SOILS, the foundation of life

FIGURING OUT WHAT YOU HAVE

Soils take hundreds to thousands of years to form. While states in the Midwest are usually blessed with deep, fertile topsoil (the layer of the soil where most of our plants grow), our Western soils can be more challenging and good topsoil can be scarce in supply. The characteristics of the soils we live on dictate what we can do with them and how we should sustainably manage them. Gathering information on the soils that exist on your property will allow you to best utilize and care for them.

In general, Wyoming soils present several special challenges. Our pHs, a measure of how acid or alkaline a soil is, are often high, which changes the availability of many nutrients in the soil. Our soils generally have low organic matter, which decreases water holding capacity and decreases the potential for deriving some nutrients from the decaying organic matter. There are areas of the state where salts and/or sodium are high, which can also interfere with nutrient uptake. Some of these issues can be dealt with by selecting the appropriate plant species for your soil; others can be minimized by proper management techniques.

In this section, we will cover how to find general information about your soil, collect soil for testing, and interpret the results.

Finding general information about your soils through a soil survey

We use soil in a variety of ways. It provides the foundation for buildings, supports crops and landscapes, and can be used to treat our wastes. To get a general idea of what your soils may be best suited for, consult a Natural Resources Conservation Service (NRCS) soil survey. These surveys, which consist of maps of the dominant soil types in your area and data about their physical and chemical properties, are the result of many years of on-the-ground scientific inventories. In addition to identifying the soil types in your area, these surveys also provide information on what uses each soil type is suited for and what limitations it might have. Though conducted on a larger scale, information from the survey is even useful for small areas as it will help you understand how the surrounding area affects your site.

The soil survey maps, soil descriptions, and data about the soil's chemical and physical properties can help you understand what you are seeing when looking at the actual site. An on-site evaluation is critical since, as mentioned previously, the soil survey is done on a broad scale and does not record small areas whose conditions may vary significantly from the majority of the surrounding landscape. You'll need your own on-site observations and the results of soil samples taken from your site before making any big decisions on how to use your land.

Much of Wyoming has been mapped, and the soil surveys are available in printed form at NRCS offices, some libraries, and online at websoilsurvey.nrcs.usda.gov. Check with your local NRCS office to find out if the survey for your area is complete. If it isn't, the local office may have preliminary unpublished maps that you can study.

For more information on soil surveys and on how to use the website read:

"You can use the web to explore your soils", – *Barnyards & Backyards* article, Spring 2009. Find it at barnyardsandbackyards.com.

Soil Tests Provide Nutrient and Soil Physical Property Information That Can Help You Grow Plants

Soil tests give you specific information about your soil that a soil survey cannot provide. They can help assess the suitability of a site for growing specific plant species and tell you what nutrients are needed, whether it is grass, alfalfa, small grains, garden vegetables, trees, or flowers.

There are many types of tests available – select your test package based on what is known about your site and what your objectives are. If growing crops and production has been acceptable and there are no obvious problem areas in forage or field-crop yields, you may only need to test for nitrate, phosphate, potassium, organic matter, pH, salt and texture. If you are looking at landscaping, you may wish to include iron, zinc, copper, and manganese. If you have had trouble growing a particular plant type, you may need more extensive tests. A University of Wyoming (UW) Extension educator or the laboratory where you have your tests run can help you decide if you need supplemental tests (specific information on testing and facilities that analyze soil is discussed later).

