EC 1492
January 1998
$1.00

Gardening and Water Quality Protection:

Understanding Nitrogen Fertilizers

G. Andrews

Adequate soil nitrogen is necessary for a healthy lawn and garden. Many Oregonians use some form of nitrogen fertilizer to enhance the nitrogen levels in their soil. In most cases, adding nitrogen fertilizer produces greener, lusher, faster-growing garden plants and lawns.

Because fertilizers are relatively inexpensive, many people are tempted to add more and more nitrogen to their home landscape, often without regard to whether plants need it at that particular time. But there are costs to using too much nitrogen fertilizer:

- Excessive fertilizer can "burn" plants and damage leaves by increasing the mineral salt concentration in the soil.
- Fertilizers high in nitrogen discourage flowering and favor leafy growth, so vegetable production and your flower garden may pay the price.
- Heavy fertilization of lawns can produce excessive growth, which makes for difficult or frequent mowing.
- Extra nitrogen not used by plants may be leached into the groundwater in the form of nitrate, a common pollutant.

Your groundwater is at higher risk of contamination from excess nitrogen fertilizer if you have soils that drain quickly, such as river loam, coastal sand, or volcanic deposits. ***Do you know what kind of soil you have?***

Water contaminated with high levels of nitrate is considered unsafe to drink. Pregnant women and infants are especially at risk because high nitrate levels can cause a type of blue-baby syndrome.

In some areas, the cost of nitrate-contaminated groundwater is great. Public water suppliers cannot use water from a contaminated source because of the health risk, and locating a safe source of water may be very expensive. Households on private wells may need to install treatment systems.

The wise use of nitrogen fertilizer by each home can greatly reduce the risk of groundwater contamination. You can have both an attractive, healthy landscape and a safe drinking water supply for the future.

The availability of nitrogen to plants is affected by many factors, including temperature, moisture, soil pH, and the chemical form of the nitrogen. Understanding these factors may help you better manage your use of fertilizers in your lawn and garden. Each section below explains a scientific concept pertaining to nitrogen in the soil, and offers a simple gardening approach. You can use these ideas to develop your own nitrogen management plan. Specific management strategies are listed in EC 1493, *Gardening and Water Quality Protection: Using Nitrogen Fertilizers Wisely*, the companion publication in this set (see "For more information," back page).

1 Forms of nitrogen available to plants

Nitrogen can be added to the soil in many forms (see Table 1). However, plants use nitrogen only as nitrate (NO_3^-), and to a lesser degree, ammonium (NH_4^+). Nitrate and ammonium ions are dissolved in the soil water taken up by plant roots.

Regardless of the original form of nitrogen fertilizer, for it to be available to plants, it must be converted to NH_4^+ or NO_3^-. Organisms living in the soil (e.g., bacteria and fungi) accomplish this conversion.

> Consider how the form of nitrogen in fertilizer you apply affects the timing of its availability to your plants.

Gail Glick Andrews, Extension water quality educator, Oregon State University. Master Gardener volunteers provided research assistance. Funds provided by the Oregon Department of Agriculture.

OREGON STATE UNIVERSITY EXTENSION SERVICE

If you add nitrogen in an inorganic form containing ammonium or nitrate, it will be available to plants almost immediately. Organic sources release nitrogen gradually over a longer time as their nitrogen is converted to ammonium and nitrate by soil organisms. The conversion and movement of nitrogen in the soil are depicted in Figure 1.

2 Adding organic matter to garden soil

If organic matter (straw, compost, manure, plant stubble, fish emulsion, etc.) is added to the soil, it will be eaten by organisms living in the soil. All living things need nitrogen to build proteins. If the organic matter is rich in nitrogen, the soil organisms use that nitrogen to live. Eventually, they release excess nitrogen into the soil as ammonia.

> Organic matter and available nitrogen are closely related, so if you add organic matter you need to consider how it will affect the nitrogen supply in the soil.

If low-nitrogen organic matter (e.g., straw or sawdust) is being broken down in the soil, however, the bacteria and fungi have to use available soil nitrogen to build their proteins, so there won't be much left for plants. If you want to provide extra nitrogen for the breakdown of course organic matter, add 3–4 lb of actual N per cubic yard of material such as dried leaves, sawdust, or shredded bark.

Regardless of the organic matter source, when it is all digested, the bacteria and other organisms that were feasting on it die. The dead nitrogen-rich bodies then are broken down by other organisms that release the excess nitrogen for eventual use by plants and microorganisms.

3 Ammonium and nitrate ions in the soil

An important step in the soil nitrogen cycle is the conversion of ammonium (NH_4^+) to nitrate (NO_3^-). This process results in nitrogen in the form most used by plants—nitrate.

