NITROGEN LOSS FOR WHEAT RESULTING FROM FROZEN SOIL APPLICATIONS

Edwin Ritchey, Carrie Knott and Lloyd Murdock – Department of Plant & Soil Sciences
University of Kentucky, Princeton, KY 42445
PH: (270) 365-7541, Ext 301; Email: Edwin.ritchey@uky.edu

Unseasonably cold temperatures in early 2014 froze the soil sufficiently to support sprayer traffic through most of January and February. Some producers took advantage of this frozen soil to make early N applications and reduce the risk of compacting or rutting the soil later in the season. Unfortunately, a considerable amount of precipitation fell while the soil was still frozen, which increased potential N loss in surface runoff water. A field study at the University of Kentucky Research and Education Center (UKREC) indicated that when N was applied to frozen soil prior to significant rain events, 49 to 75% of N was potentially lost.

The field study conducted at UKREC was initiated while the soil was frozen to a depth of 6 to 9 inches. Nitrogen, in the form of sodium nitrate ($NaNO_3^-$) was applied to a Crider soil with <1% slope and a Zanesville soil with an approximate slope of 3% on January 31st. The use of $NaNO_3^-$ represented the maximum N loss potential for common N sources and allowed us to better quantify nitrate loss without being confounded by nitrification of fertilizer NH_4^+. Three replications at 0, 40, and 80 lb N/A were utilized for both soil types. Single N applications were made on separate plots at two different times: when the soil was frozen and when the soil was thawed. Following frozen soil N applications, 3.01 inches of precipitation fell (primarily as rain) within five days of N application. An additional 1.61 inches of precipitation (snow and rain) fell in 5 events from February 8 to February 19, 2014. These precipitation events occurred while the soil was still frozen. Nitrogen was applied to adjoining plots after the soil thawed. The thawed soil N application was applied February 24th to the Crider soil in the adjoining plots at the same N rates after the soil thawed and drained sufficiently. The thawed application of N on the Zanesville soil was delayed until March 13th, due to the wetter nature of this soil type.

Our recommendations to producers at that time, based on nitrate loss in the top 12 inches of the soil, were to assume that applications made to frozen soil had lost 50% of the N applied in the first application and to account for this loss with their second N application. To confirm our recommendations, a second application was made to the same plots that received the initial N application, assuming 50% of the first N applied was lost. The second application attempted to result in 100 lb/A of available N when both applications were combined. The check plots (0 N/A) received 100 lb N/A on April 15. Plots that received 40 and 80 lb N/A when the soil was frozen received an additional 80 and 60 lb N/A on April 15, respectively. Plots that received 40 and 80 lb N/A when the soil was thawed received an additional 60 and 20 lb N/A on April 15, respectively. All plots were hand harvested on June 23, threshed, and yields calculated based on 13.5% grain moisture.

Soil nitrate nitrogen in the top 12 inches of soil was measured before the second N application. The amount of nitrate nitrogen found in the frozen Crider soil N application was only 34% and 51% of that found when the N was applied to unfrozen Crider soil at the 40 and 80 lb N/A rates respectively. The loss was even greater in the Zanesville soil where only 25% and 42% of the N was found in the frozen N application

treatments compared to the unfrozen N applications at 40 and 80 lb N/A rates (Figure 1).

Wheat yields were measured on the plots where it was assumed that 50% of the N had been lost from the N applied to the frozen soil and extra N was added to result in 100 lb N/A of available N. Wheat yields for the frozen N application were reduced on the Crider soil by 7 bu/A and 5 bu/A at the 40 and 80 lb N/A rates, respectively (Figure 2). The yields were also reduced on the Zanesville soil. This data confirms that the N loss from N applied on frozen soil was greater than the assumed 50% N loss.

Possible fates for nitrate were plant uptake, denitrification losses, infiltration below the 12 inch sampling depth, and runoff losses. Wheat plant measurements (plants/ft^2, tillers/plant, and plant height) did not indicate that plant uptake contributed to differences in soil nitrate data. Minimal wheat growth occurred between the first N application and the second application. Environmental conditions were not favorable for denitrification after the first N application to the frozen soil and were not thought to be contributing to soil nitrate differences between the frozen and thawed soil nitrate levels present. Soil samples were not collected below 12 inches, so deep infiltration of nitrate was not tested. If nitrate leached below the 12 inch sample depth, this nitrate was likely eventually denitrified and not utilized by the wheat plant when it began to grow. From this data, it was concluded that the most likely fate of the N applied to frozen soil was loss in surface runoff water.

