Effect of N Fertilization and Tillage on Nitrous Oxide (N_2O) Loss from Soil under Wheat Production

Sheel Bansal, Ezra Aberle, Jasper M. Teboh, Szilvia Yuja, Mark Liebig, Jacob Meier, and Alec Boyd

Nitrous oxide (N_2O-N) is one of the most important gases in the atmosphere because it is 300 times more powerful than carbon dioxide in its ability to trap heat, and is a key chemical agent of ozone depletion. The amount of N_2O-N emitted from agricultural fields can be quite high, depending on the complex interplay between N fertility and residue management, plant N uptake, microbial processes, environmental conditions, and wet-up and dry-down events. High N fertilizer rates generally increase yields, but may disproportionately increase N_2O-N losses due to prolonged residence time in soil when not used by the crop, and incomplete decomposition of excess N-compounds by microbes. Tillage could also affect N_2O-N losses through changes in soil moisture content. Though nitrogen monoxide (NO) is one form of N lost from the soil, especially under conventional tillage, this study objective was to quantify N_2O loss in wheat fields from applied urea on soil under no-till (NT) versus incorporated urea under conventional till (CT).

Materials and Methods

This was a collaborative study between NDSU Carrington REC (Aberle, Teboh, Yuja), the U.S. Geological Survey, Northern Prairie Wildlife Research Center (NPWRC) in Jamestown, ND (Bansal, Meier, Boyd) and the USDA-ARS in Mandan, ND (Liebig). In the study, soil N_2O gas flux was measured from wheat plots during the 2017 growing season within a long-term study examining the effects of N fertilizer rates (as sub-sub-plots), tillage (sub-plots) and crop rotations (main plots) on crop production and soil chemical properties. The plots evaluated for N_2O gas flux had urea applied at four levels (0, 50, 100 and 150 lbs per acre) within CT and NT plots. The urea was incorporated for the CT plots. Gas flux was measured every two weeks from April (prior to planting) to August (post-harvest) 2017. On each sampling date, gas was collected from chambers placed in the middle of each urea N rate treatment over a 30-min time period to provide a flux rate (g N_2O-N/area/time). There were a total of 432 gas flux measurements over the season. Total N lost to the atmosphere as N_2O-N was calculated for each subplot and then summarized by fertilizer or tillage treatment.

Results and Discussion

N_2O-N flux rates generally mirrored soil moisture content, with wetter periods having higher rates of N_2O-N emission (Fig. 1, data available at https://www.sciencebase.gov/catalog/item/5a15c101e4b09fc93dd170ab). The exceptions were at the beginning of the season when temperatures were low and at the end of the season after soil N was likely depleted. N_2O-N emissions were highly variable among N fertilizer rates (8 to 588 g/acre/season) with an average of 233 g N_2O-N/acre/season, which is similar to other studies in the region. Total N_2O-N loss to the atmosphere was nearly twice as high in the highest N rate (150 lbs/acre) compared to the control (0 lbs/acre) treatment (Fig. 2a), which was likely due to excess available N for microbes to reduce. Yields also increased with increasing N fertilizer rate with 36 bu/acre at 0 lbs, 50 bu/acre at 50 lbs, 51 bu/acre at 100 lbs, and 57 bu/acre at 150 lbs N/acre. Therefore, N_2O-N emissions per bushel did not differ significantly across fertilization treatments (about 5 g N_2O-N/bushel). Notably, the control treatment with no fertilizer application lost about 160 g N_2O-N/acre, indicating that N levels in soils would diminish even without supplemental N as fertilizer. Yield was significantly higher at 54 bu/acre for NT vs. 46 bu/ac for CT. However, there were no overall differences in N_2O-N loss between CT and NT, although there was slightly greater emission at the end of the season in the NT treatment (Fig.

2b). Even though soil moisture was higher for NT (20%) vs. the CT (15%) plots throughout the season, which probably explained higher yields in the NT plots for a year plagued by periods of drought, N_2O flux was essentially similar throughout most of the growing season. The separation of fluxes between the NT and CT during the last month was mainly attributable to differences in N_2O flux on a single date (July 19), which had the lowest soil moisture content of the season (about 5%). Overall, the total amount of N loss as N_2O was relatively low, even at the highest fertilization rate. However, due to the extremely strong heat-trapping capacity of N_2O and the extensive coverage of farmland in the region, best N management practices would be expected to minimize aggregate contribution from even small losses of N_2O per acre, which can potentially affect climate and increase frequency of drought in the region.

