

CONSIDERATIONS FOR VARIABLE RATE IRRIGATION

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ABSTRACT

The paper will focus on some items a grower, consultant and/or irrigation dealer should consider when contemplating the 'jump' into variable rate irrigation. A brief review of the status of commercially available variable rate products in the USA will begin the paper. Information on the processes used for considering variable rate irrigation will be presented. Then the discussion will move to specific information on fields' characteristics and VRI irrigation equipment. The paper will close with the conclusions and recommendations when planning for variable rate irrigation.

INTRODUCTION

Existing center pivot and linear irrigation technologies are well advanced and would conserve large amounts of water if fully implemented to the maximum extent of their capabilities. Adoption of advanced site-specific / variable rate technologies could potentially extend these water savings even more. Documented and proven water conservation strategies using variable rate irrigation (commonly referred to as VRI) are quite limited, and its cost-effectiveness has not been demonstrated by researchers (Evans 2011).

Various aspects of VRI technologies for general crop production are to beginning to gain acceptance; however, their uses are largely focused on non-irrigation of roads, ponds or rocky outcrops or addressing symptoms of poor design and less than optimal water and nutrient management. However, this significant underutilization of the potential of VRI technologies is still quite beneficial for crop production.

In the short term, adoption of these technologies will be enhanced by addressing equipment deficiencies and developing basic criteria and systems for defining management zones. The long term challenge will be to develop fully integrated management systems with supporting elements that accurately and inexpensively define dynamic management zones, sense within-field variability in real time, and then adaptively control site-specific, variable rate water applications.

Commercially available VRI choices are either speed control or zone control. Speed control varies the depth of application around the field in sectors (pie slices) by changing the speed of the center pivot in different sectors to try to meet the needs of the soil. The application depth remains uniform along the center pivot. Zone control, however, not only changes the application depth around the field but also along the length of the center pivot by pulsing sprinkler zones on and off. One caution is to not assume that by switching to VRI will automatically save water or reduce irrigation amounts. In addition currently there are no specific standards such as ASABE SW-436 for evaluating VRI systems. Manufacturers are offering ways to evaluate VRI performance.

DISCUSSION

In today's high cost environment, a grower cannot just look at overall farm income but must focus more and more on smaller areas at the field level or below. As a grower and his consultant analyze the profitability from a particular field, they have to discern all possible reasons why their yield or cost expectations may or may not have been met. Then they need to decide what changes need to be made to their operation and at what scale. Often the discussion is driven by a yield map and anecdotal information to define areas requiring different management and if VRI is appropriate. More and more, growers are looking at determining management zones within a field that are relatively homogeneous with regard to at least one characteristic or factor (e.g., similar soils, topography, microclimate, harvested yields, pest pressures, plant response and field characteristics).

The first consideration would be to decide if VRI is being looked at as a tool to apply varying depths around the field based on soils or other factors or to control the application depth (anywhere from a reduction to none) to specific areas such as ditches, ponds, wetlands, non cropped or other physical features.

If the desire for VRI is based on the need to avoid water applications on a specific area, then a conventional aerial photograph or Google Earth map will generally suffice to make a determination of how to proceed as shown in figure 1. This may be a VRI zone control package or utilization of the existing features if currently using a computerized control panel.



Figure 1

However, if the need is to apply varying depths of irrigation in different areas around the field then other analysis tools need to be found. In the spring of 2010, Valmont Irrigation began to validate the lab and field testing that had been done with the Valley VRI Zone Control package on a field near Dyersburg, Tennessee. The machine's configuration was a total length of 1,148 feet and six drive units. The flow rate was 800gpm with fixed-pad sprinklers with a medium groove pad and 15psi pressure regulator. The field challenge was that parts of the field were

either being overwatered or under watered resulting in a very large variability in crop production across the field. Available data for the field included soil maps (figure 2), grid sampling (figure 3), yield maps and antidotal information. None of this data seemed to provide the guidance necessary to determine the VRI package because of providing either too little resolution, could not be tied to specific field properties or not providing information that could be readily used to evaluate the field.



