Science Societies

Managing phosphorus and potassium Is key in conservation tillage systems

By Megan Sever

March 3, 2021



Fabián Fernández, a soil scientist and extension specialist at the University of Minnesota, is the author of a recent article in Agronomy Journal that examines how yield and root growth in corn and soybean crops are affected by tillage, fertilizer application rates, and fertilizer placement.

More and more, North American farms are moving toward conservation tillage practices, including no-till and strip-till. With this trend has come a lot of questions about how best to apply fertilizers, especially phosphorus and potassium, in conservation tillage. In a recent study, researchers examined how yield and root growth in corn and soybean crops are affected by tillage, fertilizer application rates, and fertilizer placement. The team also looked at nutrient use efficiencies and soil phosphorus and potassium levels. The findings echo the results of previous studies and provide a baseline for best practice recommendations.

Both phosphorus and potassium are essential to plant growth, but do not occur in abundance in North American soils, so farmers tend to add these nutrients to their fields. Both nutrients are also nonrenewable resources, and worldwide reserves are decreasing. Phosphorus can cause environmental damage, especially if it runs off into surface waters. And potassium, if not applied correctly, can be unhealthy for plants. In addition, if farmers provide too little of either nutrient, plant growth may be stunted, but if they provide too much, they waste money and mismanage precious resources. So it's important that phosphorus and potassium are managed carefully and used efficiently.

University nutrient guidelines offer best practice suggestions to farmers but are not updated regularly, says Fabián Fernández, a soil scientist and extension specialist at the University of Minnesota. That's certainly the case for phosphorus and potassium in Illinois where he and his team undertook an eight-year experimental study, looking at phosphorus and potassium placement under different tillage techniques at commercial-sized agricultural fields. The work was done with the hope of "providing a first step" to update the state's recommendations.

Fernández and his colleagues used three different farmers' fields and repeated each part of the experiment at least twice, ending up with six repetitions of each of the treatments. The experiments involved no-till and strip-till processes with no-till broadcast fertilizer applications and strip-till broadcast and deep-banding applications in the crop row about 6 inches below the surface. The farmers rotated crops between corn and soybean.

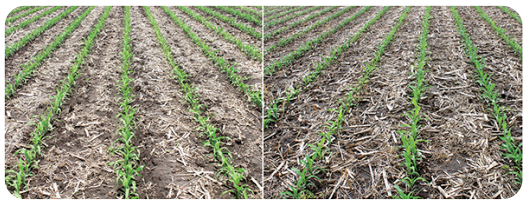
Results were similar to those of previous studies that Fernández and others have published over the last decade. It was "nice," he says, to get results that support previous work.

Yields, Root Development Not Affected by Fertilizer Placement

In this study, recently published in *Agronomy Journal* (**https://bit.ly/37r6Msf**), the team found that with strip-tillage, both deep banding and broadcast applications of phosphorus and potassium produced virtually the same yields in corn and soybean. "In general, the placement really impacts the crops only if the soil is completely depleted of these nutrients or where soil conditions result in fixation of these nutrients," Fernández says. In those cases, he says, banding the fertilizer could improve the nutrient availability. "But those were not the conditions in this study, so the placement had no agronomic impact."

In terms of how roots developed in relation to phosphorus and potassium, the team found “no relationship to the fertilizer placement—the roots grew the same way whether you were broadcasting the fertilizer or banding it,” Fernández says. While this matches what he has found previously, Fernández says it contrasts with what some researchers have postulated: that deep banding improves the efficiency of fertilizer because wetter soil at depth increases the nutrients’ availability. “That was just not the case,” Fernández says since the team found that the majority of roots and phosphorus and potassium uptake occurred in the top 2 to 4 inches of soil, a good 2 inches away from the banding. “This is a great finding and agrees with my research in Iowa,” says Antonio Mallarino, an agronomist and no-till management specialist at Iowa State University who wasn’t involved in this research.

Tillage Has Substantial Impact on Yields



This study showed that strip-till agriculture (left) produced higher yields relative to no-till (right). Photo courtesy of Fabián Fernández.

