THE IMPACT OF FERTILIZER SOURCE AND TILLAGE SYSTEMS ON NITROUS OXIDE EMISSIONS

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Background:

Nitrous oxide (N_2O) is a greenhouse gas that is a very small portion of the nitrogen cycle, but is environmentally damaging at low levels. In the lower atmosphere, N_2O absorbs infrared radiation in spectra not absorbed by other common greenhouse gases, such as carbon dioxide. Because of N_2O's unique spectral absorption range, each molecule absorbs 200 times as much outgoing radiation as carbon dioxide (Fields, 2004). Besides the large strength in absorption, N_2O has a low reactivity in the troposphere which makes it the longest lived greenhouse gas in the atmosphere.

Once N_2O enters the upper atmosphere, it becomes extremely reactive with ozone molecules which results in ozone depletion. In a process called photolysis, ultra violet light hits N_2O, producing nitric oxide (NO) which acts as a catalyst in the break down of ozone. Reduction in ozone allows for higher levels of ultra violet light reaching the earth's surface which has been linked to increased skin cancer rates. A report by Kane (1998) found that decreased ozone levels had increased ultra violet radiation reaching the surface by 10-20% which has been linked to the 20-40% rise in skin cancer since the 1970's. All of N_2O's environmental impacts make lowering N_2O emissions extremely important to manage climate change.

Nitrous oxide is naturally produced by nitrification and denitrification of soil nitrogen. Increased rates of N_2O emitted from agricultural soils has been attributed to applications of nitrogen fertilizers and increased potential for denitrification of some soil types. Agricultural fields high in clay content typically have poor drainage which can result in a large percentage of nitrogen loss by denitrification. Improving nitrogen use efficiency (NUE) in agricultural production on poorly drained soils will help reduce N_2O emissions by limiting the amount of nitrogen available for denitrification. During the period of 1980-2000, the NUE in corn production in the US increased by 36%; however, average NUE of fertilizers in 2000 was still 30-50% of the applied nitrogen fertilizer (Tilman, 2002).

Recent advances in fertilizer technology have produced enhanced urea fertilizer products which are polymer coated. Polymer-coated urea (PCU) reduces potential nitrogen loss by controlling the amount of urea available for microbial activity throughout the growing season. Release rates from PCU are related to soil temperature and moisture content; however, continued research is required to fully understand PCU's effect on nitrogen availability throughout the growing season. Merchan-Paniagua (2004) observed reduced soil N_2O emissions when comparing urea and PCU plots on claypan soils but did not have the same results in 2005. This could be due to climatic variation since urea's release rate from a prill is directly related to soil temperature and moisture.

Tillage operations in agricultural practices have a strong effect on NUE since fertilizer placement options are dictated by the tillage system used. No-till practices allow for minimal soil disturbance and have been shown to increase carbon sequestration and sustain or increase soil fertility. However, no-till practices require fertilizers to be surface-applied or banded. Broadcasting urea-based fertilizers greatly increases the potential for volatilization, immobilization of nitrogen in surface residues, and higher rates of denitrification. Many studies have suggested that no-till operations will increase soil N_2O emissions due to lower oxygen levels, increased bulk density and soil moisture content. Increased N_2O emissions from no-till operations could potentially offset the increased rates of carbon sequestration which decreases the global warming benefits associated with no-till.

Strip-till operations cause less soil disturbance than conventional tillage practices and allow the placement of fertilizers at depth in the soil profile. Incorporation of urea-based fertilizers within the soil profile can minimize volatilization and lower rates of denitrification. Lower bulk density and improved drainage should increase soil oxygen levels and reduce soil moisture content. These properties in theory would reduce N_2O emissions, however, many studies measuring differences in N_2O emissions between tillage and no-tillage systems have had mixed results. Higher N_2O emissions have been reported in no-till operation compared to conventional tillage (Mackenzie et al., 1997; Ball et al., 1999; Baggs et al., 2003; Six et al., 2004). While other studies have found lower or similar soil N_2O emissions in no-till compared to conventional tillage (Robertson et al., 2000; Elmi et al., 2003; Grandy et al., 2006). The variation in the results between these studies is thought to be a product of differences in soil type and climatic conditions. Expanded research on the impact of tillage operations on N_2O emissions for specific soil types and climates will be required to make better estimates of how tillage practices affect N_2O emissions for specific locations. The objective of this research is to examine the differences in N_2O emissions between fertilizer sources (non-coated urea (NCU) and PCU) combined with different tillage systems/fertilizer placement (no-till/broadcast and strip-till/placed at depth in soil).

Experimental Design:

The location for this ongoing research is at Greenley Memorial Research Center in Northeast Missouri on corn plots containing soybean residue from previous season. Nitrogen fertilizer application on these plots occurred in April (preplant) at a rate of 125 lbs N/acre. Treatments were arranged in a randomized complete block design with three replications. The treatments consisted of no-till + broadcast NCU, strip-till + NCU placed at depth, no-till/broadcast PCU, strip-till+ PCU placed at depth, non-treated/broadcast, and non-treated/strip-till. Gas samples were taken by replication and two N_2O subsamples for each treatment in a replicate. Samples were taken approximately every other day, but sampling increased directly after rainfall events. For each gas sample, soil temperatures were recorded and soil samples were taken for determining soil moisture and nitrate content in order to correlate soil temperature, nitrate concentration, and moisture with N_2O flux.

