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MANAGEMENT CONSIDERATIONS FOR VARIABLE RATE IRRIGATION

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ABSTRACT

This paper will focus on commercial VRI (variable rate irrigation) and the processes for making management decisions including is VRI appropriate for my farm, the selection of the type of variable rate irrigation and management during the growing season. Tools one may use for in season management will be discussed and examples presented.

INTRODUCTION

Since the introduction of center pivot irrigation in the mid1950's, the goal has been to achieve uniform application of water both along the center pivot and in the direction of travel. With a field and crop that is uniform in soil type, topography and crop health, this offers a good solution to the producer to maximize profitability. But, the agriculture community has since recognized that fields and crops are not necessarily uniform, and the agriculture equipment industry has begun to offer machines to variably apply fertilizer, seed and other crop production products. With the introduction by the University of Georgia, FarmScan and Hobbs & Holder (Hobbs & Holder 2006), a viable commercial package was made available for variable rate irrigation (VRI). Today center pivot manufacturers and some third party companies offer hardware for center pivots and linears that provide varying degrees of control to match the application of water to the field and crop conditions. The available VRI packages fall into two basic categories:

- VRI speed control: Varying the speed of the center pivot around the field
- VRI zone control: Controlling individual or banks of sprinklers

While it has been stated that water conservation strategies using variable rate irrigation are quite limited, and its cost-effectiveness has not been demonstrated by researchers (Evans 2011), many growers continue to look closely at this technology to determine if it is a good fit for their operations. As with any new technology, some farmers "adopt" the technology just because it is new. However, some farmers ask the question, "If VRI is the right fit for any of my fields, what is available to help guide me in this determination and decision making process?" And then one needs to consider how the VRI center pivot will be managed during the growing season by the use of prescriptions and what these should be based upon for the initial VRI prescription and revisions. In discussions with growers who have started using VRI and then stopped the most common reason is the preparing and updating prescriptions.

DISCUSSION

The decision to adopt VRI can be broken into a four-step process. The first step in the process is determining what the producer wants to accomplish. Does he want to accomplish:

- Vary the application depth?
- Shut off irrigation for particular areas, such as ponds, drainage ditches and other non-crop areas?

If the determination is to vary the application depth, the second step is to look at his field specifics. The basic starting point is to use typically either Veris or Dual EM data or other data such as yield maps, soil maps, aerial imagery or others to make an educated estimate as to the potential for VRI. An example is represented below Figure 1.

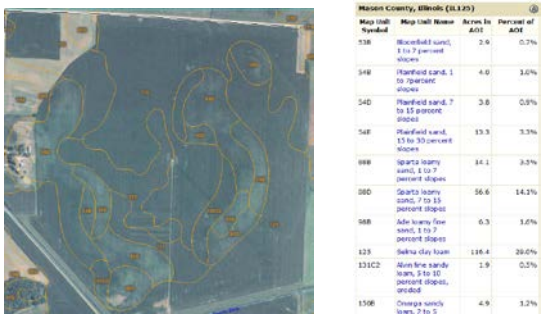

Figure 1. Graphical and tabular representation of the different types of area present in one field.

Continuing the second step, one collects information, such as the Optimum Crop Productivity Ratings for Illinois Soil, (Olson 2000) (Figure 2) to help determine the impact of varying water.

Table S2. Productivity of Illinois Soils Under Optimum Management, Slightly Eroded, 0% to 2% Slopes

IL map symbol	Soil type name	Subsoil rooting*	Corn bu/ac	Soybeans bu/ac	Wheat bu/ac	Oats[b] bu/ac	Sorghum[c] bu/ac	Alfalfa[d] hay ton/ac	Grass-legume[e] hay ton/ac	Crop productivity index for optimum management	IL map symbol
109	Racoon silt loam	FAV	130	41	51	0	103	3.50	0.00	106	109
111	Rubio silt loam	FAV	139	44	57	70	0	0.00	4.29	114	111
112	Cowden silt loam	FAV	143	45	57	0	107	0.00	4.41	117	112
113	Oconee silt loam	FAV	148	45	57	0	107	0.00	4.75	119	113
115	Dockery silt loam	FAV	156	51	62	77	0	0.00	4.52	128	115
116	Whitson silt loam	FAV	142	45	54	68	0	0.00	4.29	116	116
119	Elco silt loam	FAV	136	45	53	68	0	3.84	0.00	112	119
120	Huey silt loam	UNF	98	38	38	0	86	0.00	3.16	89	120
122	Colp silt loam	UNF	121	38	51	64	0	0.00	3.84	98	122
123	Riverwash	Crop yield data not available									123
125	Selma loam	FAV	157	51	62	80	0	0.00	4.75	129	125

Figure 2. Information from the Optimum Crop Productivity Ratings

Step three is to use the collected data such to look at the primary soils in the field (Figure 2) to help determine an estimated yield based on that soil. Knowing the area of each soil type, the potential impact of VRI to minimize under and/or overwatering can be estimated.

A consultant can be of significant assistance in helping with this process, along with helping estimate the impact of providing the optimum irrigation amount to the specific soils, as it may not be water that is limiting yields.

By looking at the soil map, an estimate can be made as to whether VRI speed control or VRI zone control would be the better choice for the field. Looking at the choices and their ROI:

VRI Type	Installed List Price	Years for Payback	Revenue over Five Years
Speed control	$ 6,300	1.1	$22,651
Zone control	$ 38,083	2.9	$27,823

These numbers reflect an assumption that water is the main limiting factor, which is a simplistic approach.

