Nitrogen Losses: A Meta-analysis of 4R Nutrient Management in U.S. Corn-Based Systems

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2015 Interpretive Summary

The specific aim of this meta-analysis project was to determine the impact of 4R N management techniques on nitrous oxide (N_2O) and nitrate (NO_3) losses relative to corn yield. The team collected and synthesized field research data published prior to July 2014 that measured N losses as affected by 4R fertilizer N management (right rate, source, timing, and placement) in North American corn-based cropping systems.

We identified 4,400 research papers that mention fertilizer, N, or nutrient management in agriculture, or fertilizer-associated N_2O or NO_3 losses. After a review of titles and abstracts, the majority of studies were discarded because they were not about crop land, corn, or N losses, were outside North America, or addressed N losses and transport after the field. This triage found 237 studies suitable for further review; only 27 and 22 studies contained N_2O and NO_3 loss data and also reported corn yield. An additional nine N_2O and five NO_3 studies reported losses but not yield. The final database included 404 observations of N_2O emissions and 396 observations of NO_3 leaching losses. Data limitations made it difficult to identify possible trade-offs between N_2O and NO_3 losses. Only one study reported losses of both N_2O and NO_3. Across all studies, the geographies for the N_2O and NO_3 data rarely overlap, and management practices for both types of field studies were diverse. For example, 60% of NO_3 observations and only 1.6% of the N_2O data were reportedly from tile-drained fields. Thirty-eight percent (38%) of the N_2O observations, and only 8% of the NO_3 observations, were from no-till systems. Fertilizer N rate response curves showed crop yield increasing as a function of N rate to a maximum point; N_2O emissions respond in an exponential fashion; and NO_3 losses tend to be linear in relation to fertilizer application rate. Statistical models found that adding nitrification inhibitors with the N fertilizer significantly reduced yield-scaled N_2O emissions. Delaying fertilizer N application until the crop was growing (sidedress) had a similar effect of reducing N_2O emissions. Nitrate leaching losses were lower in soils with more organic matter and in drier climates, but lack of data and high variability made it difficult to see any impact of fertilizer management.

To better determine management effects on losses, more data with broader regional coverage are

needed. In the meantime, process-based models calibrated to all available data may be the most reliable way to predict loss responses and to investigate relationships between losses of N_2O and NO_3.