Timing is Important

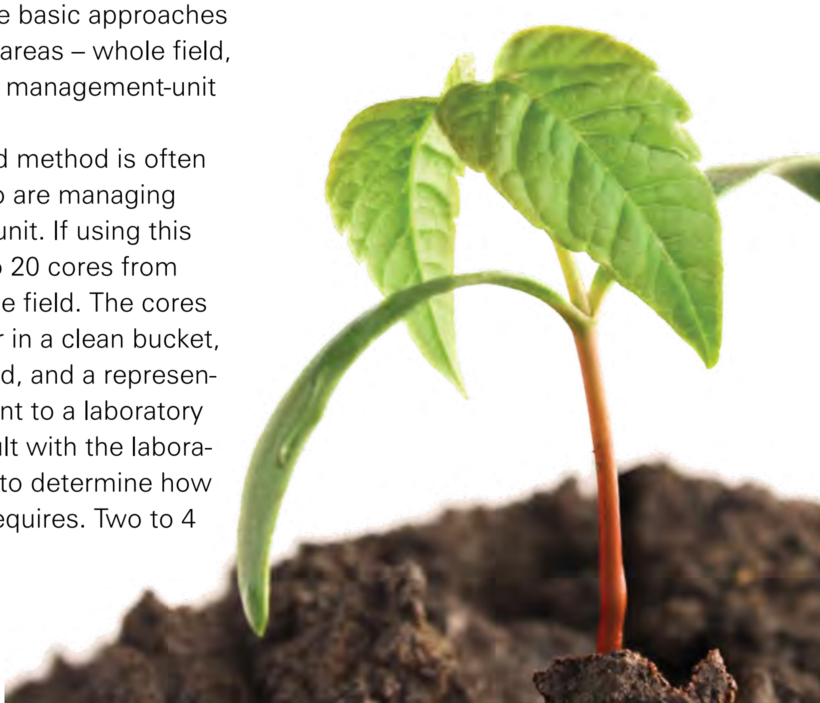
If you are planning to apply fertilizer to your land, soil sampling a few weeks before the planned date of application is usually best. Equipment and time constraints can sometimes prevent this, and samples can be taken at other times. If you are planning to test your soil multiple years in a row (such as for crop production), it is best to take samples the same time each year so results can be compared "apples-to-apples". This is because the residual nutrient content of the soil can change over time. Some nutrients leach out as the year goes on, and others can be released and made available from the organic matter or the mineral material in the soil. So establish a sampling time that suits your needs, and be consistent. For crops, keep records showing production results, and compare them to soil test reports. Remember, fertilizer recommendations are based on average crop performance, and other factors (sample timing, changing water availability, slope, etc.) may require slightly increasing or decreasing the suggested rates.

Where to Sample

Next, identify the areas to sample. There are three basic approaches to choosing these areas – whole field, grid sampling, and management-unit sampling.

The whole-field method is often used by those who are managing a whole field as a unit. If using this method, take 15 to 20 cores from random areas in the field. The cores are mixed together in a clean bucket, stones are removed, and a representative sample is sent to a laboratory for analysis. Consult with the laboratory you are using to determine how large a sample it requires. Two to 4 cups of soil are usually sufficient. Unusual areas in the field, such as salt deposits, animal watering or feeding areas, and old building sites should be avoided. If information is desired about those sites, they should be sampled separately. The whole-field method treats the entire field in the same manner and can result in over-fertilizing some areas and under-fertilizing others.

Grid sampling is the method that is often chosen by those who are growing high-value crops and have equipment that can apply varying rates of fertilizer to different parts of the fields. With grid sampling, the field is divided into uniform cells, usually one to two acres in size. Ten to 15 cores from random areas within each cell are taken. The cores are mixed, and a subsample is sent in for analysis. Avoid unusual areas. Grid sampling usually results in more accurate estimates of nutrient availability. If variable-rate fertilizer application equipment is not available, growers will not be able to take advantage of that accuracy. This method requires many samples for one field and can be expensive. Unless high-value crops are being grown, it may not be worth the additional expense.



A compromise between whole-field and grid sampling is the management-unit approach. Divide a large field into several smaller sampling areas based on known characteristics. These may be soil type (from soil survey data), historical management differences, yield data, or aerial photographs that show distinct differences in plant growth. Fifteen to 20 random cores are taken from each management-unit area. Mix these, remove the rocks, and submit a subsample to your chosen laboratory.

For landscape areas, the management-unit approach usually works well. Your lawn, garden, shrub area, and flowerbeds would each be separate samples. Take 10 to 15 random cores for each area, mix the samples from the area, pitch the rocks out, and submit a subsample for the mixed material.

Taking the Sample

A good soil test requires collecting good soil samples. First, decide if surface (0-6 inches or 0-8 inches) samples will be taken or if surface and deep samples (to 2 or 3 feet) will be taken. Deep samples are usually only taken for field crops. These deep samples are tested for nitrate. They can help the lab make a more accurate nitrogen fertilizer recommendation than if just surface samples are submitted.