Ammonium has a positive charge. Clay particles in soil have a negative charge. Since opposite charges attract, ammonium ions stick to clay. Therefore, compared to nitrate, they are not as available to most plants, nor do they leach away with heavy rains or irrigation.

> Avoid having more nitrate available than plants can use, especially if there is excess water.

Nitrate has a negative charge and is repelled by clay, remaining in the soil water solution. Thus, nitrate is readily available to plants and is leached very easily.

Very specialized bacteria convert ammonium to nitrate. These bacteria require oxygen, so they do not function well in saturated soil or at great depths. Like all living things, they require water to live, so the soil must be moist. These bacteria are not active at temperatures at or below freezing. Activity increases as the soil warms, with a maximum conversion rate at soil temperatures around 80–90°F.

If excessive amounts of ammonium are converted to nitrate, plants cannot use it all right away. If there is adequate water to carry the nitrate below the rooting zone, the nitrogen will be lost from your garden forever. The wasted nitrate may end up in the groundwater that supplies your drinking water.

4 Atmospheric nitrogen added to the soil by nitrogen-fixing bacteria

The air we breathe is about 80 percent nitrogen gas (N_2), but this source of nitrogen is not directly available to plants. However, a special kind of bacteria can convert nitrogen gas to ammonium. Most occur in nodules that form on the roots of certain host plants, mainly legumes such as peas, beans, clover, alfalfa, vetch, and lupine.

> Manage legume crops to take full advantage of nitrogen-fixing bacteria: do not add nitrogen fertilizers, but make sure that other nutrients are available and that the soil is not too acidic.

Ammonium added to the soil by nitrogen fixation is available to the host plant as well as other plants growing in the same soil. Some additional nitrogen also is available after the legume crop is removed. Bacteria associated with legumes can add a significant amount of nitrogen to the soil under optimal conditions.

Nitrogen-fixing bacteria function best when the soil is not too acidic (see section on soil pH) and there are adequate supplies of other nutrients such as phosphorus, potassium, and sulfur.

5 Effects of soil pH on plant uptake of nitrogen

Most garden plants and lawn grasses grow best in soil that is moderately acidic (pH 5.5) to slightly alkaline (pH 8). Some exceptions are blueberries, rhododendrons, and azaleas, which grow best in strongly acidic soil.

Table 1.—Common forms of nitrogen for garden management.

Form of nitrogen	Source	Availablity to plants	Remarks
Organic nitrogen (Proteins, amino acids)	• Animal manure • Compost • Plant residues • Blood meal • Many others	Not available until broken down—weeks to years.	Immobile in soil. Slowly converted to NH_4^+ in soil.
Urea	• Commercial fertilizer • Fresh manure	Available fairly quickly as ammonium.*	Rapidly converted to NH_4^+ in soil.
Ammonium (NH_4^+)	• Chemical fertilizers such as ammonium nitrate & ammonium sulfate • Fresh manure • Breakdown of organic matter in soil	Used directly by some plants; more so under acidic conditions.*	Can adsorb to clay or organic matter, reducing leaching. Converted to NO_3^- by soil organisms.
Nitrate (NO_3^-)	• Chemical fertilizers such as ammonium nitrate & potassium nitrate	Used directly by most plants.*	Highly mobile in water. Easily leached to groundwater.
Nitrogen gas (N_2)	• About 80% of air within soil spaces	Only available to plants with nitrogen-fixing bacteria, such as legumes.	Organic nitrogen and NH_4^+ are added to soil from legumes.

*Slow-release formulations are available that prolong availability to plants.

