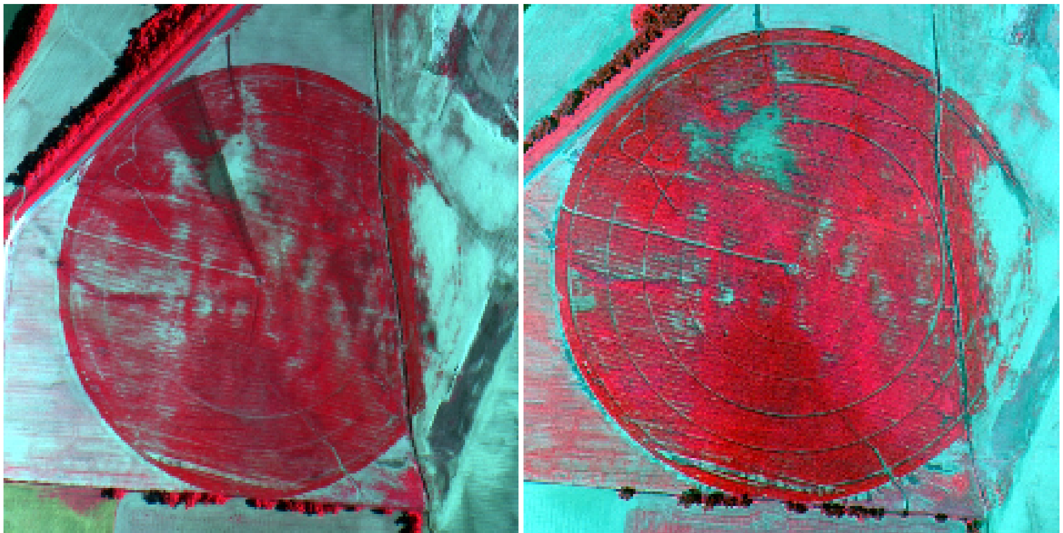
The top set of data is an area with clay loam soil that received 60% of the base application depth.

The bottom data set is an area of fine sand that always received 100% of the base depth.

Along the x axis is time, from June 15th to September 28th. The y axis is in centibars, which ranges from 0 to 100.

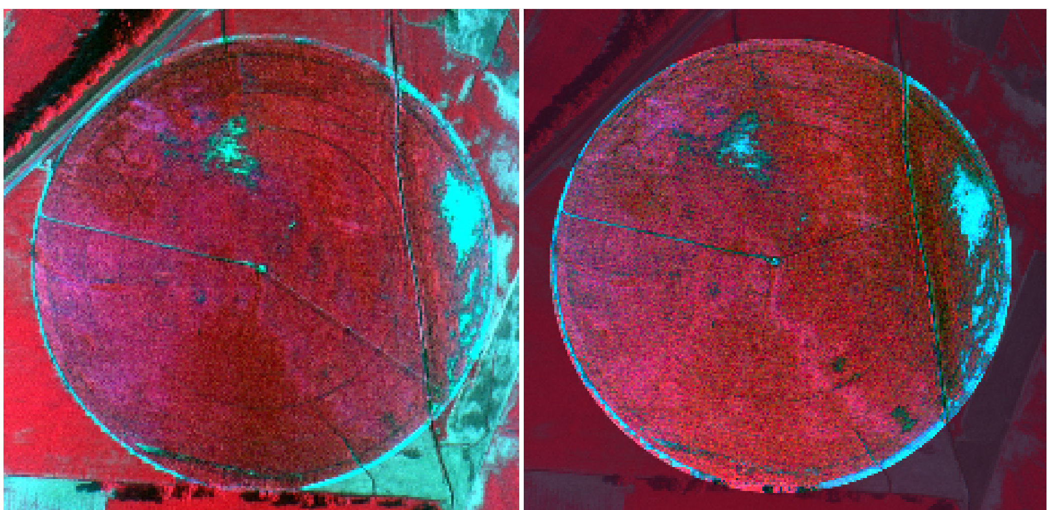
Most important from this data is that over time, the top graph did not show a drying trend; for most of the crop season it paralleled the soil moisture status of the area that received 100% of the base application depth. In addition, visual observations and use of a soil probe indicated the soil moisture was adequate in the area receiving 60% of the base application depth.

The following were a series of infrared images taken during the growing season (Figure 5).



June 16th   June 30th

Figure 5



July 23rd   August 6th

In the images above, there was gradual improvement in the ground cover and, in general, the crop appeared "good" across the field with no particular weak areas except for the areas where the crop was blown out by wind in the early season.

RESULTS

Harvest was a challenge due to a wind storm part-way through harvest that lodged the crop badly in the south-central part of the field, which traditionally was believed by Mr. Moody to have the best yields. Overall, the field variability was significantly reduced and the light textured soils yielded well in a very dry year; a total of 19.4 in per acre were applied to the crop in 61 passes of the center pivot.

19.4 in was calculated based on the hours of center pivot operation and the flowrate. This is interesting because it is incorrect – if there had been no VRI, then it would have been correct. Some sections of the field received 19.4 in because they had a prescription of 100% of the base application depth. However, the areas with a 60% prescription (40% reduction from the base depth) received 11.6 in per acre. Applying the prescription across the field to the total pumped inches indicates that, overall, 12% less irrigation was actually applied, which illustrates a significant water and energy savings. (Another VRI Zone Control pivot in western Nebraska monitored in 2010 had an overall reduction of 13% in the amount of water pumped.)

Total applied nitrogen was also reduced by using the VRI prescription. The reduction in nitrogen was 15% - another significant amount. The farmer was pleased with the performance, and based on savings and overall yield increase estimates the payback for the unit to be just over three years.

CONCLUSIONS

Historically, center pivot irrigation has treated the entire irrigated field the same and the goal has been to make uniform applications across the field. With variable rate irrigation, the farmer now has the ability to apply specific amounts of water to specific locations within the field. Based on the information collected in 2010, there are a number of areas requiring additional work and evaluation:

- Better tools to determine economic number and size of Management Zones. With the recent cooperation developed with CropMetrics™, this is one solution to overcome this.
- Better tools to determine prescriptions. This is now easy with the CropMetrics solution.
- Methods to obtain easy feedback from the Management Zones and to incorporate into the farmer's decision-making tools.
- Validation of VRI Zone Control performance
- Quantify possible benefits, such as water savings, yields increase and nitrogen use, and impact on the payback.
- Explore sprinkler package performance and how it relates to VRI.
- Management of the hydraulic issues associated with a fixed-speed pump.
- Use of variable rate chemigation pumps.

Another factor is how one thinks of center pivot irrigation. The overall goal may not be to achieve general field uniformity, but rather to apply specific amounts of water and other crop inputs to particular areas of the field.

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