New Leads on **Nitrous Oxide**

Agricultural practices, particularly the use of nitrogen-based fertilizers, generate significant levels of the greenhouse gas nitrous oxide (N_2O). But the mechanisms behind these emissions are still nebulous, and some studies suggest that N_2O emissions may be underestimated by as much as 40 percent at some sites.

"We need to know much more about how agricultural practices affect the production and consumption of greenhouse gases, including N_2O," says microbiologist Tim Parkin, who works at the ARS Air Quality of Agricultural Systems Research Unit in Ames, Iowa.

Scientists already know that N_2O emissions rise as the applications of nitrogen-based fertilizers increase. Parkin and his Ames colleagues collaborated with scientists from AgCert International Limited under a cooperative research and development agreement to learn more about how different soils and fertilizers affect N_2O emissions.

The team used chamber studies to assess variation in the emissions of N_2O, carbon dioxide, and methane from a sandy loam mix and a clay soil. The fertilizers used were urea-ammonium nitrate (UAN) and a swine manure slurry.

The researchers tracked greenhouse gas emissions for 8 weeks and found that overall N_2O emissions were highest from soils amended with swine manure slurry. The emissions peaked shortly after the first fertilizer application and reached a slightly lower peak soon after the first simulated rain.

High levels of N_2O emissions were measured from sandy loam soils amended with either UAN or slurry. But on clay soils, only those amended with slurry—and not with UAN—had elevated N_2O emissions.

STEPHEN AUSMUS (D1512-29)

ARS soil scientist Rodney Venterea (foreground) and technician Jason Leonard collect gas samples from chambers used to measure flux of nitrous oxide and other greenhouse gases from experiments in a corn field in Becker, Minnesota.

The team concluded that the difference in emissions probably stems in part from key differences between the two soils: cation-exchange capacity (CEC) and water-filled pore space. Higher CEC in clays could reduce the availability of nitrogen for conversion into N_2O, and the higher percentage of pore water in the sandy loam could prompt higher denitrification, which in turn boosts N_2O emissions.

STEPHEN AUSMUS (D1514-13)

University of Minnesota technician Sonya Ewert (left) and ARS soil scientist Rodney Venterea use a gas chromatograph to determine amounts of greenhouse gases in samples collected from the field.

Looking for Ways To Reduce N_2O Emissions

Two hundred miles north of Ames, at the ARS Soil and Water Management Research Unit in St. Paul, Minnesota, collaborator Rod Venterea is asking similar questions.

Venterea's group has been comparing N_2O emissions after application of either urea or anhydrous ammonia fertilizer.

These are two of the most commonly used nitrogen fertilizers in the United States and the world. But U.S. use of anhydrous ammonia has declined by 15 percent over the past three decades, while urea use has nearly tripled.

"Because of their widespread use and changing use patterns, it is important to measure N_2O emissions from each fertilizer," Venterea says. And as it turns out, there is a large difference in N_2O emissions between anhydrous ammonia and urea—at least in the corn cropping systems Venterea has been studying.

Over several consecutive growing seasons, Venterea found that the amount of N_2O emitted from fields fertilized with anhydrous ammonia was, on average, twice as high as emissions from fields fertilized with urea. These results strongly suggest that N_2O emissions may decline in the future as more urea and less anhydrous ammonia is used.

"But this may not be the case in all soils," Venterea notes. He believes that acidic soils emit the most N_2O when anhydrous ammonia is applied and that more alkaline soils may emit lower levels. Plans to confirm this hypothesis with field testing are under way.

Venterea is also working with the agricultural equipment company John Deere to test different techniques for injecting anhydrous ammonia into the soil, which may reduce N_2O emissions and increase crop uptake of nitrogen from the soil. He's also working with other ARS collaborators and specialty fertilizer companies Agrium and AGROTAIN International to determine whether their controlled-release and inhibitor products can lower N_2O emissions, reduce nitrate leaching to groundwater, and mitigate other impacts. (See sidebar.)

Tillage and N_2O

Another area that Venterea's group has been studying is how farmers can reduce N_2O emissions when using reduced tillage. Reduced tillage (including no-till) is being increasingly looked at for its environmental benefits. "Using less tillage can be a win-win situation," Venterea says. "It can save on fuel costs, protect the soil from erosion, and conserve water and nutrients." In some cases, it may also help store carbon in the soil.

Venterea's work has shown that N_2O emissions with reduced tillage can be minimized by injecting the fertilizer below the upper 2 to 3 inches of soil. "This upper layer is where all the microorganisms that support N_2O emissions are concentrated in a reduced tillage soil, so you need to avoid placing the fertilizer there," he says.

Maximizing Measurement Estimates

In a crop field, it's a challenge to take comprehensive measurements of anything. So most measurements of N_2O emissions are conducted using chambers that are placed on the soil surface for short periods. The rate of N_2O emissions is then estimated based on how quickly N_2O accumulates inside the chamber.

But placement of the chamber itself can disturb the emission rate. "This so-called chamber effect is something we've known about for decades, and it continues to hinder us in making very accurate measurements in the lab," Venterea says.

So Venterea developed a spreadsheet-based error-calculation tool, based on gas-transport theory, that allows researchers to estimate the error caused by any given chamber type in a given soil. Venterea has posted the spreadsheet on the World Wide Web at www.ars.usda.gov/SP2UserFiles/person/31831/CEAT2.0.xls.

"The goal is to help people design measurement systems that minimize errors and also to estimate the amount of error they are getting," Venterea says. —By **Ann Perry,** ARS.

This research is part of Global Change (#204) and Soil Resource Management (#202), two ARS national programs described on the World Wide Web at www.nps.ars.usda.gov.

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STEPHEN AUSMUS (D1533-6)

In a nitrogen fertilizer source study, soil scientist Ardell Halvorson (right) and technician Mary Smith prepare gas samples from field sampling for gas chromatograph analysis of nitrous oxide, carbon dioxide, and methane.

Specially Formulated Fertilizers Reduce Greenhouse Gas

Climate and soil conditions in the Central Great Plains make nitrogen fertilizers a necessity for ensuring sufficient yields of corn, barley, dry beans, and soybeans. But using nitrogen fertilizers leads to release of nitrous oxide (N_2O), a major greenhouse gas, into the atmosphere. They are one of the reasons an estimated 78 percent of the nation's N_2O emissions come from agriculture.

At the Soil Plant Nutrient Research Unit in Fort Collins, Colorado, soil scientist Ardell Halvorson is examining the effects of altering the types and amounts of fertilizers growers apply to minimize N_2O emissions and maximize crop yields.

Halvorson is comparing N_2O emissions from no-till corn fields treated with conventional nitrogen fertilizer (urea) or either of two specially formulated urea fertilizers: one with controlled-release polymer-coated pellets or one with stabilizers added to keep more of the urea in the soil as ammonium for a longer period. He chose a no-till system because it is known to reduce carbon dioxide emissions.

After 2 years, he found that the specially formulated fertilizers drastically reduced N_2O emissions. The controlled-release fertilizer cut N_2O emissions by a third, and the stabilized fertilizer cut them almost in half.

Halvorson's results so far are limited to the irrigated fields and cool, semi-arid conditions at Fort Collins. But N_2O releases are the result of a complex interplay of varying conditions. Soil organic matter, rainfall distribution, climatic conditions, and soil variability affect microbial activity and potential for N_2O release from nitrogen application. So Halvorson is expanding the study, with financial support from the fertilizer industry and cooperation of other ARS locations, to see how the fertilizers respond at seven sites around the United States.—By **Dennis O'Brien,** ARS.

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