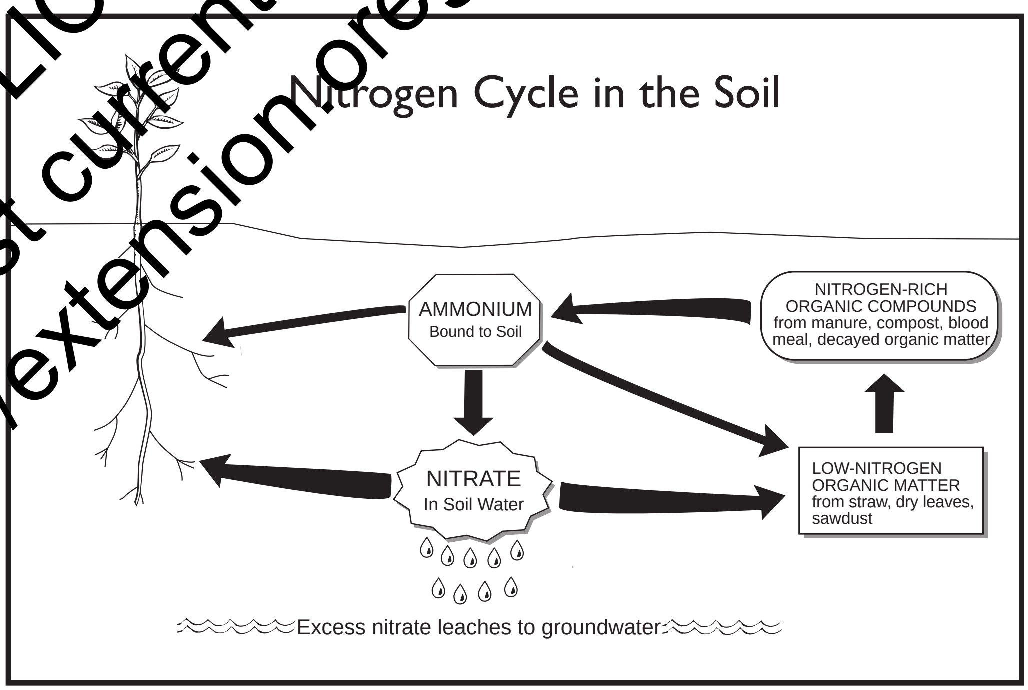

Figure 1.—All of the arrows represent biological processes in the soil. These steps proceed more rapidly when the soil is warm and there is adequate moisture, but the soil is not saturated.

Note that there are three possible fates of nitrate:

(1) It will be used by microbes to help break down coarse organic matter, such as dry leaves, if such low-nitrogen material is present.

(2) It will be taken up by plants, if they are present.

(3) Any excess nitrate not used by plants or microbes can be carried to the groundwater by heavy rains or excess irrigation.

If the pH is out of range, adding more nitrogen is not of much help to plants, because they won't be able to use it. For instance, broccoli, cabbage, and cauliflower require near neutral (pH 7) and may not benefit from N fertilization until acidic soil is limed to raise pH.

Consider the soil pH as part of your nitrogen management planning.

As a general rule, soils in western Oregon tend to be acidic, and can be improved by using about 10 pounds of ground limestone or dolomite lime per 100 square feet, every other year. Soils in eastern Oregon are closer to neutral or somewhat alkaline and seldom need liming.

Your county Extension agent can provide you information on testing your soil pH and the pH requirements of various plants.

For more information

OSU Extension publications

Cover Crops for Home Gardens, FS 304, Rackham, Robert L., and Ray McNeilan (revised 1994). No charge

Fertilizing Home Fruit, Vegetable, and Ornamental Gardens, FG 66, Hart, John, Ray McNeilan, et. al. (reprinted 1995). No charge

Fertilizing Home Lawns, EC 1278, Cook, Thomas W. and John M. Whisler (reprinted 1994). 50¢

Fertilizing Shade and Ornamental Trees, FS 303, McNeilan, Ray A. (reprinted 1997). No charge

Gardening and Water Quality Protection: Using Nitrogen Fertilizers Wisely, EC 1493, Andrews, Gail G. (1998). $1.00

Gardening with Composts, Mulches, and Row Covers, EC 1247, Mansour, N.S. (reprinted 1997). $1.00

Grow Your Own set—available for many garden vegetables

Planning and Preparing Your Vegetable Garden Site, EC 1228, Mansour, N.S. (reprinted 1994). 50¢

Selecting and Maintaining Water-efficient Landscape Plants, EC 1455, Bauer, Michael E. (1995). 75¢

The above publications were published by Oregon State University, Corvallis, OR.

Other publications

Backyard Composting in the 1990's, WAEB 1784, Cogger, Craig G., Dan M. Sullivan, and Susan K. Duncan (Washington State University, Pullman, reprinted 1995). $1.00

To order copies of the above publications, send the publication's complete title and series number, along with a check or money order for the amount listed, to:

Publication Orders
Extension & Station Communications
Oregon State University
422 Kerr Administration
Corvallis, OR 97331-2119
Fax: 541-737-0817

If you would like additional copies of this publication, *Gardening and Water Quality Protection: Understanding Nitrogen Fertilizers,* EC 1492, send $1.00 per copy to the above address.

We offer discounts on orders of 100 or more copies of a single title. Please call 541-737-2513 for price quotes.

You may order up to six no-charge publications without charge. If you request seven or more no-charge publications, include 25 cents for each publication beyond six.

World Wide Web

You can access our Educational Materials catalog and some of our publications through our Web page at eesc.orst.edu

This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties.

Published January 1998.