University of Idaho Extension

CIS 1182

Using Soil Test Results For Garden Fertilization

A Guide for Fertilizing Home Landscapes and Gardens in Idaho

by Amber Moore, Mike Bauer, Ariel Agenbroad, and Susan Bell

Introduction

Homeowners are often encouraged to have their soil tested in order to learn more about their particular piece of ground and to prevent under- and over-fertilization of their plants. Soil tests are particularly important for homeowners who suspect nutrient deficiencies in their plants, have over-applied nutrients, or do not know how much fertilizer to apply.

Photo by Ariel Agenbroad

Nutrient deficiencies can occur under a variety of situations, including:

- New gardens that have received no previous fertilizer; or
- Manure applications; or
- New construction where native topsoil may have been removed or disturbed.

Adversely, extremely high concentrations of nutrients in the soil can result from all-too-common practices such as:

- Frequent applications of lawn fertilizers; or
- Annual loads of manure; or
- Compost piled several inches high on a small garden; or
- Not following fertilizer application instructions on a fertilizer container.

Along with plant toxicity concerns, excessive applications of seemingly harmless plant nutrients can quickly move through the soil or accumulate in runoff, leading to unintended pollution of ground and surface water.

The goal of this publication is to introduce University of Idaho Extension county educators, Master Gardeners, landscape professionals, and homeowners to the most common nutrients required for plant growth, and to provide easy-

to-use fertilizer rate recommendations appropriate for home lawns and gardens, based on soil test results. These rates are designed to provide optimal nutrition for plants without overloading soil or harming the environment. Using the correct amount of fertilizer will likely help homeowners save money by avoiding both plant problems and the purchase of unnecessary products. Information about both conventional and organic fertilizer materials are provided.

This fertility guide is designed to help county educators and Master Gardeners provide guidance to homeowners who have had soil tests performed and are interested in adjusting their fertilizer rates optimally based on the results of their tests.

To use this guide effectively, we suggest that homeowners request a soil test from a local soil-testing lab for, at minimum—soil pH, nitrate, phosphorus, and potassium levels. For information on how to collect a soil sample from a garden, see University of Idaho Extension Bulletin 704 *Soil Sampling* by R.L. Mahler and T.A. Tindall (download it for free from www.cals.uidaho.edu/edComm/catalog and search for Soil Sampling). Or contact a University of Idaho Extension office; see a list of all of Idaho's Extension offices at http://www.extension.uidaho.edu/find.asp).

You will find a list of soil testing labs serving Idaho at the end of this publication.

Homeowners who do not have current soil test results for their garden may still be able to benefit from the information in this guide. Most garden soils that have not received yearly manure or compost applications tend to be relatively low in nitrogen (N) and phosphorus (P), unless you have applied excessive amounts of conventional fertilizers. If soil test potassium (K) is not known, add potassium fertilizer at a moderate level since most Idaho soils are naturally high in potassium.

Obviously, making these types of assumptions does not replace the accuracy of a soil test and may lead to money wasted on surplus fertilizer. Also, homeowners risk applying fertilizers at rates that could harm the environment. Most basic soil tests cost $25 to $50. Money spent on a soil test can often be recouped in fertilizer costs.

Nitrogen (N) and organic matter

Plants require nitrogen for vegetative growth and chlorophyll production. Here are some generalizations:

- Nitrogen-deficient plants will tend to have light green/yellow older leaves, stunted/slow growth, and possibly necrosis (death) on tips of lower leaves.
- Lawns require relatively high quantities of nitrogen to support continued grass growth after frequent mowings.
- Annual garden plants, including vegetables, generally need comparatively moderate amounts to support new plant growth.
- Established trees, shrubs, and perennials require minimal amounts of N for new stem and leaf growth. If trees and shrubs are located near a lawn, lawn fertilizer that is not taken up by grass roots will leach down to tree and shrub roots, providing adequate nutrition without additional fertilization.