A better approach for step three may be to use a more quantitative way of evaluating a field. Consulting groups, such as CropMetrics™, Simplot Soil Builders and others, offer tools to process Veris or Dual EM EC_a data and topographic information of a field to develop an estimate of the variability in the field. The assumption is that if water can be applied to match the field's variability, then crop yields can be optimized. A computer program is used to provide spatial data analysis of geo-referenced data, which is utilized to make a thorough analysis.

Step four is to determine if the grower wants to, or should, proceed with a VRI package, and which VRI package is suited for his operation. If the farmer is water constrained, then the analysis will be different, and the focus will be on applying the optimum amount of irrigation on the soils that have the greatest yield potential. The potential yield improvement is different for every field, as well as for every crop. Therefore, it is important to consider using a knowledgeable, local consultant or advisor to help analyze each particular situation (LaRue 2012)

Once the decision to utilize VRI is made then the grower needs to determine how to best utilize the investment. The information used to make the initial determination of whether to invest in VRI or not may also be used to make the initial prescription. The prescription is the information that is 'sent' to the center pivot control panel or VRI controller to tell the center pivot when to change application depth.

Again one needs to review why they are using VRI. Early season management decisions include but are not limited to:

- Over watering low or areas in the field that need to be too wet
- Potential for runoff in areas of low infiltration or slope
- Watering of areas that tend to dry out in the early season

Now the farmer is controlling not only when but how much is applied where in the field and the work is done right – absolutely not! In the large majority of cases the initial prescription is not satisfactory for the entire growing season. The reasons for this are:

- Areas that may have been too wet in the early season dry out
- The crop canopy develops changing the potential for runoff

Just as the grower changes the irrigation schedule as the crop is developing also the prescription probably needs to be changed. What can these changes be based upon:

- Detailed field scouting for varying soil moisture
    - May be done by the grower or a field consultant
    - Probably the best until the crop canopy closes
    - Challenge – resources to thoroughly scout a field
- Strategically placed soil moisture sensors (figure 3)
    - Various computer tools are available to recommend placement of the soil sensors
    - Good tool if the soil sensors are properly placed
    - Challenges
        - Proper number and placement of the soil moisture sensors
        - Resources to install the soil sensors

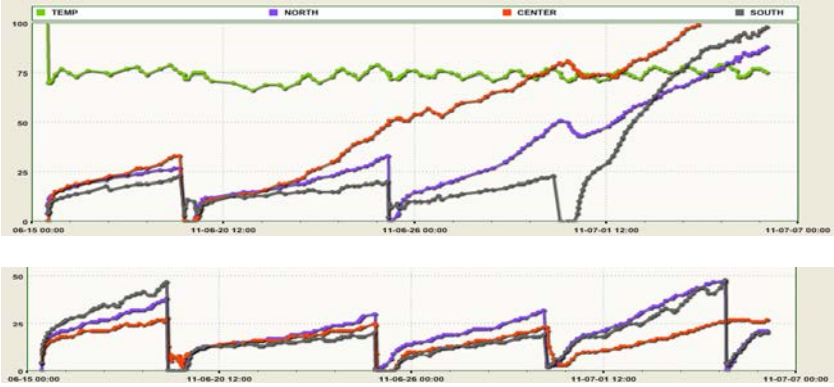

Figure 3. Information from soil moisture sensors

- Aerial imagery (figure 4)
    - Provides an image of the entire field in NDVI, infrared and other formats
    - Variety of services available providing imagery
    - Need at least 5m resolution to be able to use
    - Challenges
        - Time lag in having imagery collected until available
        - Cost for multiple images over the growing season

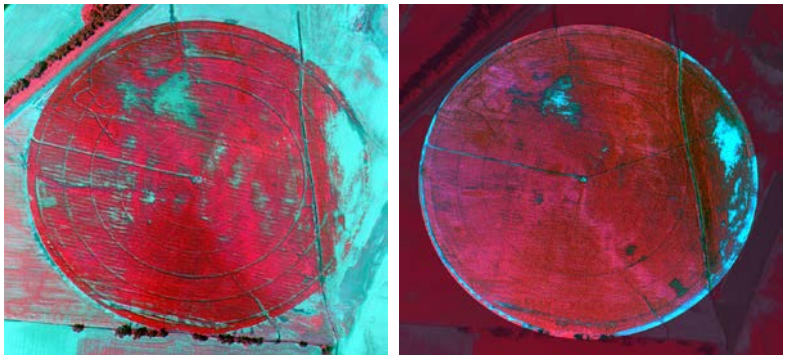

Figure 4. Information from aerial imagery, June 30 on left, August 6 on right

- Other
    - Emerging technologies such as near surface hydrogeophysics (Franz, 2013)
    - Combining of technologies to generate near real time changes (Hillyer, 2013)

Any of these tools will help guide the grower and/or consultant to change or leave the prescription as is to maximize the field productivity.

CONCLUSION

The use of VRI by farmers is increasing rapidly. Farmers who consider VRI should follow a process to help determine the ROI of the various VRI options. Determine whether they want to vary the application depth around the field or shutoff the water for particular non crop areas. But the writing and changing of prescriptions is critical to the overall success of VRI in the field. This seems to be one of the primary challenges to the continued use of VRI by farmers.

After the process is followed to determine whether to use VRI the next critical part is the management of the center pivot. The VRI prescription needs to be changed to meet crop and changing soils conditions. A variety of techniques are available to assist in the writing of and revising of the VRI prescription. Considerations also need to be made if there are limitations to available irrigation water. With this data and these tools, a grower can better utilize VRI to maximize field profitability.

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