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AE490

Agricultural Management Options for Climate Variability and Change: Variable-Rate Irrigation[1]

Calvin Perry, Clyde Fraisse, and Daniel Dourte[2]

This series of EDIS publications provides information about different agricultural management options available to improve resource-use efficiency and adapt to climate variability and change. To see the complete series of publications, visit http://edis.ifas.ufl.edu/topic_series_agricultural_management_options.

Introduction

Adapting to climate variability and change can be achieved through a broad range of management alternatives and technological advances. While decision making in agriculture involves many aspects beyond climate, including economics, social factors, and policy considerations, climate-related risks are a primary source of yield and income variability. Existing strategies can help producers minimize the risks associated with climate variability and change as well as improve resource-use efficiency. This series of EDIS publications gives information on these existing technologies, and this publication focuses on the use of variable-rate irrigation in crop production systems.

What is variable-rate irrigation?

Variable-rate irrigation (VRI) is an innovative technology that enables a center pivot irrigation system to optimize irrigation application. Most fields are not uniform because of natural variations in soil type or topography. When water is applied uniformly to a field, some areas of the field may be overwatered while other areas may remain too dry. Some farmers manage these individual zones by excluding these problematic areas from the acres cropped. However, VRI technology gives farmers an automated method to vary rates of irrigation water based on the individual management zones within a field. A VRI system can provide a simple automated way to avoid irrigating roadways, waterways, wetlands, and other non-farmed areas within a pivot. A VRI system can retrofit onto existing center pivot systems and works by integrating GPS positioning into a control system. The control system cycles through individual sprinklers or groups of sprinklers, turning them on and off, and varies travel speed to achieve the desired application rates within different management zones.

A VRI system consists of a center pivot irrigation system combined with the following: 1) valves on individual sprinklers, activated electronically or pneumatically/hydraulically; 2) a controller to activate individual sprinklers or groups of sprinklers and to adjust irrigation "walk" speed; 3) a motor controller (optional) to modulate pump speed to avoid excessive pressure if a variable-speed pump is installed; 4) a GPS so that the position of the system is known; and 5) a user interface to complete the field mapping and set up the system. Management zones for VRI are developed using the farmer's knowledge of the field, aerial photos of the field available from online sources, maps of the field showing the variability of soil electrical

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2. Calvin Perry, public service representative, Biological and Agricultural Engineering at the University of Georgia; Clyde Fraisse, assistant professor, Department of Agricultural and Biological Engineering; and Daniel Dourte, research associate, Department of Agricultural and Biological Engineering; Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

conductivity, yield, topography, and other parameters, soil water monitoring, and other relevant information.

How does variable-rate irrigation reduce climate-related risks?

Using a VRI system can reduce the total irrigation water volume required to grow field crops in two ways. First, producers can exclude non-cropped or marginal areas from water application, and second, producers can lower application rates in low-lying areas or in soils with high water-holding capacity. Field implementation of VRI systems has shown average reductions in irrigation water use of 8%–20% (Sadler et al. 2005) compared to uniform irrigation application. Using a VRI system can help reduce irrigation withdrawals, while still maintaining a well-watered crop. This allows for more efficient use of water and may reduce the risk of temporary well failures during droughts. Having the equipment and access to water for irrigation makes irrigated croplands less vulnerable to climate-related risks compared to their dryland counterparts. VRI extends this reduced risk by improving irrigation water-use efficiency and reducing freshwater withdrawals to allow for more stable water supplies.

What are the agronomic benefits?

A VRI system enhances the farmer's ability to tailor water application to varying crop needs across the field. With a VRI system, the farmer can better match irrigation application to site-specific soil types and topography. Generally, VRI is only suitable in fields where there is substantial variability in soils and yield. The agronomic benefits of VRI are as follows:

- Using VRI can lead to increased crop yields and quality because water is applied in optimal, varying amounts.
- Less leaching and runoff of applied nutrients occur.
- Weed and disease problems can be reduced by eliminating over-application when irrigation systems overlap.

What are the impacts on production costs?

