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INTEGRATING VARIABLE RATE NITROGEN AND VARIABLE RATE IRRIGATION MANAGEMENT: OPPORTUNITIES AND CHALLENGES

Tim Shaver
Nutrient Management Specialist
University of Nebraska-Lincoln
Department of Agronomy and Horticulture
WCREC North Platte, NE.
308-696-6714
tshaver2@unl.edu

Richard Ferguson
Nutrient Management Specialist
University of Nebraska-Lincoln
Lincoln, NE.

Daran Rudnick
Irrigation Management Specialist
University of Nebraska-Lincoln
WCREC North Platte, NE.

Himmy Lo
Ph.D. Graduate Student
University of Nebraska-Lincoln
WCREC North Platte, NE.

INTRODUCTION

Water is the most limiting factor for agricultural production in the semi-arid environment of central and western Nebraska. While this region sits atop a vast quantity of ground water contained within the Ogallala Aquifer, the central and western part of the state itself is semi-arid and receives less than 500 mm (20 inches) of precipitation annually. Dry climate conditions combined with a large availability of ground water has led to crop production systems that are highly dependent on irrigation for maximum yields and sustainability. Elevated societal demand for water has become increasingly important locally, regionally, nationally, and globally. This increased emphasis on the importance of water is forcing crop producers, regulatory agencies, and agronomic research entities to find new ways to increase the efficiency of water used for agriculture. With the availability of variable rate irrigation (VRI) technologies, the potential for increasing water use efficiency (WUE) is greatly enhanced.

Increasing WUE in irrigated agriculture is very important. It is equally important to recognize that water management does not occur in a vacuum. Nitrogen (N) management is directly affected by water management due to the solubility of N. Water and N are inter-related and how one is managed directly affects management of the other. By increasing the efficiency of both water and nitrogen for crop growth the over-use of water and fertilizers may be greatly curtailed aiding in the profitability and sustainability of producers and rural communities. Increasing the efficiency of these crop production inputs also enhances environmental stewardship and the sustainability of production agriculture.

With the adoption of VRI based management strategies, N management strategies may need to be adapted or changed. Fortunately there are many options for variable rate nitrogen (VRN) applications that can complement VRI application. As with irrigation water, the overall goal of these N management strategies is to increase use efficiency. Increasing nitrogen use efficiency (NUE) for crop production reduces the overall amount of fertilizers used by farmers. This is of primary importance both economically and environmentally as N is a potential environmental contaminant if exposed to streams, rivers, or ground water. This is especially important in western Nebraska due to the Ogallala Aquifer.

While the technology now exists to variably apply both water and N, knowing how to effectively use this technology for the interaction of water and N is quite challenging. This is especially true on fields with large amounts of soil spatial variability. This presentation will demonstrate some of the successes and challenges we have had trying to quantify the interaction of water and N management with VRI and VRN.

VRI x VRN RESEARCH

In an attempt to better understand the integration of VRI and VRN management a research study was conducted in 2011 and 2012 at the UNL Water Resources Laboratory (WRL) near Brule NE and the South Central Agricultural Laboratory (SCAL) near Clay Center NE. The WRL location is center pivot irrigated with full VRI capabilities. The SCAL location is linear move irrigated with VRI capabilities. Both locations have high clearance VRN capable application tractors.

A split-plot treatment design was used at both locations, with irrigation level as the main plot, and fertilizer N rate as subplots. Irrigation levels were set at varying levels of ET requirement at each location. At the SCAL site irrigation levels were set at rain-fed, 75%, and 100% of ET requirement with five N rates (84, 140, 196, 252 kg N ha^{-1}, canopy sensor-based). Sensor-based N treatments consisted of 84 kg N ha^{-1} side-dress in early June, followed by a sensor-based N application in late June at growth stage V8. At the WRL location irrigation levels were set at 40%, 70%, and 100% of ET requirement. Nitrogen levels were set at 84, 140, 196, 252 kg N ha^{-1}.

RESULTS

Results for the SCAL location are shown in Figure 1 and Figure 2 for 2011 and 2012 respectively. The results at the SCAL location are relatively straight forward and what one would expect. Generally for both 2011 and 2012 as irrigation level and N level increase, yield increases as well. The SCAL location is relatively uniform in terms of soil spatial variability and has little to no slope that would affect run-on and/or run-off conditions for both N and Water.