Nitrate test. The soil nitrate (NO_3) test is the most common and reliable test for estimating plant-available nitrogen in the soil. Nitrate is a form of nitrogen usable by plants and is measured in parts per million (ppm) in a given

sample size. Aside from being an important component of a healthy soil, organic matter, which consists of decomposing plant and animal material, also contains a small amount of N. Organic matter is measured as a percentage based on the carbon present in a soil sample. Every 1.5% organic matter in a soil provides the rough equivalent of 1 lb N/1000 sq. ft. Therefore, soils higher in organic matter will need less N added than soils with little organic matter. Applying N to soils with more than 60 ppm nitrate-N will not improve plant growth and in fact can lead to plant damage and trigger water quality pollution issues, and should be avoided.

Table 1. Nitrogen (N) fertilizer recommendations based on soil test N results and organic matter content.

Soil Test Nitrate-N[a]	Location	Organic Matter (%) <1.5	1.5 - 3.0	>3.0
ppm[b]		—lb N/1000 sq ft—		
<10	Lawn	4	4	3
	Trees/Shrubs/Perennials	3	2	1
	Vegetable gardens	4	3	2
10-20	Lawn	4	3	2
	Trees/Shrubs/Perennials	2	1	0.5
	Vegetable gardens	3	2	1
20-40	Lawn	2	1	0.5
	Trees/Shrubs/Perennials	1	0.5	0.5
	Vegetable gardens	1	1	0.5
40-60	Lawn	2	1	0.5
	Trees/Shrubs/Perennials	0	0	0
	Vegetable gardens	1	0.5	0.5
>60	All	0	0	0

[a]0-12 inch sampling depth

[b]ppm = parts per million. This may also be expressed as mg/kg or µg/g on a soil test analysis.

Fertilizer rates listed in Table 1 can be applied to trees and gardens prior to planting. For lawns, University of Idaho turf specialists recommend splitting the recommended fertilizer rates into 3 or 4 applications (early May, June (optional), early September, and late October/November). Research has also shown that grass clippings can supply 25 percent of a lawn's total fertilizer needs. Homeowners who consistently leave behind grass clippings on their lawn may be able to reduce their lawn fertilization by up to one application.

Nitrogen fertilizers can be applied on the soil surface and watered in or can be incorporated (tilled) into the soil. However, nitrogen fertilizers left on the soil surface for longer than one week without watering may lose up to 50% of nitrogen to the air (a process called volatilization), so be sure to plan on watering or incorporating N fertilizers shortly after application to get the full benefit.

Phosphorus (P) promotes roots, flowers

Phosphorus (P) is needed by plants to promote root, fruit, flower, and seed production. Garden plants, especially plants grown for flower or fruit production, require relatively high levels of phosphorus. Plants that are phosphorus deficient may have fruit that is lacking, or limited flower production, stunted roots, and, in severe cases, purpling on leaf edges. Phosphorus deficiencies are often seen in plants growing in cooler soils because the plant is biologically unable to retrieve the available phosphorus. As soil temperatures begin to warm up in late spring and early summer, these deficiencies typically resolve themselves.

Established lawn grasses need very little phos-phorus, since green vegetative growth is the primary focus. Most newly established plants need an extra boost of phosphorus to support root growth. Root stimulator fertilizers contain adequate concentrations of phosphorus for root establishment on soil with low levels of phosphorus. Phosphorus is measured on a soil test in parts per million.

Homeowners in parts of Idaho with pH levels above 7.0 (typically the southern region of Idaho) often have issues with phosphorus availability to plants. These soils are considered to be alkaline. High concentrations of calcium sometimes found in these soils will bind with

Vegetable plants, like this zucchini seedling, benefit from the correct balance of soil nutrients. In this photo, a top-dressing of compost is used to provide required minerals, improve soil organic matter, and conserve moisture, too.

phosphorus fertilizers, preventing plant uptake of phosphorus. To determine how much calcium will bind with your P fertilizer, request a test for percent free lime (also referred to as calcium carbonate equivalent by some soil labs). Most labs will choose the correct P test based on the pH of your soil.

Recommendations for P fertilizer application rates based on Olsen P and free lime are listed in Table 2. Phosphorus used for fertilizer purposes is referred to as P_2O_5.

Table 2. Phosphorus (P_2O_5) fertilizer recommendations for soils with pH greater than 7 (typically southern Idaho soils) based on soil test P results and lime content.