Research Objectives:

- Measure differences in N_2O emissions between polymer and non-coated urea combined with no-till and strip-till management.
- Obtain N_2O emissions that contribute to nitrogen loss.

- Gain a better understanding of soil temperature and moisture correlation to N_2O emission and the time period N_2O is produced after fertilizer application.
- Provide information which will help reduce N_2O emissions on claypan soil through optimal management practices.

2009 Preliminary Results:
Significant N_2O emissions did not occur until three weeks after the April 23rd fertilizer application (Figure 1). No-till, broadcast treatments had higher N_2O emissions compared to strip-till. Strip-till treatments had lower N_2O emissions presumably due to lower soil moisture and nitrate concentration throughout the growing season which reduced denitrification. However, analysis of soil samples for moisture and nitrate concentration will be required to confirm this conclusion. There is no apparent difference in N_2O emissions comparing PCU and NCU treatments. Since application, no-till treatments have averaged 0.1080 lbs N_2O loss/acre/day and strip-till treatments have averaged 0.0758 lbs N_2O loss/acre/day. It is important to note that the average daily N_2O flux values will be lower as the N_2O flux decreases due to less available soil nitrogen as the current growing season goes on. Previously conducted research in Michigan on loamy soils less conducive to saturated conditions, denitification, and N_2O emissions than claypan soils found conventional tillage over two full growing seasons averaged 0.0032 lbs N_2O loss/acre/day, while no-till averaged 0.0029 lbs N_2O loss/acre/day (Grandy, 2006).

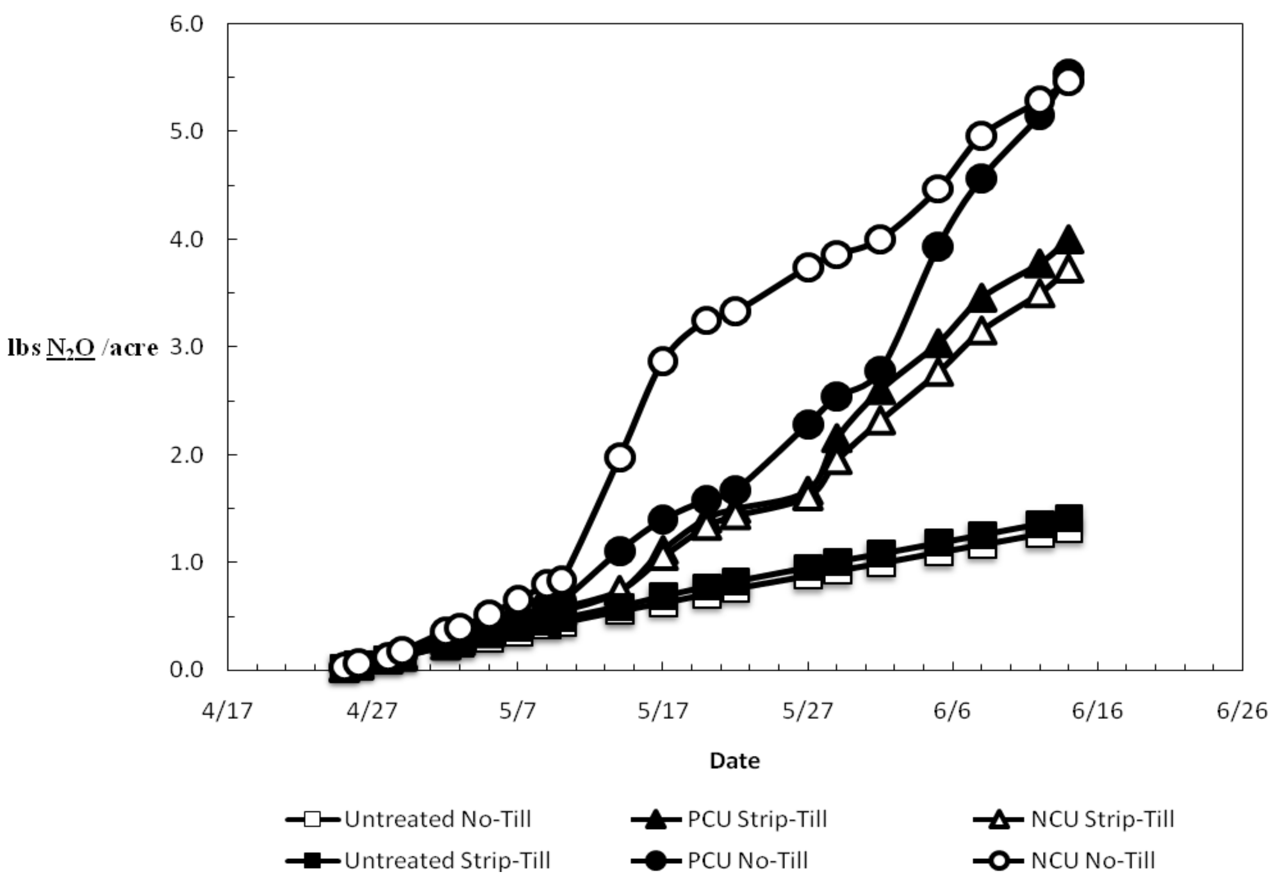

Figure 1. Cumulative N_2O emissions for preplant applied polymer (PCU) and non-coated (NCU) urea from April 23 to June 16, 2009.

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