Figure 2, NRSC Soil Map

Sample Number	Analysis											pH	Buffer	ENR	Cec		
	P	K	Mg	Ca	S	B	Zn	Mn	SS	Na	NN					OM	
	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(lb/ac)	(%)		(lb/ac)	(lb/ac)		
FARM Hog Barn Pivot																	
FIELD 1 (116.10acres):																	
1.	8704																
2.	8705																
3.	8706																
4.	8707	63	334	648	2038	14	1.8	8	263		32		1.9	7.8	7.9	10.8	
5.	8708	104	404	742	3854	16	2.2	12	290		44		2.4	7.7	7.9	13.4	
6.	8709	96	340	696	3854	14	1.8	10	284		40		2.1	8.0	7.9	12.2	
7.	8710	92	360	742	3414	12	1.6	10	268		34		2.2	7.8	7.9	12.2	
8.	8711	96	326	482	2074	14	1.0	8	160		48		1.3	7.3	7.9	7.7	
9.	8712	74	364	662	2896	16	1.4	9	236		44		3.7	7.7	7.9	10.5	
10.	8713	90	408	660	3970	18	1.6	10	296		62		3.7	7.7	7.9	12.3	
11.	8714	72	258	592	3158	16	1.8	8	250		44		2.9	7.8	7.9	10.7	
12.	8715	62	340	536	2100	14	1.0	7	174		40		2.8	7.7	7.9	8.0	
13.	8716	88	426	830	3444	16	1.6	10	334		60		2.5	7.8	7.9	12.7	
14.	8717	66	348	646	2348	14	1.4	7	222		56		2.5	7.8	7.9	9.1	
15.	8718	82	400	824	3492	16	2.0	9	332		58		2.0	7.7	7.9	12.9	
16.	8719	66	442	700	2870	16	1.8	8	246		48		2.5	7.9	7.9	10.6	
17.	8720	64	414	692	2836	16	1.4	9	216		46		2.9	7.8	7.9	9.9	
18.	8721	72	376	582	2824	14	1.2	9	206		38		2.3	7.5	7.9	9.3	
19.	8722	80	404	632	3838	18	1.6	10	272		52		2.5	7.8	7.9	12.2	
20.	8723	60	388	568	2768	16	1.4	8	210		46		2.5	7.9	7.9	9.8	
21.	8724	98	228	396	1696	12	0.6	8	142		40		2.1	7.4	7.9	6.9	
22.	8725	88	200	298	1312	14	0.6	8	130		36		1.6	7.3	7.9	4.9	
23.	8726	102	226	336	1510	14	0.8	7	132		40		2.3	7.3	7.9	5.6	
24.	8727	64	344	674	2758	14	1.2	11	258		38		2.4	7.8	7.9	10.2	
25.	8728	60	384	654	2440	14	1.2	9	210		46		2.1	7.9	7.9	9.4	
26.	8729	70	296	558	2026	14	1.0	8	164		40		2.2	7.8	7.9	7.9	

Figure 3, Grid Sampling Data

Following a discussion with Dr. Earl Vories at the Missouri Delta Center about VRI and how to determine the layout of management zones, it was decided that apparent electrical conductivity (EC_a) of the soil profile could be used to initially characterize field variability (Vories, 2008). EC_a is a sensor-based measurement that provides an indirect indicator of important soil physical and chemical properties. Figures 4 and 5 are EC_a maps done with Dual EM unit looking at EC_a with depth.

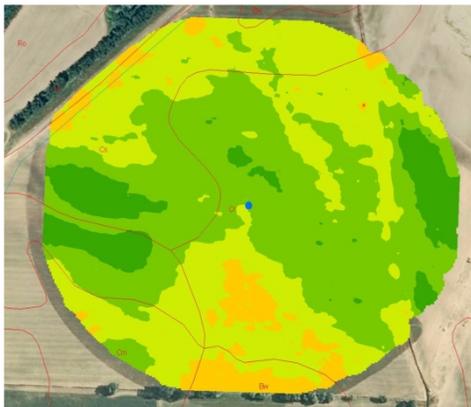


Figure 4, shallow DualME

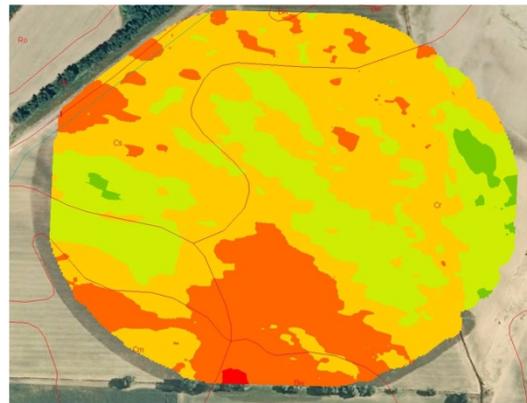


Figure 5, deep DualEM

The Dual EM data provided much better resolution than what was shown by the other available information. Using prescription software that was non geo-referenced allowed for manual design of a zone control package to proceed although it did not provide a way to evaluate the use of speed vs. zone control.

Additional, easy-to-use tools are obviously needed to quantify various field specific VRI packages. A computer program to provide spatial data analysis of geo-referenced data is needed to make a thorough analysis. One such option is using the VRI Optimization tool of CropMetrics™ (<http://cropmetrics.com/>). This appeared to be a tool that would help guide the decision to use speed or zone control based on specific data. The following example demonstrates how this tool can be used to evaluate a field. The VRI Optimization uses not only ECa data but also topographic information.

Figure 6 shows the deep Dual EM data for a specific field. From the Dual EM data the CropMetrics package calculated field variability as 26.7%. This indicates that with a uniform sprinkler package potentially only 73.3% of the field would receive the correct amount of irrigation and that 26.7% will either receive too much or too little irrigation. The roughly 27% that is under or over irrigated will probably not be able to reach its full yield potential, even with good irrigation scheduling.