Start with clean tools. A plastic bucket and a shovel are all that are needed; however, a soil probe, which removes a soil core, makes taking consistent samples easier. Many of the University of Wyoming Extension offices have a probe that you may borrow. To sample, remove plant debris (dead plants and roots, thatch, seed pods) from the top of the soil, and use a soil probe to remove a 6- or 8-inch-long core of soil. If using a shovel, dig a hole and then shave a 1- to 2-inch wide slice off the side of the hole to a depth of 6 or 8 inches. Make sure the slice is as thick at the bottom as it is at the top.

Go to other random sampling areas and repeat the process. Mix the cores or slices well, and discard any large stones. The soil should be spread on a clean, non-metallic surface (a plastic tray is a good choice) and allowed to dry in the shade. Mix the soil again, and put 2 to 4 cups of soil in a clean plastic bag. DO NOT dry it in the oven or microwave to speed the process; this can collapse the clays and trap some nutrients, therefore ruining the sample.

Submit the Sample

You are now ready to send your sample for testing. The more information provided to the laboratory, the better the quality of the recommendation. Information about your water source, watering schedule, method of irrigation, condition of current plant life, expectations for future plant life, depth of soil, manure applications, drainage, and type of fertilizer you wish to use (organic or conventional) are all considered when making a fertilizer recommendation. Most laboratories have an information sheet that you fill out and submit with your sample. It will ask for the information the laboratory needs to make a good fertility recommendation.

There are a variety of soil testing labs in the region. Contact your local UW Extension office for information on the labs that are available. The Colorado State University Soil Testing Laboratory takes samples from across Wyoming – information sheets and costs can be found at http://www.soiltestinglab.colostate.edu.

Reading your soil test report

Your soil test report can provide valuable information about soil conditions and help you become a more successful grower of crops, garden vegetables, or ornamental plants. To make the best use of the soil, you need to understand how to interpret soil test results. The soil properties covered in your soil test report interact in a complicated system. Physical and chemical properties both affect a plant's ability to grow and produce seed, foliage, roots, or fruit. The fertilizer recommendations given on the soil test report are only guidelines based on test results and information provided on the sample questionnaire when the soil sample was submitted. There may be other adjustments that should be made based on factors beyond the control or knowledge of the laboratory that makes the recommendation. Different crops require different amounts of nutrients. Follow the recommendations on your soil test report (which are based on the crop you told the lab you wanted to grow) to determine the quantity of any amendment(s) that should be added.

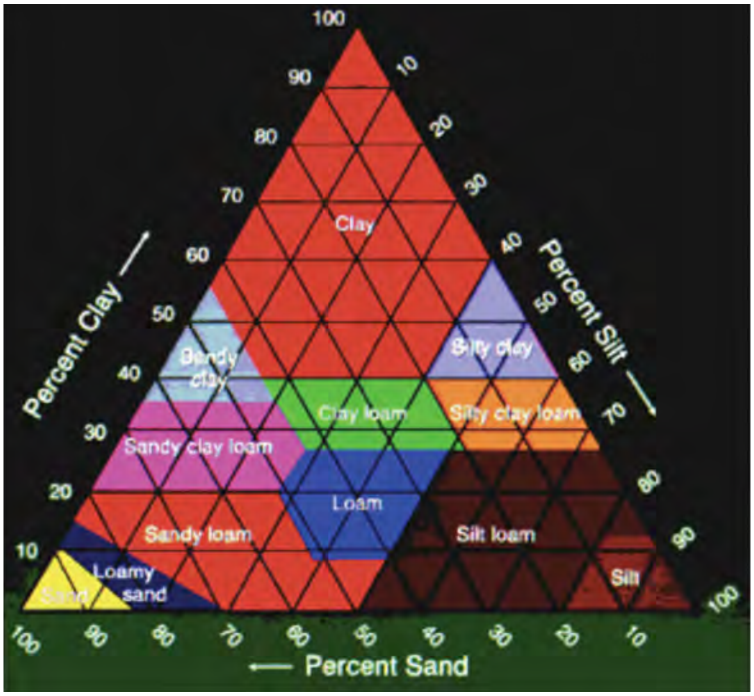


Figure 1: *Soil Texture Triangle (U.S. Department of Agriculture)*

Possible Soil Tests

Texture: Soil texture describes the amount of sand, silt, and clay in a soil. Soil textures can be divided into three broad groups: **light** (sand, loamy sand, and sandy loam), **medium** (loam, silt loam, silt, and sandy clay loam), and **heavy** (clay loam, silty clay loam, sandy clay, silty clay, and clay).

