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Assessing the Value of Adapting Irrigation Strategies Within the Season

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Introduction

A common approach to reducing water scarcity and increasing agricultural water productivity is to optimize irrigation scheduling. However, there is currently a lack of knowledge regarding how to optimize and adapt irrigation decisions the most effectively in the face of weather and climate uncertainty, as well as how the advantages of adaptive irrigation scheduling contrast with the fixed heuristics that farmers typically employ. We compare a fixed irrigation strategy, which maximizes average profits over a range of plausible weather outcomes but is not adjusted annually, to an in-season adaptation of irrigation strategies in this article. The AquaCrop-OSPy crop-water model is used to simulate a case study of irrigated maize production in a central United States region with limited water supplies for this evaluation. Over a range of historical years, irrigation strategies are defined to maximize mean seasonal profit. The case of adaptive strategies, in which the irrigation strategy is re-optimized at multiple stages throughout each season, is then contrasted with this baseline profit. According to our research, fixed irrigation heuristics typically achieve more than 90% of the potential profits that can be achieved with perfect seasonal foresight. The benefits of re-optimization are greater when it occurs more frequently or is accompanied by reliable forecasts of the weather for the week ahead. In-season adaptation marginally increased agricultural profitability. Fixed irrigation scheduling rules can be near-optimal when making realistic assumptions about farmers' potential knowledge of future weather, but the overall magnitude of these additional benefits was modest (less than 5% additional increase in average profits). We recommend prioritizing the implementation of fixed irrigation strategies over the creation of more complex adaptive strategies because fixed irrigation strategies are simpler to design, communicate, and implement than data-driven adaptive management strategies.

Description

Policymakers all over the world are concerned about the growing pressures on freshwater resources worldwide. Since irrigation uses more than 70% of the world's freshwater, many regions are looking into ways to cut down on agricultural water use to avoid conflicts and water scarcity in the future. Increasing agricultural water productivity (i.e., producing more crop output per unit of water input or consumption) is essential for reducing or stabilizing agricultural water demands due to the simultaneous need to increase food production to meet the needs of expanding populations and their shifting dietary preferences. Specific policy restrictions on abstractions like quotas and efforts to encourage greater water use efficiency and productivity by enhancing the scheduling and application of irrigation during the growing season are two ways to accomplish this objective.

There is a lot of research on how to make the best irrigation scheduling rules and strategies to help farmers make the most money or use the most water. One problem with trying to make the best irrigation management strategies is that the best rules or decisions have to be able to hedge against multiple possible weather scenarios because farmers can only guess what the weather will be like during the next growing season. In both research and practice, optimizing a single irrigation management strategy that maximizes the average profit across a range of potential weather outcomes, such as those recorded in a historical record, is a common strategy for dealing with this uncertainty. In contrast, other studies have concentrated on optimizing irrigation management rules for a single "average" year from a collection of years, such as in terms of total rainfall. Identifying mechanisms to adapt typical irrigation strategies throughout the season as more information about a particular year's weather patterns is gathered is one potential strategy for increasing agricultural water use productivity and profitability [1,2].

In this regard, a number of studies have utilized adaptive simulation-optimization frameworks to evaluate the potential benefits of using weather forecasts to adjust irrigation schedules intraseasonally. These studies came to the conclusion that such strategies have the potential to generate substantial increases in profits for producers. Additionally, a number of studies have utilized an adaptive simulation-optimization framework to evaluate the benefits of re-optimizing irrigation decision rules during the season, demonstrating that this method produced irrigation schedules that were nearly identical to those that would be possible However, a common flaw of these studies is that they do not evaluate or quantify the advantages of adaptive irrigation strategies when compared to fixed irrigation heuristics, which have been extensively developed by researchers and are utilized by farmers on a regular basis. As a result, these studies provide insufficient information regarding the potential advantages and drawbacks, as well as the potential dangers of maladaptation, of adaptive irrigation scheduling [3-5].

Conclusion

Given the extensive data requirements and associated costs of adaptive scheduling in comparison to the use of fixed or average irrigation rules, a better understanding of these trade-offs is essential for supporting improved agricultural water management decisions. Re-optimizing irrigation schedules, for instance, may necessitate additional information about the crop's current state (such as rooting depth, plant height, and leaf-area index), which may be costly to collect in addition to the time and resources needed to set up and use optimization strategies during the season

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