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Nutrient Digest

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OVERWINTER LOSS OF SOIL NITRATE

By Clain Jones and Kathrin Olson-Rutz – Dept. of Land Resources and Environmental Sciences, Montana State University

In some regions of the western U.S., soil sampling is conducted from late summer to late fall because of better soil sampling conditions than in winter or spring and because it provides more time for growers to make fertilizer decisions prior to application. However, fertilizer guidelines are often based on spring nitrate levels because they are more indicative of growing season available nitrogen (N) than fall nitrate levels. If soil nitrate levels are substantially different between fall and spring, then a producer would either over- or under- apply N fertilizer. Over-application is an economic loss and excess nitrate may contaminate groundwater. Under-application may cause sub-optimal yields and grain protein. Based on our study in Bozeman, Montana and at each of the seven Montana State University Agricultural Research Centers, N fertilizer would be over-applied by an average of 18 lb N/acre if August samples were used to make spring N recommendations. But, one in three times, it would be under-applied, and sometimes by a lot.

We measured soil nitrate levels in the upper two feet (if rocks allowed) in late summer, mid fall, and early spring at eight locations throughout Montana over three years. Soil samples were collected following four previous crop types (annual legume, fallow, oilseed and small grain). Several soil characteristics were measured at each site, such as pH, soil organic matter and texture. Unfortunately, fall to spring nitrate changes are highly

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CHOOSING YOUR NITROGEN FERTILIZERS BASED ON AMMONIA VOLATILIZATION

By Donald A. Horneck and Jess Holcomb – Oregon State University, Hermiston Agricultural Research and Extension Center

Until recently we have not been able to measure ammonia volatilization without impacting the surrounding environment. The use of the vertical flux method in this study allows ammonia in the air to be monitored to reflect ammonia loss without any impact from measurement.

The loss of ammonium nitrate as a common fertilizer has left urea as the primary dry nitrogen fertilizer. The change to urea has caught many off guard. Where most other nitrogen fertilizers can be left on the soil's surface for an extended period of time with little risk for nitrogen loss, urea generally cannot. Nitrogen loss into the air is critical from several viewpoints: NUE (nitrogen use efficiency), air quality and carbon footprint.

NUE is decreased when nitrogen is lost from the soil. The common escape routes are leaching, denitrification and volatilization. Leaching is nitrogen loss to areas below the roots. The two losses into the air are denitrification and volatilization. Denitrification is a process where microorganisms in wet soils convert nitrate into nitrous oxide (NOx) gas. Volatilization, the topic of this study, is the loss of ammonia (NH_3) into the air. Volatilization occurs from the application of ammonia based fertilizers. Volatilization means fertilizer escapes and dollars are lost, either from the need to apply more to compensate for volatilization or from the reduced yield and protein that the applied nitrogen was expected to create.

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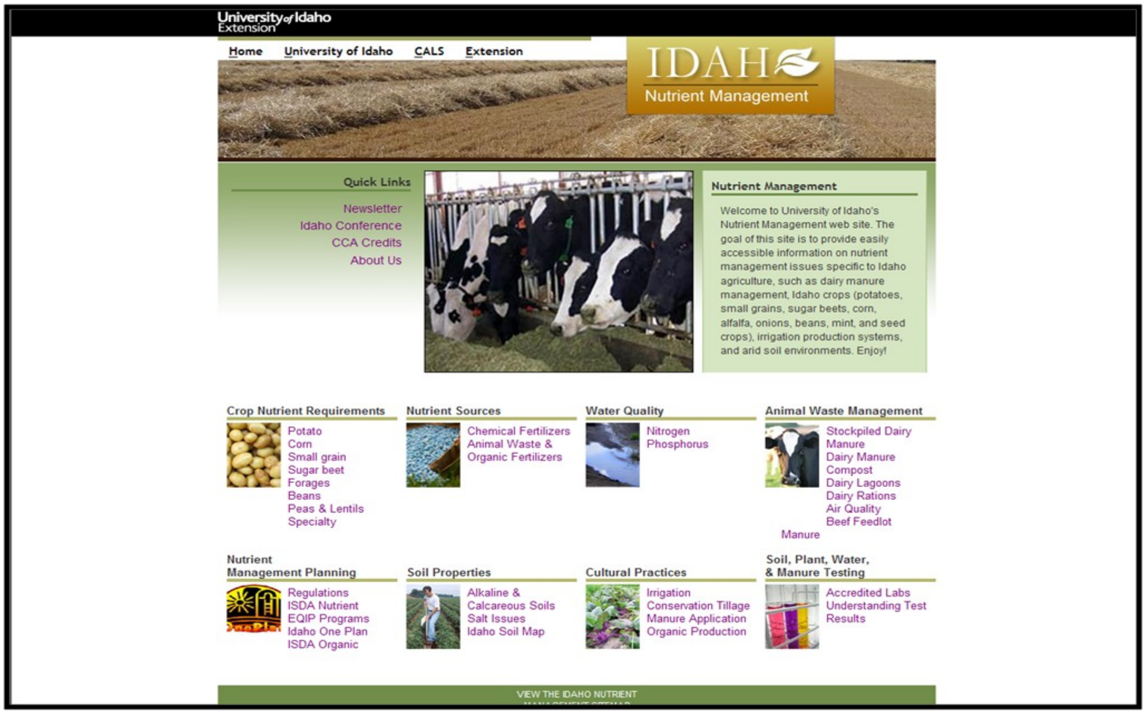
**WERA-103 is the Western Extension/Education Region Activities Nutrient Management and Water Quality Committee, composed of representatives from land-grant universities, public agencies, and private industry.*

