Scientists propose improvements to precision crop irrigation

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Credit: Michele Walfred

With threats of water scarcity complicating the need to feed a growing global population, it is more important than ever to get crop irrigation right. Overwatering can deplete local water supplies and lead to polluted runoff, while underwatering can lead to sub-optimal crop performance. Yet few farmers use science-based tools to help them decide when and how much to water their crops.

A new University of Illinois led study identifies obstacles and solutions to improve performance and adoption of irrigation decision support tools at the field scale.

"We wanted to offer our perspective on how to achieve field-scale precision irrigation with the most recent and advanced technologies on data collection, plant water stress, modeling, and decision-making," says Jingwen Zhang, postdoctoral researcher in the Department of Natural Resources and Environmental Sciences (NRES) at Illinois and lead author on the article in *Environmental Research Letters*.

Zhang says many farmers rely on traditional rules of thumb, including visual observation, crop calendars, and what the neighbors are doing, to decide when and how much to water. Better data and more advanced technologies exist to help make those decisions, but they aren't being leveraged currently to their full potential.

For example, some fields are equipped with soil moisture sensors or cameras that detect changes in crop appearance, but there aren't enough of them to provide accurate information across fields. Satellites can monitor vegetation from space, but the spatial and temporal resolution of satellite images is often too large to help make decisions at the field scale.

Kaiyu Guan, assistant professor in NRES, Blue Waters professor with the National Center for Supercomputing Applications, and project leader on the study, pioneered a way to fuse high-resolution and high-frequency satellite data into one integrated high spatial-temporal resolution product to help track soil and plant conditions.

"Based on remote sensing fusion technology and advanced modeling, we can help farmers get a fully scalable solution remotely," he says. "That's powerful. It can potentially be a revolutionary technology for farmers,

not only in the U.S., but also smallholder farmers in developing countries."

With modern satellite technology and Guan's fusion model, data acquisition won't be a limiting factor in future precision irrigation products. But it's still important to define plant water stress appropriately.

Historically, irrigation decisions were based solely on measures of soil moisture. Guan's group recently called for the agricultural industry to redefine drought, not based on soil moisture alone, but on its interaction with atmospheric dryness.

"If we consider the soil-plant-atmosphere-continuum as a system, which reflects both soil water supply and atmospheric water demand, we can use those plant-centric metrics to define plant water stress to trigger irrigation," Zhang says. "Again, if we use our data fusion methods and process-based modelling, we can achieve precision irrigation with very high accuracy and also high resolution."

The researchers also looked at challenges regarding farmer adoption of existing decision support tools. Because current products are based on less-than-ideal data sources, Guan says producers are reluctant to switch from traditional rule-of-thumb methods to tools that may not be much more reliable. Non-intuitive user interfaces, data privacy, and inflexible timing compound the problem.

Trenton Franz, associate professor at the University of Nebraska-Lincoln (UNL) and a coauthor, says farmers will be more likely to adopt precision irrigation decision tools if they are accurate down to the field scale, flexible, and easy to use. His and Guan's teams are working on technologies to fill this need and are actively testing the technology in irrigated fields in Nebraska. This includes participating with Daran

Rudnick, assistant professor at UNL and co-author of the study, in the UNL Testing Ag Performance (TAPS) program, which focuses on technology adoption and education for producers across the region.

"We're pretty close. We have real-time evapotranspiration data, and we're adding the soil moisture component and the irrigation component. Probably in less than a year this will be launched as a prototype and can be tested among the farmer community," Guan says.

More information: Jingwen Zhang et al, Challenges and opportunities in precision irrigation decision-support systems for center pivots, *Environmental Research Letters* (2021). DOI: 10.1088/1748-9326/abe436

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