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Winter Soil Processes in Cold Region Agroecosystems: Impacts on Nitrogen Cycling

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Winter soil processes in cold region agroecosystems are critical in governing water and soil quality. Biogeochemical processes governing nitrogen (N) transformations in agricultural soils during the winter season are largely unknown, however. Understanding these processes and the variables modulating them (*e.g.,* temperature, soil moisture, snow cover, soil type) are critical to predicting N availability to crops, greenhouse gas emissions, and deterioration of downstream water quality. Here, we present two studies on winter warming and freeze-thaw cycles on N loss pathways in agricultural soils. In the first project, we assessed the effects of winter pulsed warming, soil texture and snow cover on N cycling in a field-scale lysimeter experiment. The results showed that the removal of the insulating snow cover resulted in more intense soil freeze-thaw events, causing increased dissolved N loss from the lysimeter systems *via* nitrous oxide (N_2O) fluxes (from the silt loam soil) and nitrate (NO_3^-) leaching (from the loamy sand soil). In the silt loam lysimeter, we attributed the freeze-thaw enhanced N_2O fluxes to *de novo* production rather than gas build-up and physical release. In the loamy sand lysimeter, we attributed the increased NO_3^- leaching to the lower water retention capacity of this soil type. In the second project, we examined the effects of freeze-thaw cycles on N leaching from fertilized and unfertilized soil columns. The experiment and model results indicated that the high NO_3^- concentrations produced during the thawing events in the fertilized soil were due to nitrification of fertilizer N in the upper oxidized portion of the soil. The low concentrations of NO_3^- and ammonium in the non-fertilized soils leachates implied that the freeze-thaw cycles had little impact on the mineralization of soil organic N. Overall, our results highlight the important role of winter soil processes in modulating soil biogeochemical N cycling, with consequences for soil health, N_2O emissions, and nearby water quality. Consideration of these impacts is important when designing agricultural best management practices adapted to cold regions under climate change.