Soil Test P (Olsen)[a]	Location	Percent Lime 0-4	4-8	8-12	>12
ppm		---lb P_2O_5/1000 sq ft---			
<10	Lawn	2	3	4	4
	Trees/Shrubs/Perennials	3	4	5	5
	Vegetable gardens	5	6	7	8
10-20	Lawn	1	1	1	2
	Trees/Shrubs/Perennials	1	2	3	3
	Vegetable gardens	2	3	4	5
20-30	Lawn	0	0	1	1
	Trees/Shrubs/Perennials	0	0	1	1
	Vegetable gardens	1	1	2	2
>30	All	0	0	0	0

[a]0-12 inch sampling depth

Soils of northern and central Idaho generally have pH below 7.0, meaning that these soils are slightly acidic. These soils are not prone to calcium-phosphorus binding, and do not need to be analyzed for lime content. Most labs will choose the correct P test based on the pH of your soil. Recommendations for P fertilizer application rates based on Bray I P or Morgan P soil tests are listed in Table 3.

Table 3. Phosphorus (P_2O_5) fertilizer recommendations for soils with pH below 7.0 (northern and central Idaho), based on soil test P results.

Soil Test P[a] (Bray I)	(Morgan)	Location	Fertilizer P rate
ppm	ppm		---lb P_2O_5/1000 sq ft---
<14	<1.5	Lawn	2
		Trees/Shrubs/Perennials	3
		Vegetable gardens	5
14-28	1.5-3	Lawn	0
		Trees/Shrubs/Perennials	1
		Vegetable gardens	2
>28	>3	All	0

[a]0-12 inch sampling depth

Phosphorus does not readily move through the soil, so fertilizers containing phosphorus need to be incorporated or injected into the soil to the depth plant roots will grow. Phosphorus fertilizers that are applied at the surface will only be usable by roots in the top 1-inch of soil, regardless of water application rates or timing.

Potassium (K) regulates water intake

Potassium is needed by plants for regulation of water intake, movement of sugars within the plant, starch production, and root growth. It is critical for vegetative plants that are frequently cut or mowed (such as lawn grass) and for plants that produce high-starch vegetables such as potatoes. Potassium deficient plants may show burning/speckling pattern on older lower leaves. Because K availability for plants is not greatly affected by soil pH, calcium content, or organic matter, estimating K application rates using soil tests is relatively simple. Also, while there are two common soil tests used for K (sodium acetate and sodium bicarbonate), the differences in results are insignificant for gardening purposes. Recommendations for K fertilizer application rates are listed in Table 4. Potassium used for fertilizer purposes is referred to as K_2O.

Table 4. Potassium (K_2O) fertilizer recommendations based on soil test K results.

Soil Test K[a]	Location	Fertilizer K rate
ppm[b]		---lb K_2O/1000 sq ft---
<75	Lawn	4
	Trees/Shrubs/Perennials	2
	Vegetable gardens	3
75-150	Lawn	3
	Trees/Shrubs/Perennials	1
	Vegetable gardens	2
150-250	Lawn	2
	Trees/Shrubs/Perennials	0.5
	Vegetable gardens	1
250-500	Lawn	1
	Trees/Shrubs/Perennials	0
	Vegetable gardens	0
>500	All	0

[a]0-12 inch sampling depth
[b]Sodium acetate or Olsen (sodium bicarbonate) test

Smaller rates of potassium fertilizers can be watered in after a surface application (1-2 lbs/1000 sq. ft.) or incorporated/injected. For higher rates (greater than 2 lbs/1000 sq. ft), it is more effective to incorporate or inject potassium fertilizers directly into the soil if possible.

Sulfur (S) for chlorophyll production

Sulfur is needed by plants for protein synthesis and to facilitate chlorophyll production. For example, sulfur, in addition to nitrogen, will help to give lawns and other vegetative plants a deep green coloring in the leaf blades, therefore it is commonly added to lawn fertilizers. Excluding lawns, most plants grown in Idaho can get adequate S from the soil and from water used for irrigation. If S deficiency symptoms are apparent (uniform yellowing in new, upper leaves) or if soil test values are below 10 parts per million (ppm) sulfate (SO_4), you may want to consider adding 0.7 lbs of SO_4 per 1000 square feet. Elemental sulfur is often used by homeowners with high pH (above 7.0) to acidify the soil. If you have been adding elemental sulfur routinely for this purpose, you should have an adequate S supply, though elemental sulfur is not immediately available to plants and must be broken down by microbes first.