Conclusions

While it is possible to apply N to frozen soil without significant N losses under certain environmental conditions, this is a risky practice and is not recommended. When N, or any nutrient, is applied to frozen soil and a large rain event occurs while the soil is still frozen, a substantial amount of this nutrient can be lost. The lost N can contribute to reduced yields, increased fertilizer costs, and potential environmental consequences. This study reiterates that N applications should always be based on appropriate agronomic practices and environmental conditions.

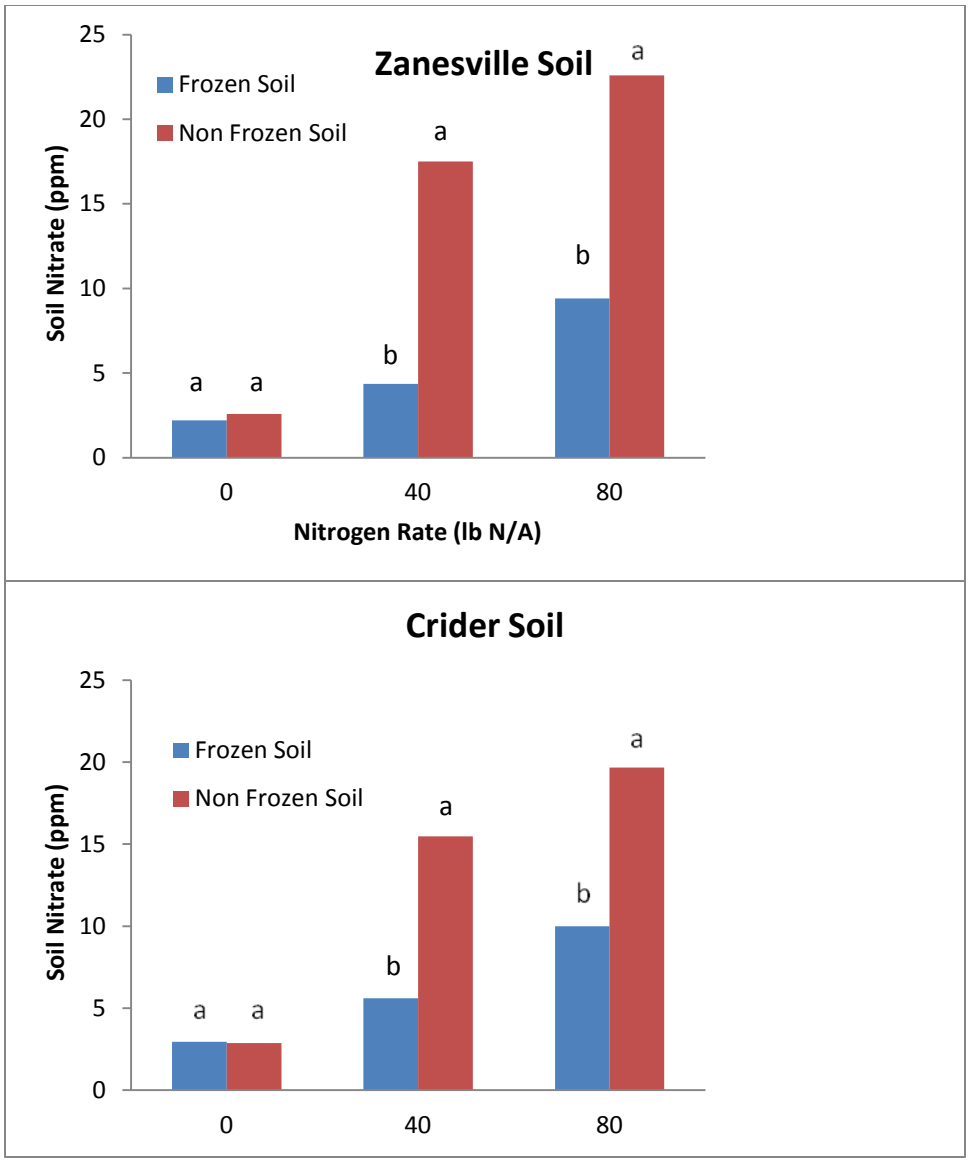

Figure 1. Soil nitrate as influenced by nitrogen rate and application time for the Zanesville and Crider soil. The first application was made on January 31st, second application was made on March 13th for the Zanesville soil. The first application was made on January 31st, second application was made on February 24th for the Crider soil. Means within each rate and soil with no common letter differ at P<0.10.

