ERS Report Summary

Economic Research Service | September 2011 | U.S. Department of Agriculture

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Nitrogen In Agricultural Systems: Implications For Conservation Policy

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What Is the Issue?

Nitrogen is an agricultural input that is critical for crop production. Human-induced production and release of reactive nitrogen has greatly affected the Earth's natural balance of nitrogen, contributing to changes in ecosystems, both beneficial and harmful, including increased agricultural productivity in nitrogen-limited areas, ozone-induced injury to crops and forests, overenrichment of aquatic ecosystems, biodiversity losses, visibility-impairing haze, and global climate change. Incentives for encouraging farmers to adopt improved nitrogen management can take many forms, from purely voluntary to regulatory. Designing a cost-effective policy requires that factors influencing fertilizer use be fully understood. Also, an understanding of how farmers are likely to respond to different incentives may help policymakers assess potential environmental tradeoffs driven by nitrogen's ability to change forms and cycle through different environmental media.

What Did the Study Find?

- Emission of reactive nitrogen to the environment can be reduced by matching nitrogen applications more closely with the needs of growing crops. This can be achieved by adopting three "best management practices" (BMPs):
  - *Rate*: Applying an amount of nitrogen at a rate that accounts for all other sources of nitrogen, carryover from previous crops, irrigation water, and atmospheric deposits.
  - *Timing:* Applying nitrogen as close to the time that the crop needs it as is practical (as opposed to the season before the crop is planted).
  - *Method:* Injecting or incorporating the nutrients into the soil to reduce runoff and losses to the atmosphere.
- Among all U.S. field crops planted in 2006 that received nitrogen fertilizers, 35 percent are estimated to have met all three of the nutrient BMPs. For the remaining cropland, improvements in management are needed to increase nitrogen use efficiency (i.e., reduce the amount of nitrogen available for loss to the environment).

- Corn is the most intensive user of nitrogen fertilizer, on a per acre basis and in total use. Fertilizer applied to corn is least likely to be applied in accordance with all three BMPs.
- Incentives for improving nitrogen use efficiency by adopting the rate, timing, and method BMPs can come from policy or market forces:
    - Government programs that provide financial assistance for adopting BMPs can be effective if they encourage the participation of farmers with land most in need of improvement and if the farmers choose the most cost-effective practices. Data suggest that the amount of cropland needing improvement would require a substantial increase in the current Federal budget devoted to nutrient management practices.
    - Including nitrogen management in compliance provisions for receiving Federal farm payments could encourage farmers to adopt more effective management practices. In 2005, producers of U.S. corn received Government payments that were much higher than the cost of improving nitrogen management. The strength of this incentive, however, has declined in recent years because of increases in crop prices and a decline in direct commodity payments.
    - Emissions markets, such as water quality trading and greenhouse gas cap-and-trade, could provide financial incentives to farmers to adopt improved nitrogen management and produce nitrogen credits that can be sold in these markets. The effectiveness of such markets would depend on market design, including rules defining who can participate and what needs to be done to produce credits.
- Onfield improvements to nitrogen use efficiency could be supplemented with off-field practices, such as wetlands restoration and vegetative filter strips that can filter and trap reactive nitrogen that leaves the field through surface runoff and groundwater flow. Of the two practices, restored wetlands can be more cost effective at removing nitrogen and provide additional environmental benefits, but they are limited to areas with suitable soils and hydrology. Vegetative filters can be employed more widely across the landscape but are not effective when existing tile drains bypass the filters.
- Policies for increasing nitrogen use efficiency should recognize the potential environmental tradeoffs when addressing particular issues related to reactive nitrogen. Focusing strictly on one issue, such as nitrate leaching, could lead to increased emissions of other nitrogen compounds, such as nitrous oxide, even when total reactive nitrogen emissions are reduced.

How Was the Study Conducted?

ERS researchers used an extensive literature review, modeling, and data from USDA's Agricultural Resource Management Survey (ARMS) of major field crops. ARMS data provided information on nitrogen use, defined by the rate, method, and timing application criteria. This, in turn, helped researchers determine the types of management improvements needed the most.

The following market forces and policy instruments were evaluated to measure their influence on nitrogen management: nitrogen fertilizer taxes, Federal financial assistance offered to farmers to adopt practices that improve nitrogen use efficiency or filter and trap nitrogen runoff, emissions markets such as water quality trading and greenhouse gas cap-and-trade, compliance with nitrogen BMPs as a condition for receiving farm program benefits, and regulation.

Because reactive nitrogen is mobile and able to transform into different compounds, researchers used a field-level nitrogen loss simulator developed by USDA's Agricultural Research Service to track how improving nitrogen use efficiency by meeting all three BMPs affects emissions of different reactive nitrogen compounds. These interactions were taken into account when evaluating alternative policy options.