Announcing the new Nutrient Management website from the University of Idaho



By Amber Moore

The Idaho Nutrient Management website from the University of Idaho is now online and available for your perusal. The website can be accessed at http://www.extension.uidaho.edu/nutrient. The goal of this website is to provide easily accessible information on nutrient management issues specific to Idaho agriculture, such as dairy manure management, Idaho crops (potatoes, small grains, sugar beets, corn, alfalfa, onions, beans, mint, and seed crops), irrigation production systems, and arid soil environments. The website is intended as a valuable resource both for Idahoans as well as for people living in the western United States who work with similar agricultural issues and environmental conditions.

One of the greatest advantages of this website is that it contains information that cannot be found anywhere else on the internet. This includes back issues of the Idaho Nutrient Digest Newsletter, conference proceedings articles and presentations from the Idaho Nutrient Management conferences, and proceedings articles from Idaho commodity schools that pertain to nutrient management.

We hope the website will provide one-stop shopping for information on soil fertility and manure management information. The website provides references and links to relevant publications and resources, and links to state and federal government programs related to nutrient management. This site is a work in progress, as there are still a few subtopics that have not been completed, and other parts will be updated as new information becomes available.

Funding for website development was provided by the University of Idaho through a Nutrient and Waste Management Critical Issues Grant.

Website contributors include: Amber Moore (UI Soils Specialist), Brad Brown (UI Soils and Small Grains Specialist), Ashley McFarland (UI Extension Educator - Water Quality), Lide Chen (UI Waste Management Specialist), Mireille Chahine (UI Dairy Specialist), Steve Hines (UI Extension Educator - Corn), Christi Falen (UI Extension Educator - Forages and Compost), Mario de Haro Mart (UI Extension Educator - Waste Management), and Glenn Shewmaker (UI Forages Specialist).

If you have information that you would like for us to link to on our website, or suggestions on how we can further improve the site, please contact Amber Moore at (amberm@uidaho.edu or 208 736-3629).

Choosing Your Nitrogen Fertilizers based on Ammonia Volatilization, continued from pg. 1

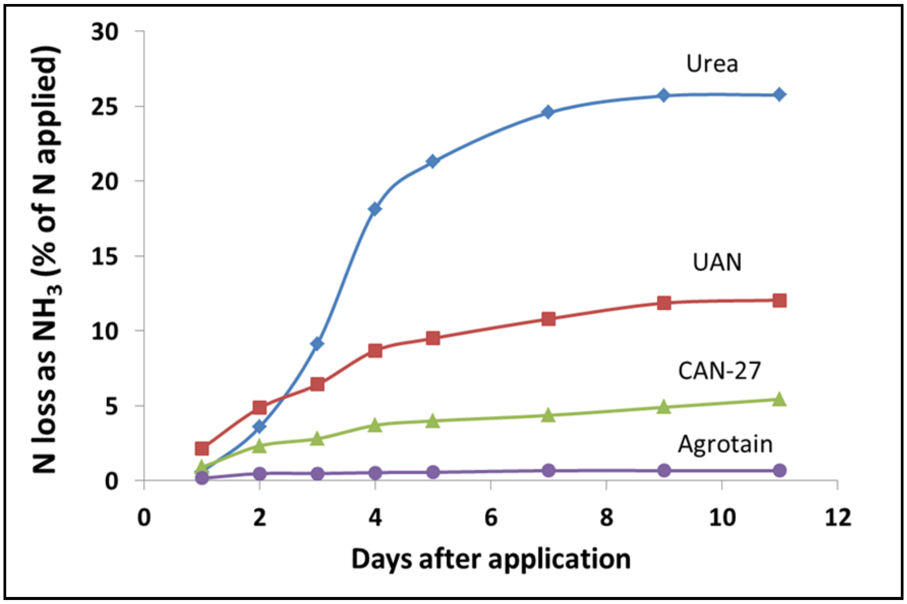


Figure 1. Loss of ammonia from four fertilizers applied to a grass seed field in the fall of 2010.