Light soils drain quickly and need to be watered frequently to maintain enough water for good growth of most plant species. Light soils allow soluble nutrients like nitrate and sulfate to be leached (travel through and out of the soil layer with water) quickly. Two or three small applications of soluble nutrients over the growing season will help prevent loss of valuable fertilizer.

Medium-textured soils are usually the most favorable for plant growth. They generally hold the most plant-available water and usually have adequate nutrient-holding capacity.

Heavy soils are often characterized by slow water-infiltration rates and high nutrient-holding capacity. They hold more water but generally do not release as much of it to the plants as a medium soil will release. Heavy soils may require more phosphorus but are less prone to nutrient leaching losses and require less frequent irrigation than lighter soils.

Figure 1 shows the sand, silt, and clay percentages for different soil textures.

Very light and very heavy soils can create management problems. Soil texture is not easily modified, and soil texture problems are usually corrected by careful water management and building up soil organic matter.

Soil Organic Matter: Organic matter is important in maintaining the soil's desirable chemical and physical properties. Organic matter improves water-holding capacity (especially plant-available water), permeability, aeration, and resistance to compaction. Organic matter increases the soil's ability to absorb and hold plant nutrients and releases nutrients as it decomposes. Herbicide rates can be affected by soil organic matter levels. Some herbicides are adsorbed by organic matter and this can cause their effectiveness to change. Consult the product label for specific guidelines. Organic matter is also important in maintaining necessary biological activity in soil. Many Wyoming soils have less than 2 percent organic matter and will benefit from practices that encourage organic matter accumulations. Over time you should try to build your soil organic matter up to 5 or 6 percent if you are trying to grow crops. Organic matter is a tool you can use to help address a number of soil issues. You can use it to modify drainage, water retention, or soil texture/structure problems. Add high quality organic matter when needed, fall or spring. Use manure and compost carefully because both can be a source of disease, contaminants, and salts. Use only well-aged or composted manure (see this guide's "Manure" section for more information on composting). Other sources of organic matter include: sawdust (If you use sawdust, you'll need extra nitrogen, about 2lb N /cu yd of sawdust), green manure from a cover crop, leaves, straw, or peat moss.

Lime Estimate: Lime is a source of calcium, an essential plant nutrient, but high-lime soils (lime content >2 percent), which are common in Wyoming, require more phosphorus and possibly more potassium than other soils. Many nutrients exist in plentiful quantities in these soils but some can't be used by plants due to the excess calcium and high pH of high-lime soils. Therefore, some plant nutritional imbalances may be observed. (For example, iron, though abundant in many of our soils, becomes insoluble and unavailable to plants at high pH. This is a common problem in home landscapes.)

