Keeping Nitrogen in the Soil and out of the Water

Summary: Crop and fertilizer management can be used to keep nitrogen in the soil, feeding the crop, and out of groundwater.

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Database: University/College of Agriculture, LRES, Extension

From MSU News Service

BOZEMAN – Nitrogen is important for optimal crop production, but it can be lost to leaching. High amounts of nitrate in drinking water can be harmful to people, especially infants and pregnant women. While most groundwater in Montana has nitrate levels below the drinking water standard, the Montana Department of Agriculture has found high nitrate levels in certain areas of the state including parts of northeastern and central Montana. Fortunately, "there are management practices that can help keep the nitrogen in the soil and out of the water", says Clain Jones, Extension soil fertility specialist in the Department of Land Resources and Environmental Sciences (LRES) at Montana State University.

In Montana, nitrate leaching from dryland agriculture is thought to be insignificant during the growing season because plant uptake of water generally greatly exceeds precipitation, preventing downward movement of water. However, in fall and winter, the opposite is true resulting in increased potential for nitrate leaching. In addition, overwinter organic matter decomposition can add soluble nitrogen to the soil, increasing the amount of soil nitrate available to be leached. This is not only a health concern but a direct financial loss to the producer.

Shallow or sandy soils or those with cracks that connect the surface to below the root zone have high leaching potential. High precipitation can exacerbate the problem. Jones and Chengci Chen, associate professor at the Central Agricultural Research Center in Moccasin, found that in a wet winter nitrate levels decreased by up to 25 pounds of nitrogen per acre from fall to spring. Actual nitrogen lost to leaching was likely higher because soils at this site can gain up to 40 pounds of nitrate per acre from organic matter decomposition over the winter. This suggests a total of up to 65 pounds of nitrogen per acre could leach into groundwater from shallow soils.

Annual soil testing and realistic yield goals should both help producers calculate fertilizer rates and reduce nitrate leaching, since unused available nitrogen is subject to overwinter loss. In the study at Moccasin, there was no change in nitrate from fall to spring on fields that received 40 pounds of nitrogen the previous year, while fields that received 120 pounds per acre lost more than 25 pounds of nitrogen per acre. The higher fertilization rate left more residual nitrogen in the soil, which was lost most likely to leaching over winter. This illustrates that either the crops use it, or you can lose it.

"Recropping, rather than fallow, and reduced tillage both help reduce nitrogen losses", said Jones.

Upendra Sainju and associates with the USDA-Agriculture Research Service compared the estimated initial soil nitrogen level in 1983 to the fall 2004 level from a plot study near Culbertson, in eastern Montana. The spring tilled wheat-fallow rotation lost an average 26 pounds more nitrogen per acre each year than spring tilled continuous wheat. The twice tilled (fall and spring) continuous wheat rotation lost an average 14 pounds more nitrogen per acre per year than the no-till continuous wheat, which had the lowest average annual nitrogen loss of 8 pounds nitrogen per acre. While it is not known what fraction of that lost nitrogen was lost to leaching, rather than erosion or volatilization, leaching loss is likely, given the coarse soils at that study site.

Planting a diversity of crops, including perennials and deep rooted crops, such as alfalfa, sunflower and wheat, or a winter crop, helps ensure readily available nitrogen is used and harvested or held on site as plant biomass.

Jones suggested planting annual legumes for seed or forage because “they are good scavengers of available nitrogen and they do not need nitrogen fertilizer as long as sufficient phosphorus, potassium, sulfur and the correct inoculants are available for nitrogen fixation.”

Jones also noted “spacing crops for optimal density and yields will optimize resource use, and decrease potential for nitrogen leaching.” For example, Chen found spring wheat had a higher efficiency of nitrogen fertilizer use at 6 inch row spacing than at 12 inch spacing.

Ideally, conventional nitrogen fertilizer is applied right before the plants need it most, which is from seedling to tillering stages in cereal grains and seedling to early branching in oilseeds.

“This can be followed by in-crop fertilizer topdress applications based on plant demand or growth stage, rather than calendar date,” said Jones. “By using such split applications, there is less potential for over fertilizing during a dry year, because nitrogen applied is based on the current year’s growing conditions. That leaves less unused nitrogen in the soil to be subject to leaching.

“There are also advances in fertilizer and application technology that help increase the amount of applied fertilizer actually used by the crop, which decreases the amount of fertilizer susceptible to leaching,” said Jones.

Enhanced efficiency fertilizers slowly release their nutrients over time. Recovery of nitrogen fertilizer by wheat has been found to be 4 to 14 percent higher with one of these slow release products than conventional urea. “These deserve consideration, especially as the price difference compared to conventional urea fertilizers decreases,” said Jones. “But, timing of application is a little different than with conventional fertilizer,” he cautioned.

Variable rate application is another tool to help ensure nitrogen is applied where it is needed most and not in places where it will be lost. By identifying areas in the field that are limited by factors other than nitrogen, the producer can limit nitrogen leaching loss by applying just enough nitrogen to meet that area’s production potential. By using available technology and management practices, producers can make sure their fertilizer dollars are spent feeding a crop, rather than lost to leaching, and can help reduce the potential for nitrate contamination of ground water.

MSU Extension has documents on enhanced efficiency fertilizers (http://landresources.montana.edu/SoilFertility/PDFs/EEF720.pdf and water quality

considerations and regulations (http://landresources.montana.edu/nm/Modules/NM12layout.pdf), among others. For information on well testing, contact the MSU Extension Water Quality Program at http://waterquality.montana.edu/ or phone 994-7381.