Science Societies

Careful placement allows manure to replace starter phosphorus in corn

By Megan Sever

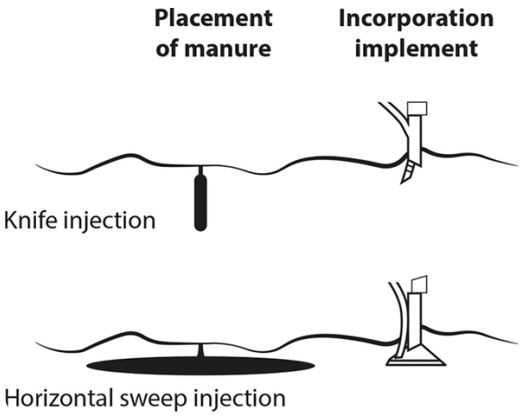
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Most crops in northern climates benefit from a boost from phosphorus to get started. Previous studies have looked into whether manure could replace mineral phosphorus starter fertilizer in corn, but results have been iffy on how exactly to do this. Some research has even indicated manure can be detrimental to corn roots and growth. A new article published in *Agronomy Journal* confirms that manure can replace starter phosphorus fertilizer in corn, but farmers must be careful in where and how it's applied.

Manure is the single largest resource for recycled phosphorus in Europe and a growing resource in North America. Because phosphorus is a finite resource—and because most crops in northern climates benefit from a boost from phosphorus to get started—being able to use a renewable resource is important. Using manure as a fertilizer also gives farmers a way to reuse their manure instead of having to manage that waste stream. Previous research has been iffy on how exactly to use manure to replace mineral phosphorus starter fertilizer in corn. Some research has even indicated manure can be detrimental to corn roots and growth. A new article published in *Agronomy Journal* (**https://doi.org/10.1002/agj2.20097**) confirms that manure can replace starter phosphorus fertilizer in corn, but farmers must be careful in where and how it's applied.



When applying manure as starter phosphorus, knife-banding (top) is not recommended due to the possibility of nitrogen in manure burning the seeds or roots. It's preferred to inject a manure slurry in a way that better distributes it such as sweep injection (bottom). Illustration by Karen Brey (adapted from the University of Nebraska).

Manure has often been applied to the surface of fields, and ideally, it is quickly incorporated to reduce phosphorus and nitrogen runoff with heavy rains. That helps build up a field's baseline phosphorus and nitrogen levels. Broadcast manure does not provide the phosphorus needed for boosting growth of the juvenile plants, especially in cool soils. So, if manure is being used to replace starter phosphorus, it has to be placed in close proximity to the seed row. Knife-banding of manure, "the old system for applying starter phosphorus," was "kind of like laying down a sausage underneath the soil," says Michael Schmitt, a soil scientist at the University of Minnesota who has worked on manure and crops for 30 years but was not involved in this research. "The manure would come out of the back of a circular orifice underneath the soil surface, and if seeds got close to that sausage, it was bad news," he says. That's because the nitrogen in manure can burn seeds or roots. Knife-banding is thus not recommended. What is recommended, Schmitt says, is injection of a manure slurry in a way that better distributes it such as sweep injection.

However, some previous research has also shown that cattle slurry injected too close to corn seeds restricts primary root growth. That's a problem because early-season root growth affects water and nutrient acquisition for the entire growing season. Inject the slurry too far from seeds, and they won't get the benefit. So "precision-placed slurry" is really important, says Shabtai Bittman, a research scientist at Agriculture and

Agri-Food Canada who has worked on precision injection of slurries in cornfields in British Columbia for more than a decade but was not involved in this study. If placed correctly, Bittman says, manure slurry can replace the phosphate mineral starter and save a lot of phosphorus fertilizer on corn.

Study Design, Results

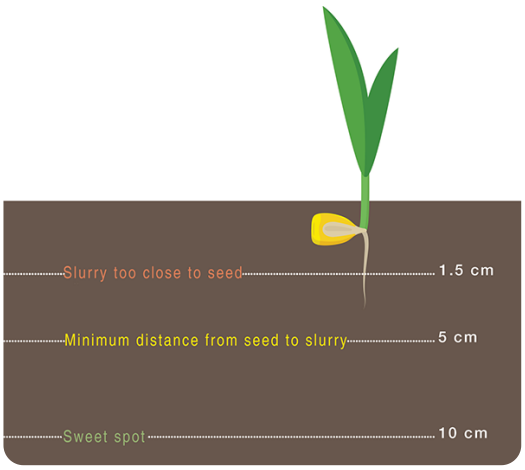
Ingeborg F. Pedersen, a researcher who studies fertilizer–plant–soil processes in the Department of Agroecology at Aarhus University in Denmark, and her colleagues decided to see if they could determine the precise distance that slurry should be placed to help corn growth without injury. They also wanted to assess root growth over a longer timescale to see if roots damaged initially could recover and whether initial damage might affect corn yield. “Specifically we examined if a short vertical distance from seed to a slurry band can compromise any positive effects of placed slurry on corn growth,” Pedersen and colleagues wrote in the *Agronomy Journal* article.

