Effect of Granular Urea Placement on Nitrous Oxide Production from a Silt Loam Soil

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Introduction

Nitrous oxide (N_2O) is a powerful greenhouse gas and is involved in the destruction of the stratospheric ozone layer. During the past 50 years, the atmospheric N_2O concentration increased 9%, or 26 parts per billion (ppb) to its present level of 316 ppb. There is considerable concern about its accumulation in the atmosphere because it has 300 times the global warming potential of carbon dioxide (CO_2). Agricultural activities, in particular fertilizer nitrogen (N) inputs, are thought to be the major human-caused contributor of N_2O to the atmosphere according to the Intergovernmental Panel on Climate Change (IPCC, 2001). This trend will likely continue into the future as global fertilizer N consumption rises due to increased demand in developing countries. Urea is the primary fertilizer N source consumed by Montana farmers. It is frequently applied as a surface broadcast application in Montana, though subsurface band applications are possible with many modern air-drills. In developing countries, where there is an abundance of hand labor, placement of urea in small holes or nests is a common practice particularly for production of row crops. Placement of fertilizer N in concentrated zones, such as subsurface bands and nests, has been promoted because it can enhance fertilizer N use efficiency or recovery by crops. Increased effectiveness compared to broadcast applications has been attributed to slower nitrification rates and N losses as a result of nitrate-N leaching, reduced ammonium-N fixation to clays, and reduced N immobilization in soils with considerable crop residues. Only a few studies have compared the potential impact of urea prill placement on N_2O production, and the fraction of fertilizer N lost as N_2O. The objective of this study was to compare N_2O emission patterns and losses from urea prills applied to a silt loam soil using band, nest, and broadcast application methods.

Methods

Field plots (5 x 10 feet) were established at a field site seeded to canola (*Brassica napus* L) April 17, 2007. The experiment is located on the property of MSU-A.H. Post Farm, and the soil is classified as an Amsterdam silt loam (fine-silty, mixed, superactive, frigid Typic Haplustolls) with pH 6.5. Fertilizer N was applied May 2, 2007. Treatments consisted of broadcast, band, and nest placements of urea-N at two N rates (90 and 180 lb N/acre), plus an unfertilized control. The seven treatments were replicated four times in a randomized complete block design. Broadcast urea applications were spread evenly on the surface and incorporated into the surface 0.5 in of soil with a rake. Band applications of urea were applied mid-row (10 in. spacing) to a 2 in. depth. Fertilizer nests were located 2 in. below the soil surface on a 10 x 12 in. grid spacing, such that each nest was positioned between the middle of two crop rows. Gas sampling was conducted using vented chamber techniques. Nitrous oxide flux was estimated from the concentration change in the chamber headspace over a 30-minute collection period. Samples were drawn from the headspace using a syringe and then transferred to pre-evacuated containers. The concentration of N_2O in the container was determined using a gas chromatograph.

Results

Soil emissions of N_2O were enhanced by application of urea-N, and as anticipated, production of this gas was greater at 180 lb N/acre compared to the 90 lb N/acre rate. Nitrous oxide emissions from broadcast urea rose to a peak and returned to background levels more quickly than emissions from band and nest applications (Figure 1). Overall emissions from the broadcast placement were modest and fluxes were similar to the unfertilized control from June 24 (54 days post-fertilization) until the end of the experiment (201 days post-fertilization). Placement of urea prills in concentrated zones delayed urea hydrolysis and nitrification, and resulted in a more prolonged period of elevated N_2O emission activity. The impact of urea placement on the N_2O production vs. time relationship was most apparent at the higher N rate. Peak emission activity for the broadcast application occurred only 12 days following fertilization, while for the band and nest placement it occurred 48 days following fertilization Nitrous oxide emissions were low,. or near background levels for all

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fertilizer placements between July 5 and September 3. The absence of emission activity during this period was a result of extreme drought conditions at the field site (0.6 in. precipitation), which dried soil to less than 10% water content. Cumulative N_2O losses for the different fertilizer placements were computed by integrating the area under the N_2O production vs. time curves in Figure 1. Fertilizer induced N_2O emissions were then calculated by subtracting the cumulative losses for the unfertilized control from the fertilized treatments. This value was divided by the applied urea-N rate to express the fraction (or percentage) of applied N lost as N_2O. Cumulative N_2O losses were affected by fertilizer placement with broadcast applications showing lower N_2O losses than the band and nest placements (Table 1). The fraction of applied urea-N lost as N_2O averaged 0.17, 0.66 and 0.59% for the broadcast, band, and nest placements, respectively. The results indicate that placing fertilizer in concentrated zones, i.e. band and nests, elevated emission losses by more than three times what was observed for the diffuse, broadcast placement.