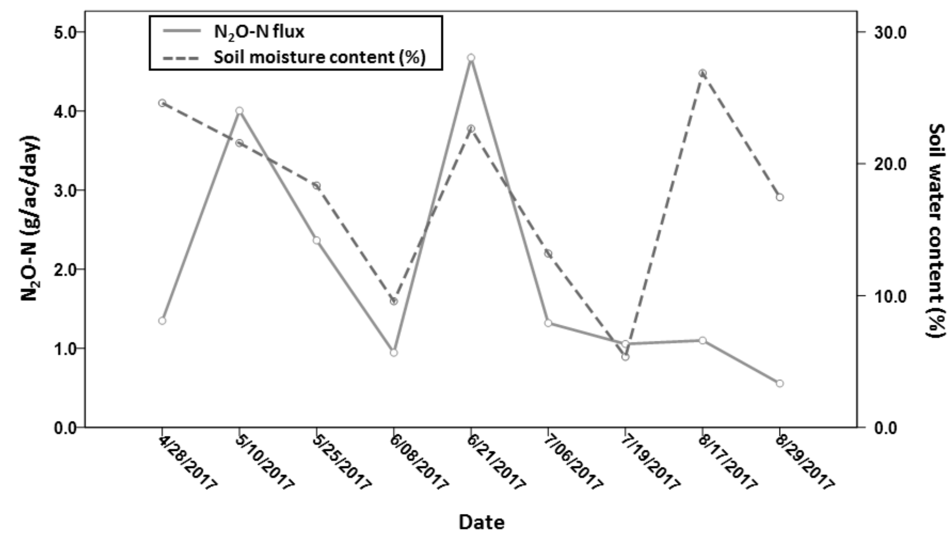

Figure 1. Seasonal N_2O-N flux rates (g/acre/day; solid line) and soil water content (%;dashed line) during the 2017 growing season on wheat plots at the NDSU Carrington Research Extension Center.

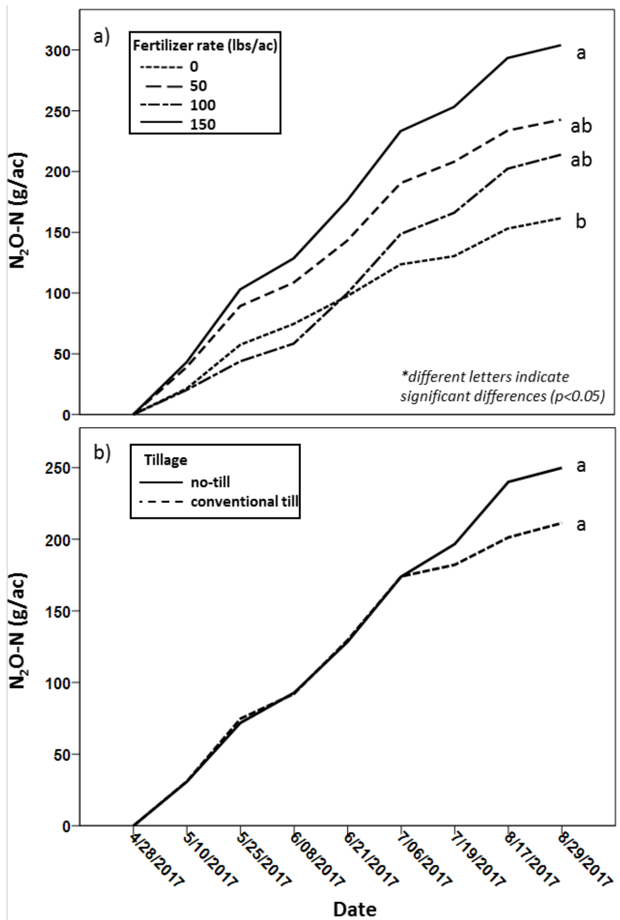

Figure 2. Cumulative loss of nitrogen as nitrous oxide gas (N_20-N) over the 2017 growing season in wheat plots under a) four fertilization rates and b) two tillage treatments.