Science Societies

Combining light sensors with AI to improve potato farming

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Photo courtesy of Pixabay/FotoRain.

Potato farmers need to make sure they aren't applying too much—or too little—nitrogen fertilizer in order to grow lots of high quality potatoes without harming the environment. Find out how new advancements in both monitoring technology and artificial intelligence can be used together to help thread the nitrogen needle.

This article is part of our Down to Earth series, which breaks down and explains food, farming, and environmental sciences for readers of all backgrounds, including those without formal scientific training.

Potatoes, the most consumed vegetable in America, are an undeniably large industry. The U.S. produces 20 million metric tons of potatoes every year to sell internationally and domestically. Potato farmers need to manage their farms properly in order to keep up with this demand, but certain practices, like nitrogen fertilizer management, are a true balancing act. Farmers need to make sure they aren't applying too much—or too little—fertilizer in order to grow lots of high quality potatoes without harming the environment.

New advancements in both monitoring technology and artificial intelligence, however, can be used together to help thread the nitrogen needle. A study published in *Agronomy Journal* combined light sensors with artificial intelligence-powered prediction models to see if the light spectrum can tell farmers anything about nitrogen

needs and potato yields, potentially cutting down on the labor required to monitor fertilizer application.

Measurement and management challenges

Having too little or too much nitrogen can prevent tuber growth. In addition, applying too much fertilizer can cause excess nitrogen to run off into the groundwater supply, damaging water quality. One of the most common ways that farmers monitor nitrogen needs is by sampling total plant mass, which can tell a farmer about how well their plants are growing, how efficiently their crops are using nitrogen, and potentially what their crop yields will be. Unfortunately, this method is destructive and requires much labor, time, and cost to do on a large scale.

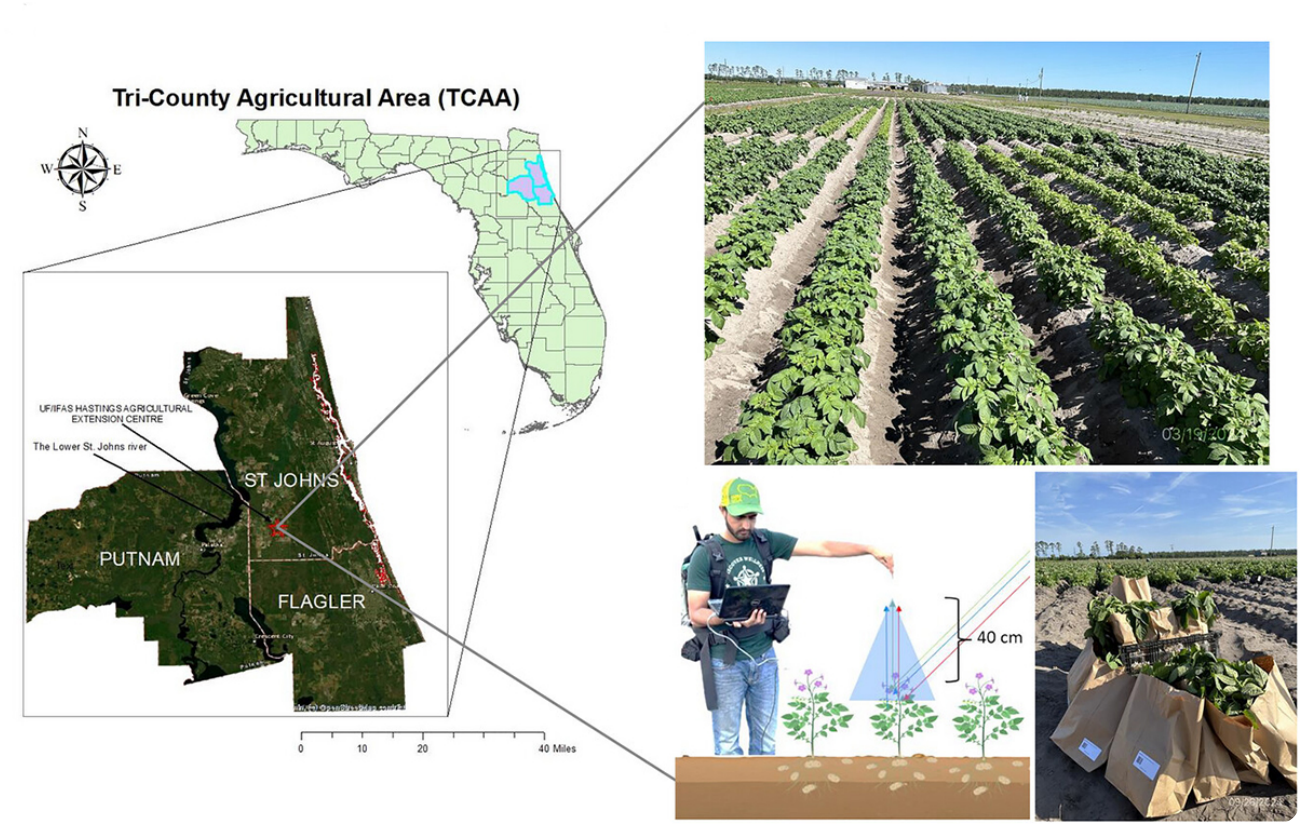
Adding to the complexity, Florida—one of only two U.S. states that can grow spring potatoes—struggles to balance nitrogen levels on its potato farms due to sandy soils and heavy rainfall, which create an environment that poorly retains nitrogen. That's why researchers from the University of Florida aimed to use emerging technology—light sensors and AI—to see if there's an easier way to monitor fields for fertilizer needs.