The tillage, however, does have substantial impact on yields, Fernández says. The team found that strip-till agriculture produced higher yields relative to no-till, regardless of the way phosphorus or potassium was applied. The finding contrasts with what some previous studies suggested but supported what others found. Why strip-till is much better than no-till may have to do with how tillage affects roots, Fernández says. The team found that in no-till systems, plants put more energy into their roots, and that seems to continue throughout the growing season. A strip-till system provides crops with better initial soils to obtain the nutrients and water they need, so plants can focus their energy on producing yield. In strip-till systems, the team even found that

roots shrunk as the season went on: Plants didn't need to keep pumping energy into roots, so they could focus it on producing yield—a nice finding, Mallarino says.

That doesn't mean that strip-till is better in all cases or that deep banding or broadcast are better overall, Mallarino and Fernández say. This study along with a companion study focused on phosphorus runoff show that deep banding combined with strip-till makes it easiest for nutrient uptake while reducing the risk for nutrient runoff at the surface (as can happen with broadcast applications). But farmers, who are interested in producing as much as they can using the fewest resources, might be inclined to go with broadcast applications, Fernández says. If fields need the same amount of phosphorus and potassium for either type of application—as this research showed—but banding takes longer, requires specialized equipment, and provides no real agronomic benefit, then it's hard to recommend a farmer do banding.



This study showed that both deep banding (shown here) and broadcast applications of phosphorus and potassium produced virtually the same yields in corn and soybean. Source: YouTube/TJW (https://youtu.be/wnpNwZsTn6g).

Any recommendations must work for the farmer, Mallarino says. "We have to consider the economics of farmers … so it's very difficult to offer one-size-fits-all recommendations," he says. But overall, Mallarino says, the results of this study support what his own research and that of others have shown over 25 years in Iowa, Indiana, Kansas, and Ontario: that whether a farmer chooses deep banding or broadcast for phosphorus does not affect the eventual yield. Mallarino's research has shown some yield advantage in western Iowa—where springs tend to be drier and later than in eastern Iowa and Illinois—from deep banding for potassium. However, he says, even

there, the benefit of deep-banding potassium may not offset the additional cost, except in dry years. (The Iowa State University phosphorus and potassium guidelines, which differ from those of Illinois, can be found here: **https://bit.ly/3blhjWV**.)

Confusion from Inaccurate Soil Testing

Fernández says he and his colleagues started this study because they wanted to help farmers who were having trouble determining the fertility of their fields with deep banding. The primary reason for the confusion, he says, is inaccurate soil testing. When farmers would test their soil fertility, they would often find "hot spots," locations near the banding, for example, where there was a hefty dose of phosphorus or potassium from years past. "Banding increases soil sampling errors exponentially—it's a nightmare with no clear solution," Mallarino notes. Therefore, he adds, "banding the primary phosphorus and potassium should be done only when it is really needed to avoid diagnostic problems and save money."

"Because of these hot spots, farmers would think they could get away with applying less," Fernández says. But this study showed that is not the case. "We found that there was no difference in terms of the amount of phosphorus and potassium needed." On the flip side, if farmers don't test as deep as they band, they might end up overapplying fertilizer. But there are ways around both of these issues, Fernández says. (See his 2012 paper in the *Soil Science Society of America Journal*, which focused on testing issues and best practices: **https://bit.ly/2ZB58zG.)**

Fernández says he hopes this research will kickstart updating Illinois state recommendations on phosphorus and potassium best practices. "I would not go off our findings to say, 'Oh, we need to change the recommendations this way or that way,' but [we offer] a first step."

More Information

- *Agronomy Journal* article, "Soil and Crop Response to Phosphorus and Potassium Management under Conservation Tillage": **https://bit.ly/37r6Msf**
- Iowa State University phosphorus and potassium guidelines: **https://bit.ly/3blhjWV**
- *Soil Science Society of America Journal* article, "Assessment of Soil Phosphorus and Potassium following Real Time Kinematic-Guided Broadcast and Deep-Band Placement in Strip-Till and No-Till": **https://bit.ly/2ZB58zG**

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