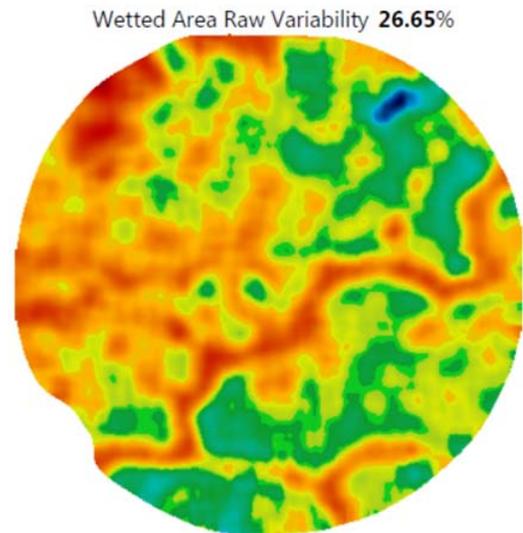


Figure 6

A VRI system would be able to compensate for these differences. Every field is different as to what the potential yield improvement is possible for each crop being grown. Thus, another important component to consider is the recommendation to use a knowledgeable, local consultant or advisor to help analyze each particular situation.

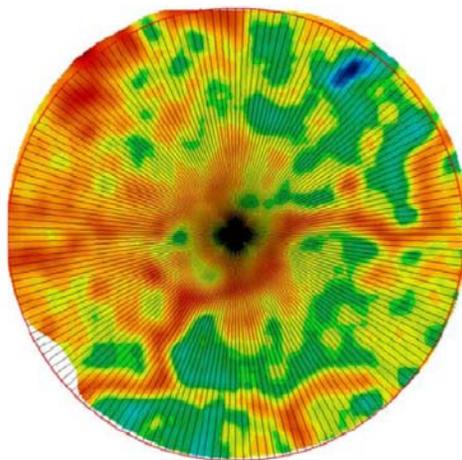


Figure 7

Next using a VRI optimization tool one can determine the potential improvement that may be possible using speed control as shown in figure 7. This shows the potential of how much the variability could be reduced by breaking the field into two degree sectors. The speed of the center pivot can be changed in each of the slices and by changing the speed change the application depth. In this case the variability in watering can be reduced to 21% with an improvement of 5% of the field being over or under watered.

Lastly how much improvement could be achieved if zone control is applied?

Map: DualEM Deep
a= 105.7ac
r= 1211ft

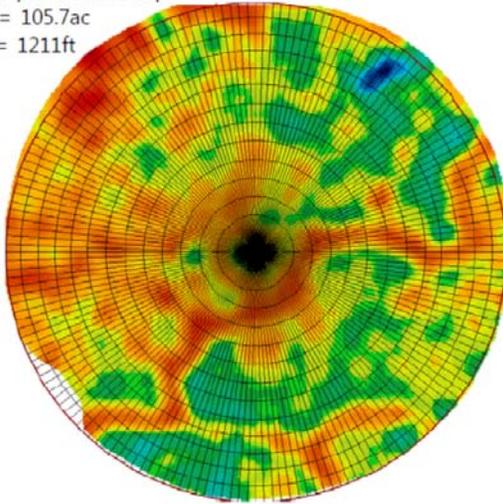


Figure 8

Again using the VRI Optimization tool shows the variability could potentially be reduced to 7.4% as shown in figure 8. This example uses fourteen zones and 180 sectors to reduce the variability to just over 7%. In this application there would be 2,520 different management zones that each could receive a different irrigation application depth.

Using speed control on this field one could achieve an improvement of 5% and with zone control could obtain another 14% improvement to the point 93% of the field is watered optimally.

CONCLUSIONS

When considering whether to switch to VRI the challenge is determining the value and the return on investment for changes. Each case is different due to the characteristics of the field and costs may vary significantly. Computer tools to evaluate a field using EC_a data from DualEM or Veris can simplify the decision process by providing comparison of VRI options. Often taking advantage of the capabilities of the features of a computerized control panel can help meet the need for a few management zones around the field. When one moves to true VRI, often speed control may be added to a center pivot as simply as updating the control panel software (depending on the manufacturer and the control panel). Another option would be to add a separate controller usually on the end of the center pivot independent of the control panel with costs in the range of \$1,500 to \$2,500. Zone control costs for a typical quarter mile center pivot may range from \$12,000 to \$28,000 or more depending on the specific design and field application. Since each field is different and has different yield potentials for each crop, it is not possible to make general statements on the potential value of switching to speed or zone control. In general and from data collected so far, a 5% or greater improvement seems to justify the change to speed control and 15% or more for zone control although exceptions exist. Specific numbers or potential improvement ranges for making decisions on whether to change to VRI are difficult to quantify. A combination of data analysis tools coupled with local agronomic expertise can provide guidance for a specific field. Other good reasons to consider VRI include the ability to reduce runoff and reduce or stop the watering of non crop areas. Work is needed to help better describe the potential value of changing to variable rate irrigation.

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