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Does Dairy Manure Injection Affect Small-Grain Growth and Require Specialized Soil Sampling?

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Background

In 2012, anecdotal reports from producers in Virginia suggested that fall manure injection caused differences in growth and maturity where manure was injected compared to the areas between injection bands. These differences can be seen in figure 1, where barley shows dark green bands directly above the manure injection band and lighter green bands in the area where manure was not injected. This is referred to as "banding," although it is sometimes called "streaking."

Figure 1. Banding in barley from manure injection.

Note: A farmer provided this photo in 2012. We were not able to reproduce this banding across 24 sites from 2021 to 2023. The equipment used in the above photo had six injectors spaced 30 inches apart (figure 2), but the photo appears to show banding in groups of four. Therefore, we think two injectors were plugged, and a higher rate of manure than anticipated was applied from the other four.

Figure 2. Manure injection unit with six injectors spaced 30 inches apart.

Banding could be caused by the increased concentration of nitrate in the manure injection band compared to that between bands. The increased nitrate could lead to differential growth and quality in small grains, with the plants growing on the injection band having access to more nitrate than others. Furthermore, this concentration of nitrate in the injection band could make it difficult to take a representative soil sample of the whole field. It would therefore be beneficial for producers to know if banding from manure injection causes differences in small-grain growth, warranting changes in management practices and soil sampling methods.

Small-Grain Banding

To provide producers with data on small-grain banding, 12 unique on-farm study sites were established in the fall of both 2021 and 2022 in the Shenandoah Valley region of Virginia, for a total of 24 sites studied (Hilfiker et al., 2024a). Soil was sampled to a 12-inch depth both in the injection band and between bands one month after manure application and at small-grain silage harvest, and these soil samples were analyzed for nitrate concentration. Small-grain growth-stage measurements

using the Zadoks scale were also taken in the injection band and between bands one month after planting and at silage harvest. Small-grain dry matter yield and forage quality parameters of crude protein, neutral detergent fiber, and acid detergent fiber were measured at silage harvest in and between injection bands. Silage harvest occurred at the end of elongation or the beginning of booting.

Site Information

Manure was typically applied to sites in early fall, before planting, except at four sites, where it was applied eight days after planting. Planting dates ranged from Sept. 28 to Oct. 28, while manure application dates ranged from Sept. 23 to Oct. 16 across sites. A triticale/ryegrass mix was planted at 14 sites, followed by cereal rye at seven sites, and wheat at three sites. The plant-available nitrogen from applied manure ranged from 58 to 96 pounds of nitrogen per acre, reflecting differences in manure management practices across farms. Spring topdress nitrogen application rates ranged from 60 to 80 pounds of nitrogen per acre; however, topdress nitrogen applications were omitted on three sites to show how manure injection alone affects small-grain banding.

Soil Nitrate

Soil nitrate in-band concentrations averaged across sites were 118% greater than between-band soil nitrate concentrations one month after manure application (fig. 3). This difference did not persist through small-grain silage harvest, when in-band and between-band soil nitrate concentrations were the same, likely due to crop uptake depleting soil nitrate. At the three sites where spring topdress nitrogen applications were omitted, no band differences in soil nitrate were observed at silage harvest. These results show that manure injection does not result in increased in-band soil nitrate by silage harvest.