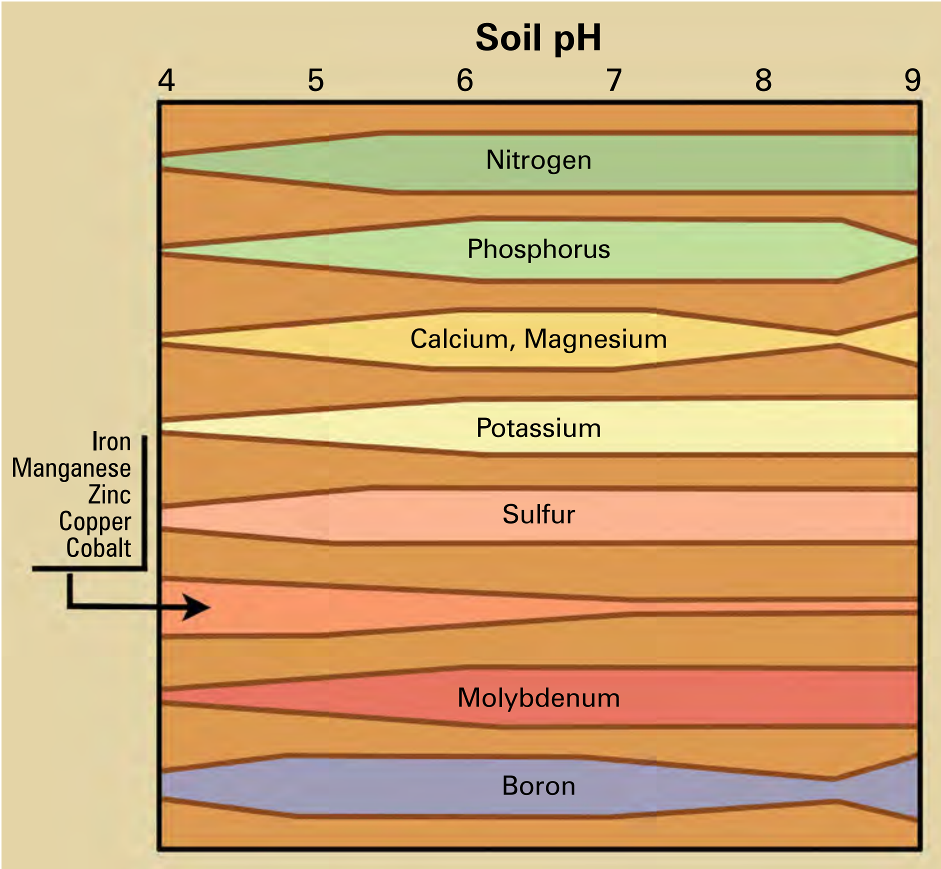


Figure 2: *Nutrient availability at different pHs A wider bar indicates the nutrient is more soluble at that pH and therefore more available to plants. (Source: eXtension)*

Soil pH: pH is a measure of the acidity or alkalinity of a soil. The pH of most Wyoming soils is between 7.0 and 8.5. As a comparison, lemon juice has a pH of about 2, while ammonia has a pH near 11. A pH above 7.0 is alkaline; a pH below 7.0 is acidic. A pH of 7.0 is considered neutral. The optimum pH for most common plant species grown in crop fields or gardens will fall between about 6.0 and 7.0 (slightly acid), but many plants will actually tolerate a wide range in soil pH. If the pH is below 6 or above 8, the solubility of some essential nutrients changes dramatically (see Figure 2.), and toxicities can even occur at the extremes. Perhaps the most common problem observed with soil-pH extremes is nutritional imbalance. Soil pH can also affect herbicide activity.

Very acidic soils can be improved by adding lime, but alkaline soils resulting from high lime are not easily changed. The higher pHs of Wyoming's soils are usually due to the presence of free calcium carbonate (lime). Neutralizing lime is difficult to do on a landscape basis, and over time the soil usually returns to its original pH. If you want to grow plants that prefer acidic soils, consider purchasing potting mixes formulated for acid-loving plants and grow them in pots or other decorative containers.

Salt Estimate: Salt buildup, or soil salinity, is common in arid and semiarid regions and is often caused by poor quality irrigation water and/or poor soil drainage. Soil salinity may usually be corrected by improving soil drainage and leaching. The sensitivity of plants to salts vary with growth stage. Many species are more sensitive to salts during germination and emergence than during vegetative growth.

Salts can come from many sources: the rock from which the soil weathered, dissolved salts in water, manure or fertilizer applications, or salts from applications to roads and sidewalks during wintry weather. High salt levels can cause wilting, leaf burn, stunting, germination failure, and nutrient uptake failure in plants.

In general, if the problem is salt and you have good drainage, the answer is to leach the soil with good water and then retest the soil. If you do not have access to good water or cannot establish good drainage, consider choosing plants that are tolerant to salt. Tables 2 and 3 show the salt sensitivity of some common Wyoming crops. If you are trying to grow trees and shrubs in these areas, read the Spring 2010 *Barnyards & Backyards* article "Establishing trees and shrubs on salt-affected sites" (at barnyardsandbackyards.com) for more information.

Sodium is a component of some salts and creates special problems in the soil. In addition to causing symptoms similar to high salt, sodium can cause a loss of soil structure, which can slow water infiltration and movement or even stop it. Under sodic (high sodium) conditions, the pH often increases to 8.5 or above, and the decay of organic material may be slowed.