Ammonia in the air creates two environmental problems; the first is smog and the second is deposition. Ammonia creates smog in the air by combining with NOx in the air. Smog or haze has particles that impair visibility. The particles can be breathed into your lungs and are difficult to remove. Deposition of the particles and the nitrogen in them can impact growth of algae and plants, as well as species distribution.

Nitrogen fertilizer is one of the largest carbon footprint items for a grower. Increasing NUE decreases carbon footprint.

Ammonia volatilization is a function of several climatic conditions and soil properties. These include: wind speed, temperature, soil moisture, soil pH, and surface residue. Recent work would indicate that temperature is not as critical as once thought. In this study, we found volatilization losses as high as 60- 70% of nitrogen applied when air temperatures were 50 °F. Similarly, research from Montana has also shown high volatilization losses from urea applied to frozen soils (see page 5 of this digest).

Our research has been looking at ammonia volatilization of different fertilizers that are surface applied. Figure 1 shows how fertilizer product influences volatilization. Urea lost about 30% of the 150 lb N/acre applied, whereas UAN (32% solution) and CAN-27, a lime-ammonium nitrate fertilizer (Yara), lost 12-18%. Agrotain®, added to urea, inhibits the urease enzyme which is necessary for volatilization. Agrotain use reduced ammonia loss to near zero.

Figure 2 shows ammonia volatilization loss for an application made in the spring of 2010 on a pivot irrigated wheat field. The field was uniformly pre-irrigated, fertilized, and then irrigated with different amounts immediately after urea application. Where no irrigation was applied, volatilization losses were almost 65% of N applied. The more irrigation water that was applied, the less the ammonia volatilization loss. Irrigation is an effective management tool to reduce volatilization losses from urea fertilizers.

When nitrogen is applied as urea to the soil surface and left for a period of time it should be protected from volatilization with Agrotain® or sufficient irrigation water so that yield and NUE can be maximized.

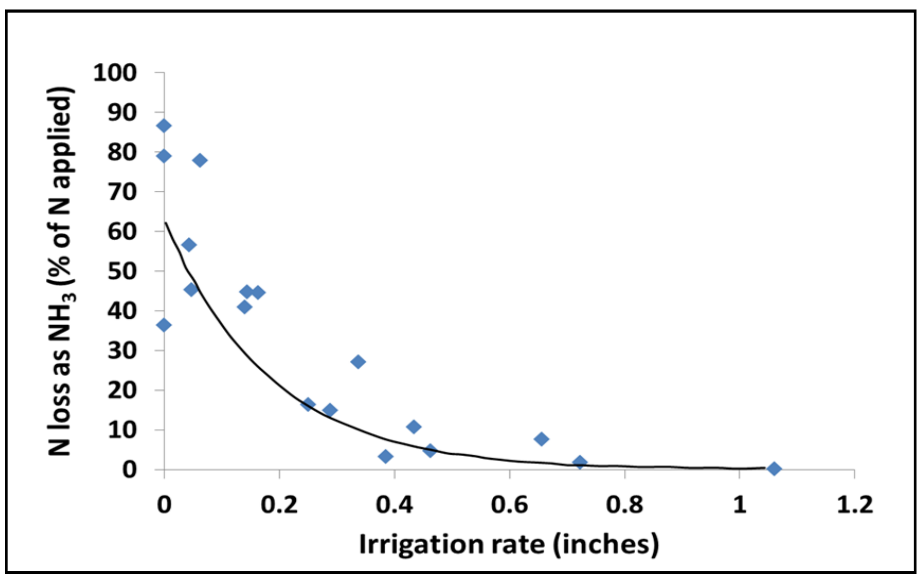


Figure 2. Loss of ammonia from a urea application applied to a wheat field in the spring of 2010 as a function of irrigation rate.

Overwinter Loss of Soil Nitrate, continued from pg. 1

variable (Figure 1) and hard to predict, as we found very little correlation between soil characteristics and nitrate changes.