The team ran their experiment in pots filled with a coarse sandy soil—a common soil type of Danish cornfields—in a climate-controlled chamber using local dairy cow slurry. The temperature, amount of light, and soil moisture levels were chosen “to mimic Danish corn-growing conditions in spring.” They applied a 2.2-cm layer of slurry completely covering the soil at varying depths in four pots and used pots with no fertilizer or inorganic phosphorus and nitrogen fertilizer as the controls. Fertilizer bands ranged from 4.5 cm to 15 cm below the surface. Then, corn seeds were planted at varying distances from the fertilizer layer: 1.5 cm, 5 cm, 8.5 cm, and 12 cm. The team also left some pots unplanted to study the soil environment near the slurry band.

From the planted pots, the researchers harvested corn plants 24, 39, and 55 days after sowing, which corresponds to the two-, three-, and five-leaf stage (V2, V3, and V5), respectively. They also removed the intact root systems and separated them into

primary, seminal, and nodal roots.

Placement of slurry 1.5 cm below the seed damaged the primary root, “which subsequently reduced shoot biomass and nitrogen uptake.” High concentrations of ammonium and nitrate observed in the soil weeks after slurry application are thought to have caused the damage to the primary root, they wrote. That carried through to the seminal roots as well as to the plant, which ended up with lower shoot yields than plants where the seeds were farther from the slurry. Shoot yields and root development were similar among the 5-, 8.5-, and 12-cm depths to slurry at V2 and V3, and at V5, the 12-cm-depth had the largest primary root. Nodal roots revealed no differences among any of the slurry treatments, which makes sense, Schmitt says, because toxicity of the slurry would decrease by the time nodal roots are really taking hold.



New research in Agronomy Journal shows that placement of manure slurry 1.5 cm below the seed damaged the primary root, which subsequently reduced shoot biomass and nitrogen uptake. Seeds need to be placed at least 5 cm above the slurry for maximum

benefit and minimum damage. Shabtai Bittman, a research scientist at Agriculture and Agri-Food Canada, says his research has established 10 cm as the sweet spot for distance from seed to slurry.

The team also found that phosphorus uptake was not affected for any of the treatments or depths tested. “They showed the phosphorus uptake was good,” Schmitt says. As the study was aimed at finding out if sweep-injected manure slurry could replace inorganic starter phosphorus, it was successful, he says. However, he adds, the nitrogen findings were challenging. “This phosphorus study all of a sudden became a nitrogen study.”

Interestingly, the team found that corn plants were able to take up nitrogen from the slurry band even when the roots were damaged and even at 12 cm away. The problem arises when seed placement is too close to the slurry, Schmitt says. The study showed that seeds need to be placed at least 5 cm above the slurry for maximum benefit and minimum damage. And therein lies the problem: how to precisely apply the manure slurry to avoid the seed placement.

Precise Placement Is Key—But It’s a Challenge

Farmers can regulate their manure injectors to hit a certain depth, Schmitt says. But in injecting manure, they’re tilling the soil and “fluffing” it up, and it’s hard to predict how much it’s going to settle back down, he says.“Therefore, when you come through with the planter, you need to be really careful that your manure injection is [at least an inch or two] lower than where the seed is going to be placed to account for settling of the soil.” Sweep injectors are the way to go, Schmitt says, and the new results bear that out, but even with those, caution must be taken to ensure the distance from seed to slurry is adequate. In addition, Bittman says, “these results should be verified in the field under a wider set of conditions,” such as delaying planting after manure injection and testing the effects in different textured soils.

Bittman and Schmitt say that generally, this new study's results agree with their previous results. Bittman notes that in 15-plus years of studying precision manure application in the field, usually measuring at V6, he's only had one case where there were a few damaged plants. His research has established 10 cm as the sweet spot for distance from seed to slurry.

"There are limited examples [in the literature] of actual precision ag with manure," Bittman says. "In some respects, it is an oxymoron since manure is inherently unpredictable and variable. Precision placement of slurry for phosphorus is an exception, and that is why it is a breakthrough technology in our view."

"Manure is a great resource," Schmitt says. "It recycles nutrients; it's a holistic approach to nutrient management. Yet, there are some dangers involved with it because it can be a toxic product, especially to sensitive things such as a new seed that's germinating."

The takeaway, Schmitt says, is that "when you're using manure as a fertilizer, crop management is really important. You need to be respectful of manure and its value but also its potential ramifications on early crop growth." Thus, he says, "this study is a reminder [of what we've seen in the field] that there are some significant effects that can happen from not managing your manure properly."

More nutrient management

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