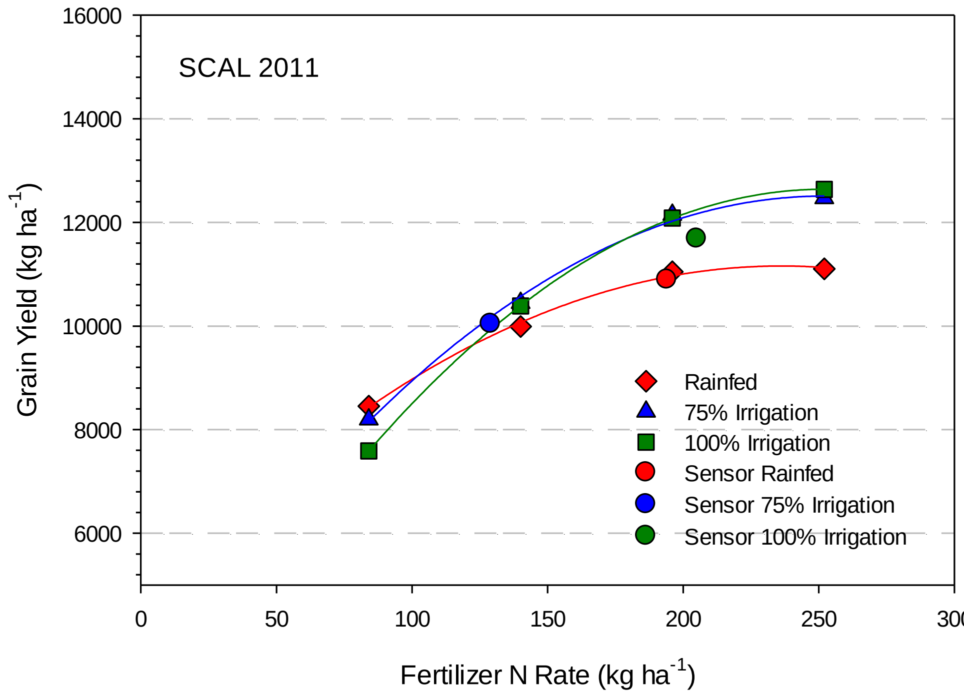

Figure 1. Grain yield influenced by fertilizer N rate and irrigation level, SCAL 2011.

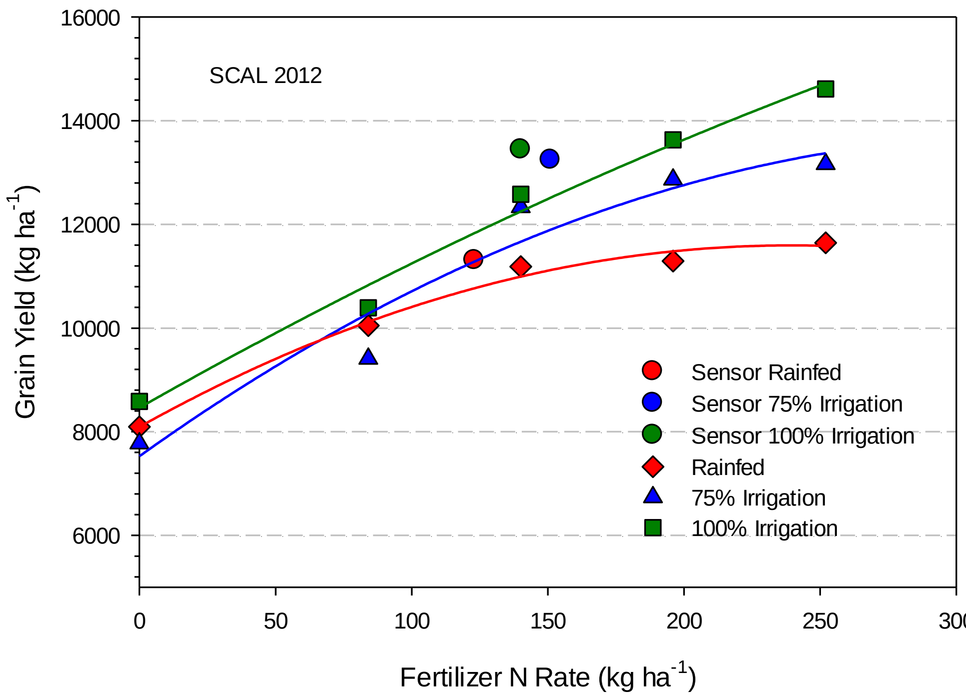

Figure 2. Grain yield influenced by fertilizer N rate and irrigation level, SCAL 2012.