Laboratory tests can determine if the problem is high salt, high sodium, or both. If soil is high in sodium, the treatment becomes more difficult. There are a number of materials (gypsum, sulfur, and lime sulfur, for example) that can be used to replace sodium in the soil. After the material has been allowed to react with the

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Table 1. Relative crop tolerance to soil salinity.

Relative crop salinity tolerance rating	Salt estimate at which yield loss begins
Sensitive	<1.3 dS/m (deciSiemens per meter)
Moderately sensitive	1.3 – 3.0
Moderately tolerant	3.0 – 6.0
Tolerant	6.0 – 10.0
Unsuited for most crops (unless reduced yield is acceptable)	>10.0

From Ayers, R. S., and D. W. Westcot. 1985. Water quality for agriculture. FAO Irrigation and Drainage Paper no. 29.

Table 2 – Relative salt tolerance of field and forage crops.*

			Interpretation		
Field crops	Forage grasses	Forage legumes	Low	Moderate	High
			------mmhos/cm------ or dS/m		
------Sensitive------					
Dry bean Onion	Meadow foxtail	Alsike clover Ladino clover Red clover White Dutch clover	0-2.0	2.1-4.0	>4.0
------Moderately Sensitive------					
Corn Oat (forage) Potato Rye (forage) Millet Sunflower Turnip	Bluebunch wheatgrass Garrison creeping foxtail (seeding) Grasses (general) Green needlegrass Intermediate wheatgrass Meadow fescue Needle and thread Orchardgrass Redtop Reed canarygrass Slender wheatgrass Smooth bromegrass Timothy	Alfalfa (seeding) Cicer milkvetch	0-3.0	3.1-6.0	>6.0
------Moderately tolerant------					
Canola Oat (grain) Rape Rye (grain) Safflower Sorghum Sudan grass Sugar beet Wheat	Beardless wildrye Canadian wildrye Crested wheatgrass Garrison creeping foxtail (established) Indian ricegrass Native ricegrass Streambank wheatgrass Tall fescue Tall wheatgrass Western wheatgrass	Alfalfa (established) Birdsfoot trefoil White sweet clover Yellow sweet clover	0-6.0	6.1-12.0	>12.0
------Tolerant------					
Barley Asparagus	Altai wildrye Russian wildrye Tall wheatgrass (established)		0-9.0	9.1-15.0	>15.0

*This list is only an indication of the salt tolerances of major plant groups. These "indicator" plants can be useful in determining the salt tolerances of closely related plants or plants adapted to similar sites.

Table 2 – Relative salt tolerance.*

			Interpretation		
Woody fruits and trees	Ornamentals, grasses, and groundcovers	Herbaceous fruits, vegetables, and flowers	Low	Moderate	High
			———mmhos/cm——— or dS/m		
———Sensitive———					
Apple Cherry & Prunus *spp.* Chokecherry Currant Gooseberry Pear Plum Raspberry	American linden Cotoneaster Littleleaf linden Mock orange Oregon grape Redtwig dogwood Rose	African violet Bean Carrot Onion Parsnip Strawberry	0-2.0	2.1-4.0	>4.0
———Moderately Sensitive———					
Aspen Black locust Cottonwood Fir Grape Green ash Honeylocust Maples (most) Poplar Siberian elm Spruce Willow	Clematis Common snowball English ivy Honeysuckle Kentucky bluegrass Lilac Orchardgrass Privet Serviceberry Wayfaring tree Yellow sage	Broccoli Cabbage Cantaloupe Corn Cucumber Flowers, general Gladiolus Lettuce Pea Pepper Potato Pumpkin Radish Spinach Tomato Turnip Watermelon	0-3.0	3.1-6.0	>6.0
———Moderately tolerant———					
Autumn olive Evergreens Hackberry Juniper Pine	Blue grama Buffalograss Caragana Crested wheatgrass Fine fescue Perennial ryegrass Potentilla Tall fescue	Beet Carnation Chrysanthemum Squash, zucchini	0-6.0	6.1-12.0	>12.0
———Tolerant———					
	Alkali grass Creeping bentgrass Iceplant	Asparagus	0-9.0	9.1-15.0	>15.0

*This list is only an indication of the salt tolerances of major plant groups. These "indicator" plants can be useful in determining the salt tolerances of closely related plants or plants adapted to similar sites.

soil, the treated area is leached to remove the sodium.