Turning spectral data into predictions

Light sensors pick up data that the human eye cannot see. *Hyperspectral sensing* nondestructively detects light waves that plants reflect beyond the range of visible light (380 to 700 nm). The data are highly sensitive to changes in the field, which provides insight into crop health, nitrogen content, and other plant traits. But hyperspectral sensing gives you a lot of complex information, so how do you make sense of it all? And which parts of the light spectrum are most helpful in determining nitrogen needs, or even yields? These questions are why the researchers tested

several prediction models to see if this data interpretation can be automated—and which models can do this the most accurately.

Over the two-year study, biomass (total plant mass) and nitrogen uptake data were collected along with final potato yields. The researchers compared these on-the-ground data to spectral reflectance measurements (350–2500 nm) taken on the same days the ground truth data were collected. Afterwards, they "cleaned up" the data with one of three preprocessing methods. Finally, the researchers used part of the physically collected data to train several kinds of algorithms and the other part of the physically collected data to test the ability of these algorithms to predict plant biomass, nitrogen uptake, and final potato yields based off of spectral reflectance measurements.



Location of and images from the potato trials. Image republished from Singh et al. (2025).

Out of six predictive models, two models had the best performance: A one-dimensional convolutional neural network (1D-CNN; an advanced "deep learning" model) was the best at predicting plant biomass and nitrogen uptake while a ridge regression model (RR; a "machine learning" model) was the best at predicting final yield. Further analysis identified key parts of the light spectrum that influenced predictions.

There are still limitations to this data. This study only tested two sites over two years, which means the results aren't generalizable across different environments. However, they show us the potential of this new technology to be able to inform farmers about precise nitrogen fertilizer management. Data storage and costs are also some big challenges preventing the widespread adoption of these methods, but as time goes on and technology advances, these problems are expected to improve. Hopefully, with these tools, farmers can better adjust fertilizer levels to what their plants need, when their plants need it, boosting both the environment and their bottom lines.

Dig deeper

Singh, R., Kaur, S., Singh, R., Katoch, K., Zotarelli, L., Singh, H., Bhadha, J. H., Kakani, G., & Sharma, L. K. (2025). Advancing prediction of biophysical and biochemical traits in potatoes using hyperspectral data and artificial intelligence. *Agronomy Journal*, *117*, e70172. https://doi.org/10.1002/agj2.70172

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