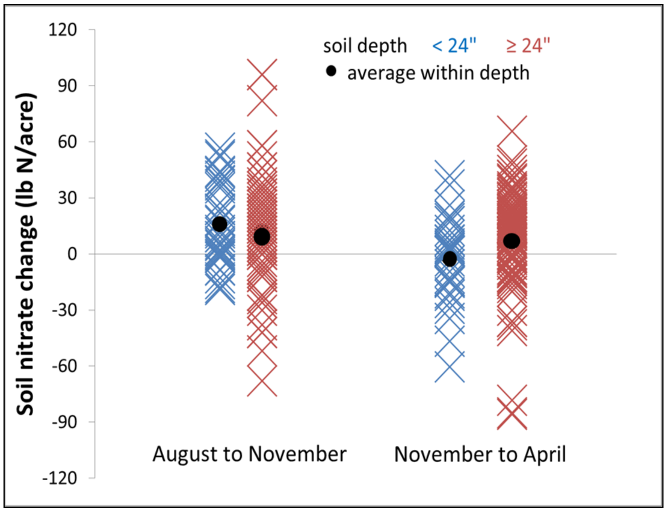


Figure 1. Change in soil nitrate from August to November and November to April for soils either less than or more than or equal to 24-inches deep. A positive number means that nitrate increased from previous year, whereas a negative number means nitrate decreased. Each 'X' represents one data point.

Many soils gained nitrate from late summer to spring, with most of those gains occurring from August to November. Fresh residues and warm soils in late summer and fall would encourage plant decomposition leading to increased available N. Generally there was less nitrate gained from November to April, especially in soils less than 24-inches deep (Figure 1). Shallow soils may have gained less nitrate either because there was less organic N to become available over a smaller depth or these soils were more prone to leaching. Soils with higher initial nitrate levels also tended to have lower overall nitrate gains from August to April, likely because more nitrate was available to be lost (to leaching, atmospheric losses, or microbial tie-up). In other words, high residual nitrate in late summer does not necessarily carry over to the following spring. If nitrate isn't used by plants in a growing season, it may be lost from the system over winter. On average, there were gains on deeper soils with less initial nitrate and better chance for losses on shallow ground with high initial nitrate.

We found prior crop influenced late summer to early spring nitrate changes. Nitrate levels increased more from August to April following broadleaf crops (annual legume and oilseed) than following small grains or fallow (Figure 2). Many, but not all, fields should be given higher overwinter N credits after broadleaf crops than small grain or fallow fields. On average, November samples more closely represented April nitrate levels regardless of the prior crop.

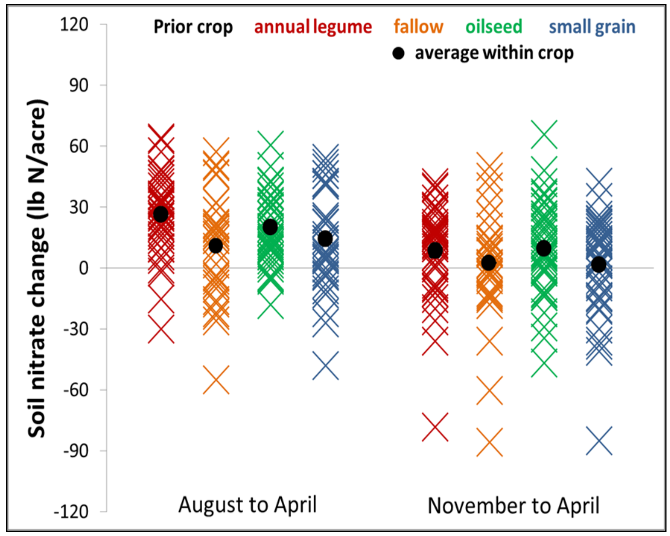


Figure 2. Change in soil nitrate from August to April and November to April on fields with different prior crops. A positive number means that nitrate increased from previous year, whereas a negative number means nitrate decreased.

August to April differences in soil nitrate levels ranged from losses of 55 to gains of 64 lb N/acre. The large range suggests that late summer or early fall soil samples may not accurately determine spring fertilization rates. August and April soil nitrate levels were within 20 lb N/acre of each other 46% of the time, but 54% of the time they were off by more than 20 lb N/acre. This leads to spring fertilizer wasted or yield and grain protein compromised. Sampling in late fall or later is recommended to best capture growing season N availability. If fall nitrate levels are very high (e.g. greater than about 60 lb N/acre) and soil depth is less than two feet, a second sampling in spring is strongly suggested because there is a higher likelihood of overwinter nitrate losses.