Figure 1 illustrates an example of management zones where irrigation depths can be moderately or greatly reduced based on field variability. Wetland areas, drainage ditches, farm roads, sandy-soil areas, and heavy-soil areas can all receive different application rates, resulting in lower water and energy costs. VRI can reduce production costs in the following ways:

- Potentially lower pumping costs because non-cropped areas are not irrigated, and applied water is better managed.
- Reduced costs associated with weed management in non-cropped areas because water and nutrients are not applied.
- Fertilizer costs can be much lower if a VRI system is used to apply the nutrients.
- Less nutrient loss to leaching and/or runoff.
- Available for all center pivot irrigation system hardware (new or old, large or small).

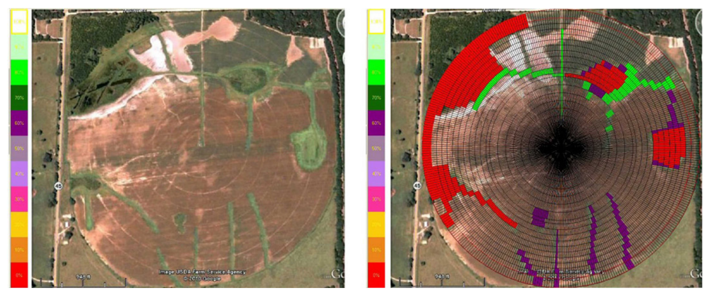

Figure 1. Example of management zones in an irrigated field having substantial variability in soil properties and planted areas. Colored zones indicate areas where irrigation is reduced or eliminated.
Credits: Calvin Perry

What is the investment cost?

VRI systems can cost as little as $5,000 to as much as $30,000. The cost depends on the length of the center pivot system and the number of sprinklers that are controlled. Systems are designed to last many years and require little annual maintenance. Assuming a short system life of 5 years, Almas et al. (2003) estimated break-even yields (that is, yield increases required to cover investment costs) of between 3 and 24 bushels/acre depending on crop type and field variability. It should be noted that farmers often will upgrade their sprinkler package and/or end gun controls when investing in VRI so that they are applying water as efficiently as possible.

What are the impacts on greenhouse gas emissions?

Depending on field variability, variable-rate irrigation may offer significant reductions in water withdrawals for irrigation. Energy-related CO_2 emissions can also be reduced as a result of the lower required pumping volume. In irrigated dairy pasture and corn in New Zealand, a reduction in CO^2-equivalents of about 20% (Figure 2) has been observed for the VRI fields (Hedley et al. 2009). Reductions in irrigation application and energy use depend largely on the spatial variability within the fields under consideration.

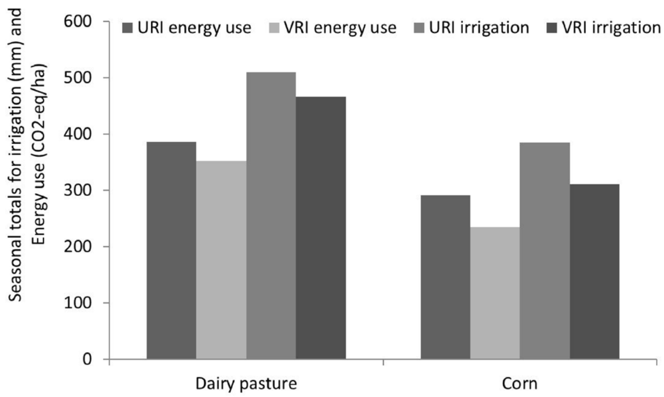

Figure 2. Irrigation and energy use for dairy pasture and corn in New Zealand under uniform-rate irrigation (URI) and variable-rate irrigation (VRI); data from Hedley et al. 2009.
Credits: Daniel Dourte

What are the barriers and incentives for implementation?

Barriers

- Farmers' reluctance to add more complexity to their irrigation system
- Economic investment
- Lack of information about such systems

Incentives

- Reduction of water and energy use
- Flexibility (can be implemented on nearly any system)
- Much greater control over irrigation system operation
- Nutrient and pest management improvement

Cost-share programs are available through the following:

- USDA Environmental Quality Incentives Program (EQIP) funding
- Agricultural Water Enhancement Program (AWEP)
- Conservation Innovation Grants (CIG)
- Research grants and others

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