A new study from Colorado State University (CSU) shows how combining the strategies of zone management and active remote crop sensing for variable-rate nitrogen management can increase nitrogen use efficiency in irrigated corn while potentially raising yield.

The clearest and most consistent benefit of combing zone management based on soil properties with in-season remote sensing is the noticeable increase in nitrogen use efficiency, says lead author Louis Longchamps, postdoctoral research associate at the Precision Agricultural Laboratory (PAL) in the Department of Soil and Crop Sciences at CSU, who measured the benefits of combining the two management approaches.

“Our results demonstrate that combining both soil and crop information for variable-rate nitrogen management resulted in the highest nitrogen use efficiency while maintaining productivity,” the research team concluded in the study.

Longchamps presented the paper, titled “Variable Rate Nitrogen Management Integrating Soil and Crop Properties,” at the Annual Meeting of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America in Tampa, FL last November. The presentation highlights the outcomes of the project funded by a USDA-NRCS Colorado Conservation Innovation Grant and led by Raj Khosla, professor and director of PAL at CSU. Khosla and his graduate student Rafael de Siqueira are both coauthors to the paper Longchamps presented.

To test their hypothesis—that using both soil and crop information to determine nitrogen application rate and placement would be more effective at increasing nitrogen use compared with using only crop or only soil information—the research team studied center-pivot irrigated corn from 2010–2012.

Four different modes of fertilizer management were compared in the study: Traditional uniform rate of nitrogen throughout the field, variable rate by zone management to account for soil production potential, variable rate by remote sensing to monitor in-season plant health, and variable rate by using the combined approach of zone management and remote sensing.

Zone management

For the zone management approach, fields were divided into high-, medium-, and low-performance sub-regions using bare soil imagery, field topography, and the farmer’s experience about the field to determine spatial variability, a technique that was developed by Khosla and his research team more than a decade ago.

“The idea is to break up the field and come up with the areas where you have the best productivity and areas where you have the lowest productivity, and some intermediate zones,” Longchamps says. “And then, manage accordingly.”

Bare soil imagery was used to determine a variety of soil qualities, including bulk density, texture, compaction, organic matter, and moisture content. Elevation maps, meanwhile, were used to correlate grain yields with topography to indicate where water was pooling in the field.

“We created an elevation map to find out where the water flows and where the water pools, and we found out this was well correlated with the yield,” Longchamps points out.

Farmers also provided important information based on their personal experience and knowledge, he says, including useful facts on the land’s previous management, history of land use, tillage, pests and weeds, and other observations. In one quick meeting with the farmer, the researchers were able to glean a substantial amount of valuable information in addition to the bare soil imagery and topography maps.
Armed with these three sources of information, the fields were delineated into the high-, medium-, and low-potential zones that were then color-coded on a screen. Carving the field into the three different zones, he stresses, was crucial for achieving greater nitrogen use efficiency.

“We have learned from our previous research that when you have low productivity potential, there is no point to putting on more nitrogen because something else there is limiting the yield in the field,” Longchamps explains. “But in the high zones, all the factors are coming together where you can push the yield even more by putting on more nitrogen. So, the idea is to use less nitrogen in the low zone and more in the high zone.”

But relying exclusively on zoned management based on soil characteristics and topography has its limitations, he adds, as the approach misses the smaller details of plant health during the growing season.

“The management zones give us a good idea about the macro-variability of our field, but it doesn’t tell much about the micro-variability at a finer scale,” he says. “This gives us just half of the picture.”

Active remote sensing

To gain deeper insight about nitrogen usage as the crop was growing, the research team employed active remote sensing by measuring plant health with handheld GreenSeeker devices, which use optical sensors that measure the greenness of the plant.
“We have discovered we can use these sensors to improve the nitrogen use efficiency because by sensing the vigor of the crop, we can determine if the crop is doing well or if you can add more [nitrogen],” Longchamps says.

However, just like zone management, using remote sensing alone to monitor crop status while the crop is utilizing nitrogen also has its limitations, he notes. While a plant may be green and healthy as indicated by the handheld remote-sensing tool, the overall yield potential of the plant might be different from other plants simply because of its location in the field and the soil health in that particular zone.

“Active remote sensing has been shown to improve crop yield and nutrient use efficiency, but it still doesn’t tell about the potential of the soil,” he notes. “What is going on under there? So, again, we have half of the picture.”

A combined approach

To test the theory, Longchamps compared four different types of nitrogen management strategies to quantify nutrient use efficiency: Uniform-rate application throughout the field, variable rate with zone management, variable rate with remote sensing, and variable rate with zone management and remote sensing combined.

In the first approach of traditional uniform application, a rate of 150 lb/ac was applied throughout the area. For the second approach under zoned management, low-productivity zones received 100 lb/ac, medium zones 150 lb/ac, and high-productivity zones 200 lb/ac. Under the third approach with remote sensing, the field received 56 lb/ac less. The fourth approach used zone management to increase nitrogen in high-potential zones and decrease rates for low-productivity zones but with more precise placement based on the health and greenness of the plants.

The results of the study were just as the team expected. The dual approach of zone management and remote sensing created the greatest nutrient use efficiency of all four approaches. The most noticeable difference, notes Longchamps, was between the traditional uniform-rate application across the field and the combined approach of zone management and remote sensing. All three years showed a significant difference between those two approaches, he says.

The combined approach showed an improvement of 60 units (kilograms of grain yield per kilograms of applied nitrogen) over the uniform rate in 2010, 30 units of difference in 2011, and 50 units in 2012. The combined approach also showed improvement over both single modes of variable-rate application but were not as significant or consistent. In 2011, the zone management approach was equivalent to the combined approach, he says, while all other years showed an improvement.

Yield also showed a slight improvement through the combined approach compared with uniform rate, says Longchamps, with the first year showing a 50 bu/ac advantage. The other two years, though, showed no significant yield difference.

Longchamps is expanding the study for another three-year experiment that will include two more sites in Colorado along with cooperation from researchers in Nebraska and Oklahoma.

The results of the study reveal the importance of how precision technology can be used to enhance nutrient use efficiency, he says. But more work still needs to be done so that the benefits can be better understood and applied at the farm level.

“You can reduce the amount of nitrogen we use to get the same yield,” he says. “That would be a benefit for profitability and for the environment.”

Active remote sensing: Using GreenSeeker to determine plant health. Courtesy of Trimble.

Digital Extra

Video: View the presentation

Click on the video to the right to view Louis Longchamps’ presentation of this research at the Tampa, FL Annual Meeting last fall. Note: When you close out of a video when using Firefox or Internet Explorer browsers, you may still hear it playing in the background until you move to the next page.