Clain Jones's Web site (http: //landresources.montana.edu/soilfertility/) has more information on soil sampling and determining fertilizer rates (under 'Fertilizer Information') and on this study (under 'Reports'). You can contact Clain at 406-994-6076, or at clainj@montana.edu.

UREA APPLICATION ON COLD SOILS

By Rick Engel and Clain Jones – Dept. of Land Resources and Environmental Sciences, Montana State University

Urea broadcast from mid-fall to early spring on soils at or near freezing was historically considered fairly safe from ammonia loss to the atmosphere, termed volatilization. Not so, according to our recent research in Montana. We found that up to 44% of urea surface broadcast between October and April was lost to volatilization.

The three year study measured ammonia volatilization loss from surface-applied urea and urea amended with a urease inhibitor designed to decrease volatilization on producers' fields in south-west, central and north-central Montana. In 8 of 13 field trials, peak urea volatilization loss occurred when soil surface temperatures were below 41°F. Cumulative ammonia losses from urea varied, but averaged about 20% of applied nitrogen.

Surface soil moisture was a major contributor to overwinter urea volatilization on these fields. The largest nitrogen losses (30-44%) occurred when surface applications were made to moist soils followed by at least 2 weeks with no or little precipitation (less than 0.2 inches). Even when the soil surface was frozen at the time of application, volatilization losses were high. In one trial, urea was applied on January 27 to a calcareous soil covered with approximately 5 inches of snow. As the snowpack disappeared, the ammonia losses picked up and peaked 5 weeks after application. By early April, 24% of the applied nitrogen had been lost.

The lowest nitrogen losses (<10%) occurred when urea was broadcast on dry soil followed by at

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Rick Engel alongside the integrated horizontal flux system used to measure urea volatilization from broadcast urea.

least ¾-inch rainfall. Light rainfall (<1/3-inch) on dry soil resulted in nitrogen losses of 10-20%. Urea broadcast on dry soils should have at least ½-inch of rain or irrigation in one event to move urea deep enough into the soil to minimize volatilization and yield reductions associated with nitrogen loss.

Urease inhibitors are one class of chemical compounds that can be added to urea fertilizers to inhibit transformation to ammonium and ammonia. The most common urease inhibitor is N-(n-butyl) thiophosphoric triamide (NBPT), used in Agrotain®. NBPT can reduce ammonia volatilization for 2 to 10 weeks. In general, its longevity declines as soil temperature and moisture content increase. In this study, coating urea with NBPT (0.1% by weight) reduced cumulative ammonia losses by about 2/3. Volatilization protection lasted 2-3 weeks on acidic soils (pH 5.5-6.5), and more than 7 weeks on an alkaline soil (pH 8.4).

This study demonstrated that significant ammonia losses from surface-applied urea can occur during cold weather months. Ideally, broadcast urea should be incorporated by tillage, rainfall or irrigation. Coating urea with NBPT can help protect surface applied urea for several weeks to allow time for incorporation by tillage or by at least ½-inch of water in one event. An alternative for dryland no-till producers who do not want to rely on unpredictable rain events is to double-shoot, or subsurface band, urea into the soil at seeding.

A portion of this study has been published in Soil Science Society of America Journal. 75:2348-2357. https://www.soils.org/publications/sssaj. For more information on urea loss, check Engel's Web site at http://landresources.montana.edu/ureavolatilization/ or Jones's Web site at http://landresources.montana.edu/soilfertility/ammonvolat.html, or contact Rick Engel (406-994-7060, rengel@montana.edu) or Clain Jones (406-994-6076, clainj@montana.edu).

Percent of nitrogen lost to volatilization from cold-season surface applied urea with and without NBPT on no-till fields.

Region in Montana	Fertilization date	Urea	NBPT
North-central	April 3, 2008	8.4	4.4
North-central	Oct 8, 2008	3.1	1.4
North-central	Nov 14, 2008	31.5	4.0
North-central	March 25, 2009	35.6	18.0
North-central	March 26, 2009	39.9	18.1
North-central	Oct 6, 2009	10.7	3.3
North-central	Oct 13, 2009	10.4	4.8
North-central	Oct 19, 2009	15.7	3.4
Southwest	Jan 27, 2010	24.3	9.3
Southwest	Feb 26, 2010	44.1	11.9
North-central	March 29, 2010	6.1	1.7
North-central	April 20, 2010	14.7	1.4
Central	March 5, 2011	20.7	10.1
Average		**20.4**	**7.1**