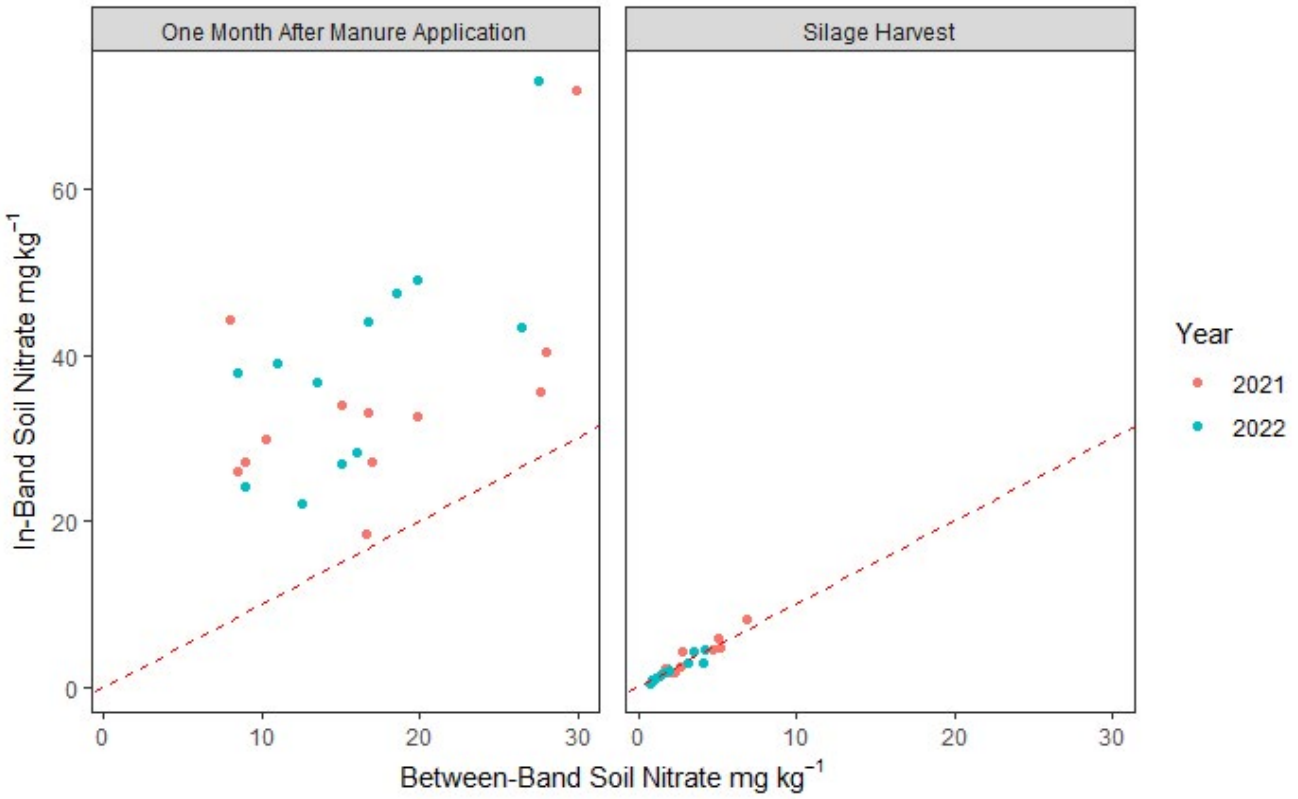

Figure 3. In-band versus between-band soil nitrate one month after manure application and at silage harvest. The dashed line represents a theoretical perfect 1:1 relationship between values. Points above the dashed line indicate greater in-band soil nitrate concentrations; points close to the dashed line indicate similar soil nitrate in-band and between-band.

Small-Grain Growth

The small-grain growth stage was not different when the in-band and between-band areas were compared one month after planting in 2021, likely due to wet conditions delaying planting. One month after planting, small grains tended to mature faster in-band than between-band in 2022 because planting dates were earlier than in 2021. This allowed the small grain to put on more fall growth and tillering, which were both increased in the injection band by the elevated soil nitrate concentrations observed there. As with soil nitrate, these differences in growth and tillering did not persist through small-grain silage harvest, even at the sites that did not receive a topdress nitrogen application. Similar results were seen with dry matter yield and forage quality parameters at silage harvest, as no consistent differences between bands were observed across all sites. Furthermore, the three sites that did not receive a topdress nitrogen application did not result in differential dry matter yield or forage quality parameters between bands.

Management Implications

Initial differences of in-band versus between-band did not persist through small-grain silage harvest, where the data show no meaningful differences in soil nitrate, small-grain yield, growth stage, or forage quality across all sites and both years. Because no consistent differences were observed by silage harvest time, we recommend that producers make no adjustment to their management practices for fields where manure was injected. While no adjustments need to be made, producers utilizing fall manure injection in small grains should be aware that they will most likely observe some visual signs of banding throughout the growing season, but these will typically fade by silage harvest time. We think the anecdotal reports of banding may have been due to some clogged injector units, resulting in higher than planned rates of manure going through the unclogged units, as explained in figure 1.

Soil Sampling Methods Where Manure Has Been Injected

Multiple on-farm studies have been conducted across Virginia's Shenandoah Valley to assess soil sampling following both fall and spring manure injection. In-band soil nitrate concentrations have been shown to be 128% greater than between-band concentrations following a spring manure application. This leads to concerns about the standard soil sampling method — which takes soil cores from representative areas in a field — not being able to obtain the correct proportion of soil from the in-band and between-band areas.

For manure injected with a 30-inch spacing, the equispaced method of soil sampling takes five soil cores 6 inches apart from each other and perpendicular to the injection band; it was developed and recommended by Pennsylvania State University (Meinen et al. 2023). The equispaced method takes into account both the in-band and between-band areas, but it is more difficult and time consuming than the standard method because producers must take more soil samples and must know the direction of the injection band. In Virginia, Bierer et al. (2020) found the standard soil sampling method to be just as accurate as the equispaced method when measuring soil nitrate across seven on-farm sites over three years. Another eight-site on-farm study found that the equispaced method potentially underestimates soil nitrate due to results with concentrations that were on average 18% lower than a weighted average of in-band and between-band soils (Hilfiker et al., 2024b). The widespread use of banded starter nitrogen fertilizer at corn planting further complicates the use of the equispaced method, as it does not allow for the soil sampler to avoid the starter band.

Due to spatial variability, there is no silver bullet for soil sampling following manure injection. However, as the equispaced method presents the soil sampler with additional work without a clear benefit compared to the standard soil sampling method, we recommend using the standard soil sampling method while keeping in mind that this may underestimate soil nitrate. More details on these can be found in Nitrogen Soil Sampling for Corn in Virginia, Virginia Cooperative Extension publication SPES-484P, and Soil Sampling Instructions for the Farm, Virginia Cooperative Extension publication SPES-141NP.

Additional Resources

Maguire, R., and S. Heckendorn. 2019. *Soil Sampling Instructions for the Farm*. Virginia Cooperative Extension publication SPES-141NP. https://www.pubs.ext.vt.edu/content/pubs_ext_vt_edu/en/SPES/SPES-141/SPES-141.html

Maguire, R. O., W. Thomason, G.E. Evanylo, and S. Pokhrel. 2023. *Nitrogen soil testing for corn in Virginia*. Virginia Cooperative Extension Publication SPES-484P. https://www.pubs.ext.vt.edu/418/418-016/418-016.html

References

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Hilfiker, D., R.O. Maguire, G. Ferreira, W.E. Thomason, and R.D. Stewart. 2024a. "Impact of Fall Manure Injection on Spatial Variability in Soil Nitrate, Carbon, and Small Grain Growth." *Agronomy Journal*. 116(2) 689–703. https://doi.org/10.1002/agj2.21526

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Meinen, R. J., D. B. Beegle, S. Vishwanath, P. J. A. Kleinman, L. S. Saporito, J. Spargo, H. Karsten, and J. Dillon. 2023. "Monolith Soil Core Sampling To Develop Nitrate Testing Protocol for Manure Injection." *Soil Science Society of America Journal* 87 (2): 378-89. https://doi.org/10.1002/saj2.20509.

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