Never begin treatment for a salt or a sodium problem without having the soil tested and consulting with a qualified professional. If treatments are done improperly, soil conditions can become worse. After leaching a saline or sodic soil, have the soil retested to establish the effectiveness of the process.

Nitrate-NO3-N: Nitrogen (N) is usually the nutrient required in the greatest quantities by plants. The nitrate form of N is available to plants. Most nitrogen fertilizer will be transformed to the nitrate form if water and oxygen are present in the soil. Be aware, however, that excessive N applications can be detrimental to both the crop and the environment. Because nitrate is easily leached from the soil, excess nitrate can end up in the ground water (high levels in water can cause methemoglobinemia, or blue baby syndrome, and excess nitrogen in soils can also be toxic to plants). Nitrogen recommendations are usually adjusted for soil organic matter, past manure applications, cropping history, and several other factors as necessary when such information is available. Follow application recommendations carefully, and do not exceed the recommended rate.

Phosphate-PO_4-P: Phosphorus (P) is essential for all plants and is often applied as fertilizer because much of the total P in the soil is in forms unavailable to plants. It functions as one of the major factors in photosynthesis, nutrient transport, and energy transfer. Phosphate application is often recommended when soil P has not been built up by previous fertilization. Phosphorus is considered immobile in soil, does not leach readily in soil, and does not usually constitute an environmental hazard when soil erosion is prevented. Soil-test phosphate is an index of phosphorus availability and should not be considered a measure of the actual amount available to plants. Different labs use different methods for determining an available phosphorous index so be sure to only compare results between laboratories if they have used the same method. Phosphorus recommendations are often increased on heavier soils (sandy clay loam, clay loam, silty clay loam, sandy clay, and clay) and on high-lime soils.

Potassium: Potassium (K) is usually required by plants in relatively large amounts. Potassium assists in photosynthesis, stronger stalks and stems, and movement of water, nutrients, and carbohydrates in plant tissue. Potassium is considered immobile in soils and does not usually constitute an environmental hazard. Most Wyoming soils have large K reserves, and K fertilizer applications are usually not necessary. However, some K deficiencies have been observed in some parts of the state having soils that have been under production for many years in areas where the soil is light in texture. Potassium analysis is recommended if the soil has not been tested for K recently.

Iron and Zinc: Iron (Fe) and zinc (Zn) are often abundant in Wyoming soils but are in forms unavailable to the plant. Deficiencies of these nutrients may be observed in susceptible plants growing in high-lime soils. Zinc may be applied to soil, but soil applications of Fe are often ineffective because the iron is rapidly transformed to an unavailable form. When Fe and/or Zn deficiencies are confirmed, foliar fertilizer treatments may be beneficial.

Copper and Manganese: We don't usually see a plant response to copper or manganese in Wyoming. Apply these at the recommended rate if your soil test report indicates low levels.

Calculating Your Fertilizer Needs:

Fertilizers are rated by percentage of available nutrients. Diammonium phosphate fertilizer with a grade of 18-46-0 contains 18 percent nitrogen (N), 46 percent phosphorus (P_2O_5), and 0 percent potassium (K_20).

One 10-pound bag of 16-20-0-24S contains 16 percent (1.6 pounds) nitrogen, 20 percent (2 pounds) phosphorus (P_2O_5), no potassium, and 24 percent (2.4 pounds) sulfur. The rest is filler or companion ions.

To calculate the amount of fertilizer needed:

$$\frac{\text{(Pounds nutrient needed) X 100}}{\text{\% nutrient in fertilizer}} = \text{pounds of fertilizer needed}$$

For example, if the fertilizer grade is 34-0-0 (34% N, 0% P_2O_5, 0% K_20), and you need 1 pound N/1,000 sq ft, you would apply 2.94 pounds:

$$\frac{\text{(1 pound N/1,000 sq ft) X 100}}{\text{34\%}} = \text{2.94 pounds fertilizer (34-0-0)/1,000 sq ft}$$

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