Sulfate fertilizers can be watered in after surface application or incorporated, while elemental sulfur should be incorporated (if possible).

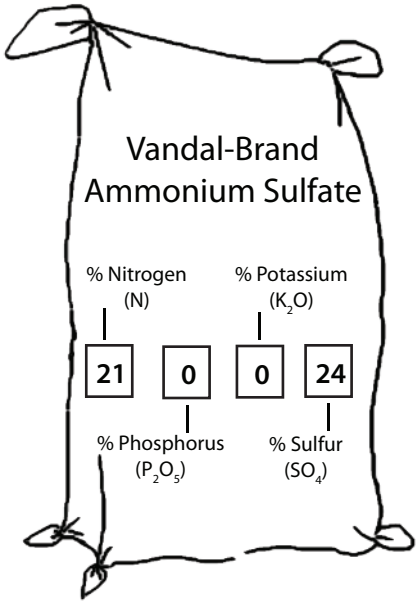
Table 5. Sulfate fertilizer recommendations based on soil test S results.

Soil Test SO_4 (ppm)	Fertilizer SO_4 rate —lb/1000 sq ft—
<10	0.7

Fertilizer contents: what the numbers mean

On most fertilizer packaging, you will notice three to four numbers listed together in a set order. Some examples are 15-15-15, 21-0-0-24, and 1-1-1. These values are commonly referred to as the N-P-K or N-P-K-S analysis of the fertilizer. The first number always represents the percentage by weight of nitrogen (N), followed by the percentage phosphorus (P_2O_5). The third number represents the potassium (K_2O) percentage by weight in the given fertilizer. If a fourth number is listed, it will be the percentage by weight of sulfur (SO_4), and will only be listed on fertilizer products that contain sulfur.

For example, the package of ammonium sulfate, illustrated at right, is a common lawn fertilizer and has the analysis 21-0-0-24, or 21% N and 24% SO_4. For more information on specific garden fertilizers and application methods, refer to the relevant publications available through the University of Idaho Extension catalog, listed on page 7.



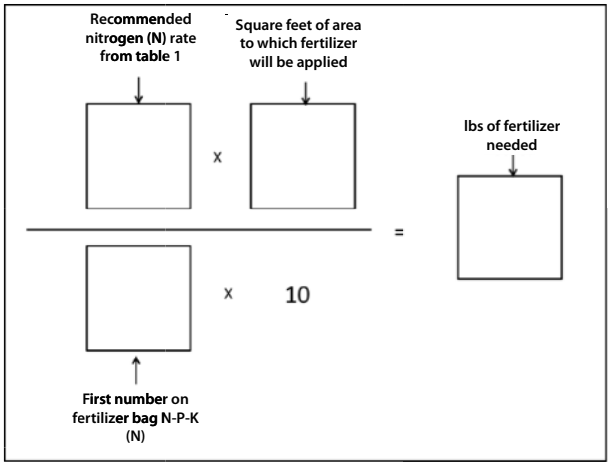
Meeting nutrient needs with specific fertilizers

The amount of a specific fertilizer that you will need to apply will be based on the product you choose, recommendations listed in this publication's tables, and the size of the area that you intend to fertilize. The calculations on page 6 will help you to determine how much fertilizer to apply, based on these factors. Garden square footage can be calculated by multiplying the length by the width of your garden area (Example: 10 ft. X 20 ft. = 200 sq. ft.). Trees and shrubs should be fertilized based on the size and spread of the root zone or trunk size.

