Nitrate Leaching

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Nitrate leaching can be a health and economic concern throughout Montana, though there are several agronomic practices available to minimize nitrate leaching. This Soil Scoop summarizes information based on regional research presented in *Minimizing Nitrate Leaching from Cropland*.

BACKGROUND

Nitrate is plant-available nitrogen (N) that can come from fertilizer or decomposition of organic matter and manure. It is highly soluble and easily lost to leaching as water moves through the soil profile.

High amounts of nitrate in drinking water can be harmful and likely equate to billions of dollars in lost fertilizer N statewide. In addition, nitrate leaching can contribute to soil acidification, an emerging issue in parts of Montana. Whether leached nitrate ends up in groundwater depends on many factors.

SOIL AND WATER FACTORS THAT INCREASE LEACHING POTENTIAL

Sandy or shallow soils have higher leaching potential than clay, loam or deep soils. Whenever water input exceeds the soil's ability to hold water against drainage ("field capacity"), there is potential for leaching. Irrigated fields have higher leaching potential than dryland cropping. Dryland systems are susceptible to leaching when fall, winter or early spring rains exceed field capacity, since there is little water uptake by plants during these periods.

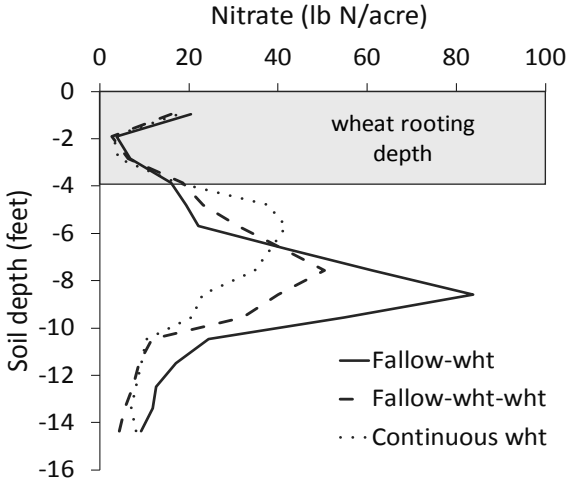

FIGURE 1. Soil nitrate after 37 years of dryland cropping (Campbell et al., 2006, Saskatchewan).

Irrigation should be managed to meet the crop need, but not exceed the soil's field capacity. Sprinkler irrigation allows better water control than furrow and flood irrigation. Montana State University has several resources to guide irrigation practices and Colorado State University offers specific guidelines for irrigation management to retain soil N (see document end for links).

CROP MANAGEMENT

In dryland cropping systems, reducing fallow is likely the most important management option to reduce water and nitrate movement below the root zone, since fallow fields have no crop in place to take up water or nitrate. As cropping frequency increases, nitrate leaching decreases (Figure 1).

Annual legumes such as field pea can substantially reduce nitrate leaching compared to fallow. In addition to using soil water, they are good scavengers of available N and do not need N fertilizer as long as conditions are suitable for N fixation.

Cereal forages, green manures and cover crops can be used to manage crop available water. Cover crops can catch N in intensively managed systems with high N inputs and extended overwinter/early spring bare periods (e.g., corn, sugarbeets) as well as in home and market gardens which are often close to residential wells

Fall-planted crops are ideal following fallow to take up some N before spring rains. Perennials or deep rooted annuals, such as sunflower, canola, safflower and winter wheat, use water and N that may escape shallow rooted crops. While alfalfa is an excellent scavenger of soil nitrate, the large supply of N remaining after alfalfa is terminated

can release nitrate. To avoid leaching loss of this nitrate, recrop rather than fallow fields after alfalfa termination, and credit the N contribution from alfalfa in fertilizer N rate calculations to avoid over fertilization.

Seeding for optimal plant density will optimize N use and decrease leaching potential. Generally, reducing tillage reduces residual soil nitrate levels. Increasing annual crop diversity and including perennials is more important in tilled than no-till systems.

Water and crop management on high leaching potential soils:

- Recrop rather than fallow
- Diversify to include perennial and/or deep rooted cannual crops
- Reduce tillage
- Seed for optimal resource use and plant yield
- Sprinkle rather than flood irrigate, and irrigate to meet but not exceed crop needs

FERTILIZER MANAGEMENT

A major goal is to reduce soil nitrate left after harvest. Annual soil testing and realistic yield goals help avoid over-fertilization. Spring soil tests are a better measure of available N than fall soil tests. Fall samples are especially likely to underestimate soil nitrate following a cover crop, pulse crop, or brassica crop, leading to over-fertilization.

Ideally, conventional N fertilizer is applied right before the plants need it most, which is from seedling to late tillering stages in cereal grains and seedling to early branching in oilseeds. Fertilizer topdress applications should be timed based on plant demand or growth stage, rather than calendar date. By matching N rates to plant needs and using split applications, there is less risk of over-fertilizing, leaving less unused N in the soil. Nitrogen release from crop residue better matches the timing of crop growth and N uptake than any N fertilizer and results in less N lost to leaching. In addition, legume crop residue can reduce the need for N fertilizer.

There are advances in fertilizer and application technology that help increase the amount of applied fertilizer actually used by the crop. Enhanced efficiency fertilizers deserve consideration, but, they are not the best fertilizer choice for all situations and timing of application is different than with conventional fertilizer.

Often, most nitrate leaching comes from only a fraction of the total area of a field. Low productivity zones contribute more to nitrate leaching than high productivity zones. Areas of a field that are limited by factors other than N should receive just enough N to meet that area's production potential.

A deficiency in other nutrients such as phosphorus, potassium, or sulfur can result in less crop growth, less water uptake and more N left in the ground, especially after fallow. Sulfur can be especially critical for N uptake and yield, thereby reducing N susceptible to leaching. See *Developing Fertilizer Recommendations for Agriculture* for assistance with fertilizer rate calculations.

Fertilizer management on high leaching potential soils:

- Know your soil type
- Soil sample annually in the spring to 3 feet or more in deeper soils
- Base N rate on soil tests and reasonable yield potential
- Credit N from all sources, such as manure and previous legume crops
- Apply conventional N fertilizers close to peak crop N uptake or use a slow release fertilizer
- Split applications – use conservative pre-plant N rate and topdress as needed
- Retain crop residue and include legumes in rotation
- Use variable rate/zone specific technology
- Provide other nutrients for optimal yields

Reference:

Campbell et al., 2006. *Nitrate leaching in the semiarid prairie: Effect of cropping frequency, crop type, and fertilizer after 37 years*. Canadian Journal of Soil Science. 86:701-710.

For more information:

MSU Extension Water Quality Program http://waterquality.montana.edu/farm-ranch/irrigation/ or 406-994-7381

CSU Extension http://extension.colostate.edu/topic-areas/agriculture/nitrogen-and-irrigation-management-0-514/

The following can be found at http://landresources.montana.edu/SoilFertility/publications.html

Developing Fertilizer Recommendations for Agriculture (MT200703AG)

Minimizing Nitrate Leaching from Cropland (available soon)

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