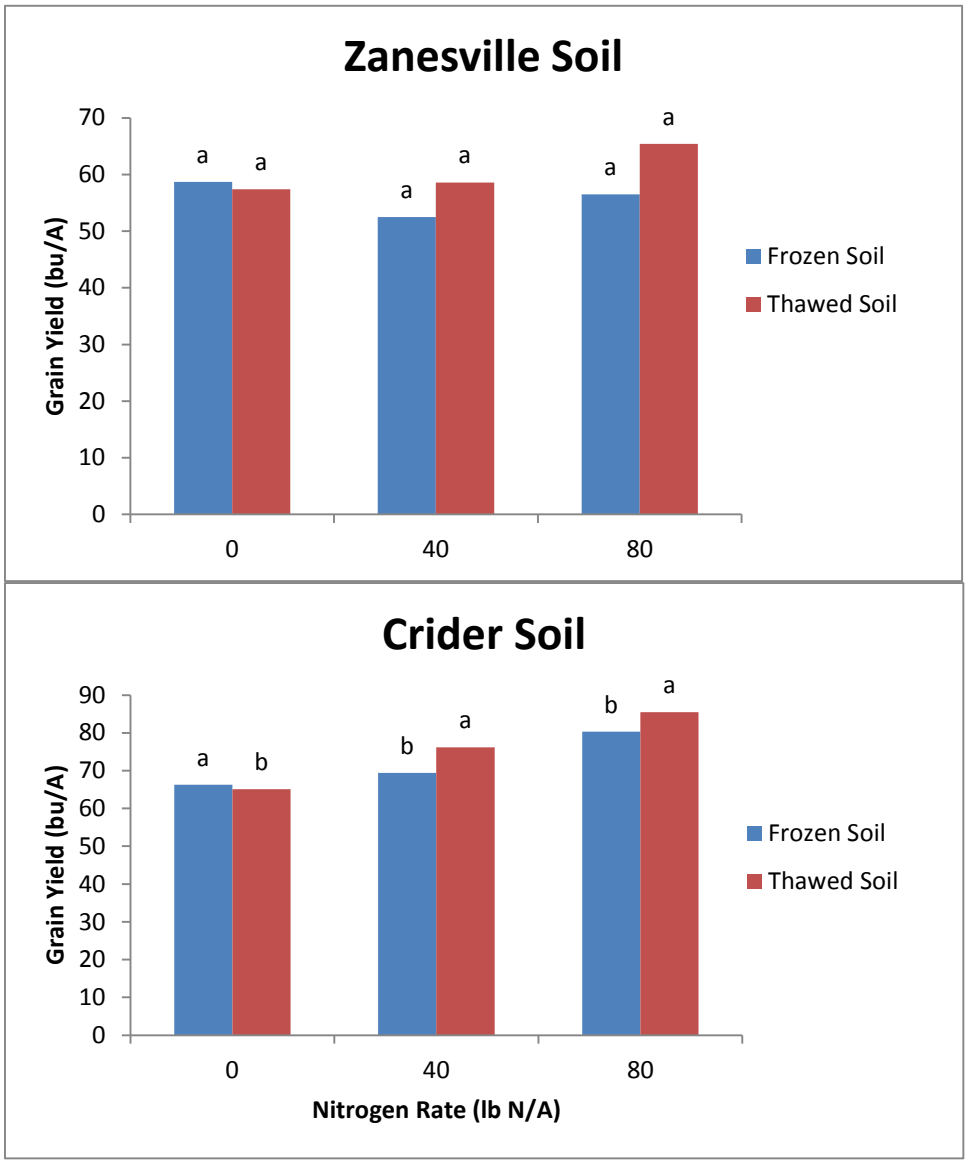

Figure 2. Wheat grain yields for the Zanesville and Crider soils when a total of 100 lb N/A was split applied, assuming 50% of the first frozen soil nitrogen applications was lost and 0% of the first thawed soil nitrogen application was lost. Means within each rate and soil with no common letter differ at $P<0.10$.