Results for the WRL location are quite different than those at SCAL and are shown in Figure 3. The WRL location shows no significant differences and not significant trends in the data. The results show no response to applied N and the 70% irrigation had higher yields than the 100% irrigation. This site has significant spatial soil variability and significant landscape variation with significant potential for N and water run-on and run-off. This site demonstrates the challenges associated with integrating variable rate N and water management due to the variability that exists.

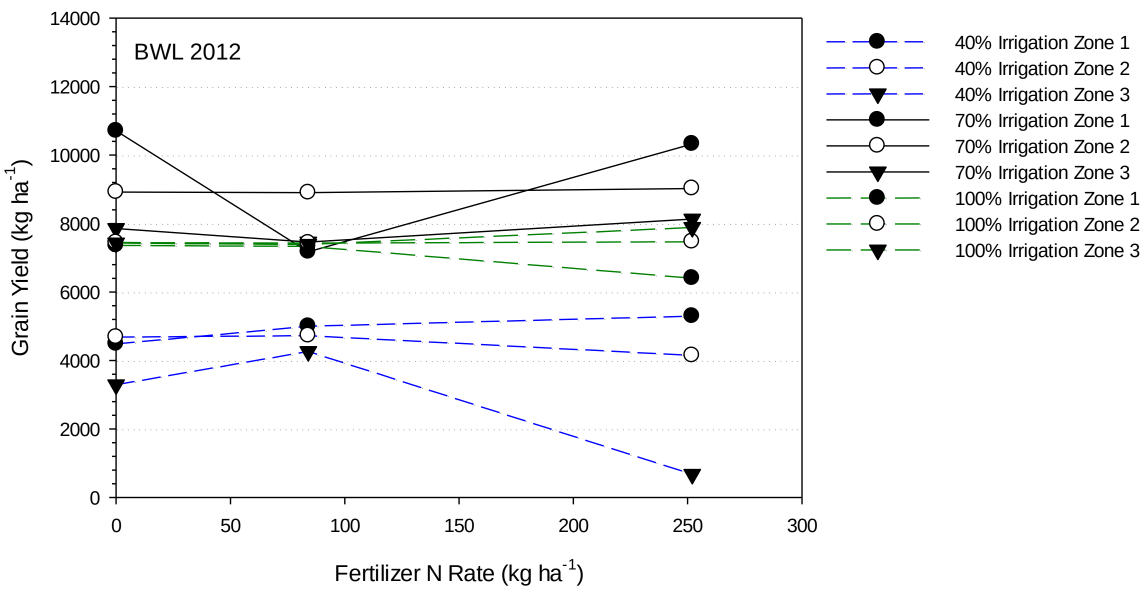

Figure 3. Grain yield, BWL 2012, as influenced by N rate, irrigation level, and productivity zone (1=Low, 2=Medium, 3=High Productivity).

CONCLUSIONS

The results from this study show the opportunities and challenges associated with the integration of variable rate N and water management. At the SCAL location with uniform soils with little to no landscape variation, the integration of N and water management can be intuitive and quite straight forward. When reducing water application it is prudent to also reduce N applications and vice versa. At the WRL location the challenges associated with this integration come to the forefront. This location has significant soil variation and landscape variation making the quantification of the variability extremely difficult. This, in turn, also makes it very difficult to determine appropriate VRI and VRN applications and this difficulty magnifies when trying to integrate the two. Overall, the integration of VRI and VRN management is necessary to effectively increase the use efficiency of both inputs. In some cases this may be straight forward, and in other cases this may be very difficult to accomplish. More work is needed on this important topic and research continues at UNL to develop an approach that will work on uniform as well as highly variable fields.