Currently, many regional and global estimates of N_2O production from agriculture have adopted the default methodology of the IPCC, which assumes that 1.25% of all N inputs, including fertilizer N, are lost directly as N_2O. In no case did we find N_2O emission losses from fertilizer N at, or above, this level even for the concentrated band and nest placements. Given that most fertilizer N in Montana is applied as a broadcast application, the results from our study indicate that emission losses from fertilizer N are considerable below this level, and suggest a lower fertilizer-induced N_2O loss coefficient would be more applicable to our region.

Fertilizer Facts

- N_2O emissions from broadcast urea rose to a peak and returned to background levels more quickly than from band and nest applications.
- Cumulative N_2O emissions and the fraction of fertilizer lost as N_2O were lower for the broadcast application compared to the concentrated band and nest placement.

Table 1. Cumulative nitrous oxide (N_2O) losses and fraction of applied urea-N lost as N_2O for different placements and rates.

Placement	N rate	Cumulative N_2O loss	Urea-N lost as N_2O†
	lb/acre	lb/acre	%
control	0	0.15	-
broadcast	90	0.28	0.14
	180	0.48	0.19
band	90	0.50	0.39
	180	1.80	0.92
nest	90	0.60	0.50
	180	1.38	0.69

† Urea-N lost = 100x(Cumulative loss – control loss)/N rate

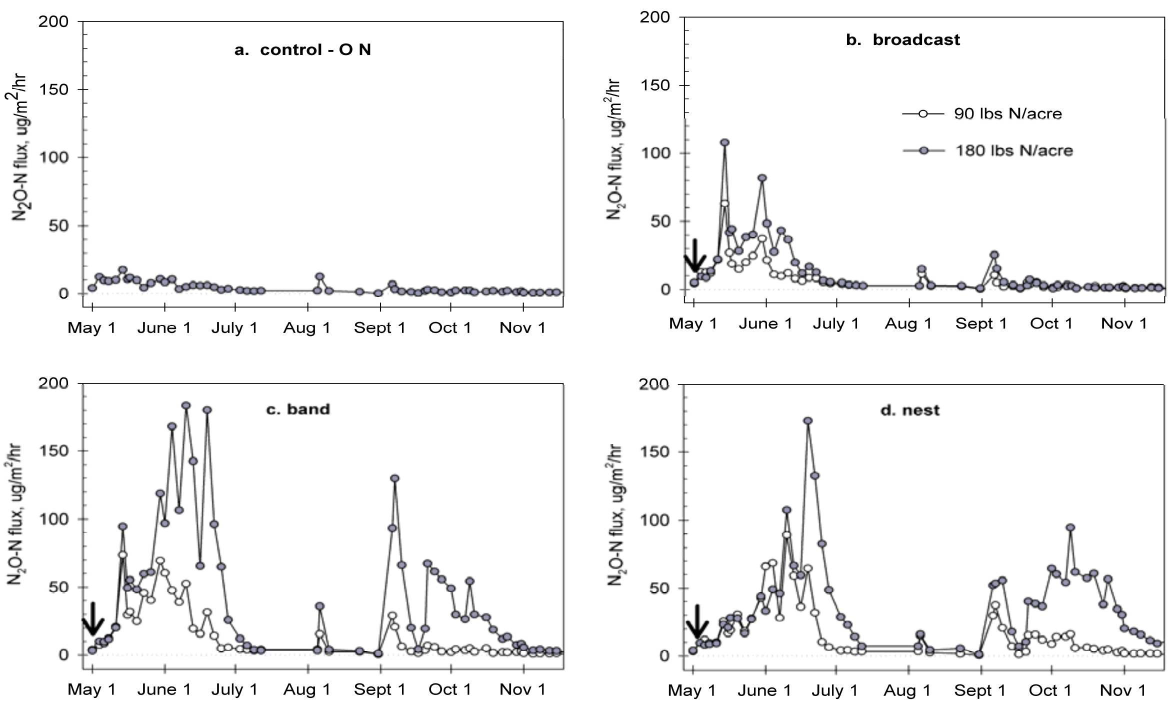

Figure 1. Nitrous oxide production vs. time relationships for the control, broadcast, band, and nest urea-nitrogen placements at 90 and 180 lb N/acre. Arrow indicates date of fertilization.

Reference:

Intergovernmental Panel on Climate Change (IPCC). 2001. Climate Change 2001: Synthesis report. Summary for Policy makers. IPCC Plenary XVII. Wembley, UK. Sept. 24-29.

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