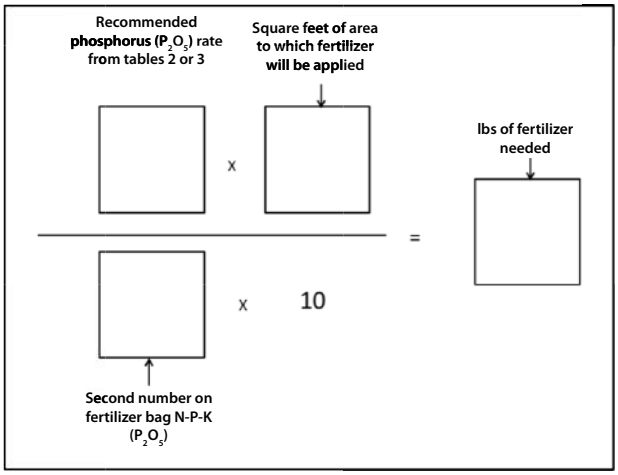
If your soil test indicates that you are short on two or three of the N-P-K nutrients, than you have several options for fertilization. One option is to do the calculations for all of the nutrients that you need and base your fertilizer product choice on the highest calculated fertilizer need. The one disadvantage to this option is over-application of nutrients that are not needed. If there is not an excessively high concentration of the "extra" nutrient(s) based on soil test values, application of these nutrients will likely not cause any serious issues.

To avoid adding nutrients that are not needed, another option is to purchase separate fertilizer products to meet the individual nutrient needs. Also, specific fertilizer blends can be selected to match the nutrient needs of the plant. For more information on specific garden fertilizers and application methods, refer to the relevant publications available through the University of Idaho Extension catalog.

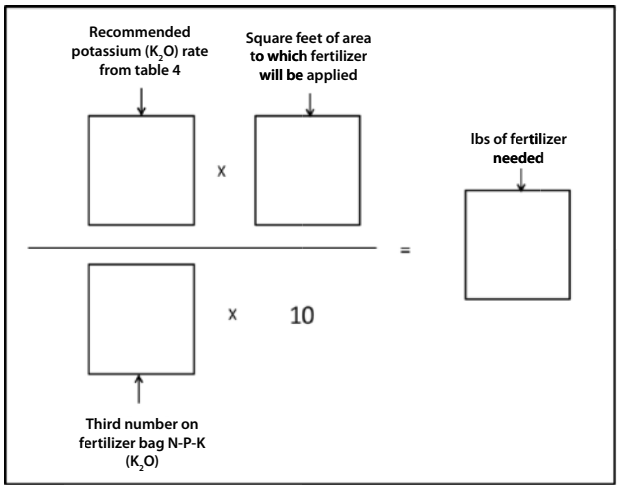
Calculation #1 - To determine how much nitrogen (N) fertilizer to apply, use the calculation below:



Calculation #2 - To determine how much phosphorus (P) fertilizer to apply, use the calculation below:



Calculation #3 - To determine how much potassium (K) fertilizer to apply, use the calculation below:



For fertilizing smaller gardens and individual plants, you will likely be working in quantities like ounces, cups, and teaspoons instead of pounds. Conversion rates to reduce pounds to smaller measuring units are listed in Table 6 below.

Table 6. Common conversions used for fertilizing gardens.*

To convert from:	To:	Multiply lbs (pounds) by
lbs (pounds)	Teaspoons	144
	Tablespoons	48
	Cups	2
	Pints	1
	Ounces	16

*Conversions between weight measurements (pounds and ounces) and volume measurements (pints, cups, tablespoons, and teaspoons) will vary slightly, depending on the fertilizer. For precise conversions for specific fertilizers, refer to *Determining amounts of fertilizer for small areas*, New Mexico Cooperative Extension Service, Guide H-119. http://aces.nmsu.edu/pubs/_h/h-119.pdf

Example Soil Test

Below is an example of typical soil test results you can expect to receive from either private soil testing labs in Idaho or the University of Idaho Analytical Sciences Lab. Keep in mind that individual labs will vary slightly on how they choose to express their results, but the basic analyses and results will generally be the same.

Typical Soil Test (Idaho private labs)	Soil Test (University of Idaho Analytical Sciences Lab)	Results
pH	pH	8.0
Nitrate-N (ppm)	Nitrate-N + Nitrite-N (µg/g)	3
Phosphorus (ppm)	Available Phosphorus (µg/g)	19
Potassium (ppm)	Available Potassium (µg/g)	215
Excess lime, Lime (%)	Calcium Carbonate Equivalent (%)	6.8
Organic matter (%)	Organic matter (%)	1.7

At right, see an example of how to compute fertilizer needs based on the soil lab analysis above.

Related University of Idaho Extension resources

University of Idaho Extension Online:

Idaho Landscapes and Gardens website. http://www.extension.uidaho.edu/idahogardens/lt/index.htm.

Relevant University of Idaho Publications:

CIS 1066 *Composting at Home*

EXT 686 *Fertilizer Questions*

CIS 922 *Fertilizing Gardens*

CIS 1054 *Low Input Landscaping*

CIS 1016 *Don't Bag It! Recycle Your Grass Clippings*

CIS 911 *Northern Idaho Fertilizer Guide: Northern Idaho Lawns*

CIS 846 *Southern Idaho Fertilizer Guide: Southern Idaho Lawns*

BUL 775 *Planning an Idaho Vegetable Garden*

CIS 866 *Homeowner's Guide to Fruit Tree Fertilization*

CIS 815 *Northern Idaho Fertilizer Guide: Blueberries, Raspberries, and Strawberries*

PNW 121 *Nutrient Disorders in Tree Fruits*

Example fertilizer calculation for a vegetable garden in southern Idaho

1. Homeowner is growing a 15 ft. X 10 ft. vegetable garden.
2. Homeowner sends off a soil sample to be tested, and receives back the results listed in the example soil test at left. The soil sample was collected to a 12" depth.
3. Homeowner has a big bag of 15-15-15 with which he wants to fertilizer his plants.
4. **Question – How much fertilizer does this homeowner need to apply before planting?**
5. Starting with nitrogen:
   a. Soil Nitrate – N test – 3 ppm
   b. Organic Matter % - 1. 7
   c. According to Table 1, this homeowner will need to put down 3 lbs N/1000 sq. ft.
   d. Following calculation #1 – (3 X 150) / (15 X 10) = 3 lbs of 15-15-15 fertilizer will meet his N needs
6. Moving on to phosphorus:
   a. Available Phosphorus – 19 ppm (assume Olsen P, since pH is greater than 7)
   b. Excess (free) lime % - 6.8
   c. According to Table 2, this homeowner will need to put down 3 lb P_2O_5/1000 sq. ft.
   d. Following calculation #2 – (3 X 150) / (15 X 10) = 3 lbs of 15-15-15 fertilizer will meet his P needs
7. Now looking at potassium:
   a. Available Potassium – 215 ppm
   b. According to Table 5, this homeowner will need 1 lb of K_2O/1000 sq. ft.
   c. Following calculation #3 – (1 X 150) / (15 X 10) = 1 lb of 15-15-15 fertilizer will meet his K needs
8. **Final recommendation –**
   a. As mentioned earlier, the homeowner needs to pick the highest overall fertilizer recommendation to meet the N, P, and K need of his plants. **Therefore, this homeowner needs to apply 3 lbs (or 6 cups) of 15-15-15 fertilizer to his garden.**

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Soil Testing Labs serving Idaho:

Best-Test Analytical Services
3394 Bell Rd. NE
Moses Lake, WA 98837
509-766-7701
www.besttestlabs.com

Northwest Agricultural Consultants*
2545 W. Falls Ave
Kennewick, WA 99336
509-783-7450
www.nwag.com

SoilTest Farm Consultants*
2925 Driggs Dr.
Moses Lake, WA 98837
509-765-1622
www.soiltestlab.com

Stukenholtz Laboratory, Inc.*
2924 Addison Ave E
PO Box 353
Twin Falls, ID 83301
208-734-3050
www.stukenholtz.com

Tremblay Consulting Inc.*
394S 335E
Jerome, ID 83338
208-324-1148

University of Idaho Analytical Sciences Laboratory*
Holm Research Center
2222 West Sixth Street
Moscow, ID 83844-2203
208-885-7900
www.uidaho.edu/asl

Western Laboratories*
211 Hwy 95
PO Box 1020
Parma, ID 83660
208-722-6564
www.westernlaboratories.com

If you would like your soil-testing lab to be added to this list, please send your request to Amber Moore at amberm@uidaho.edu.

*North American Proficiency Testing Program - Performance Assessment Program (NAPT-PAP) Labs – Accredited for 2011. (NAPT-PAP accreditation is a voluntary program used by Idaho NRCS to validate accuracy of analyses used by soil testing laboratories).

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October 2011