Managing Soil to Keep It Productive

Lesson Description

Learning the fundamentals of applying organic and chemical fertilizers is the first step in becoming successful at growing a crop, pasture or garden. If applied correctly, fertilizers can help create healthy plants and increase economic return without increasing pollution. Understanding your property's soil characteristics in relation to potential uses can save a lot of time, money and frustration. This lesson, the second in the Your Living Soil module, is divided into two sections. The first part of the lesson covers soil fertility as a continuation of the first lesson. The second part of this lesson will explain how to use a soil survey to interpret a soil's characteristics and capabilities.

Lesson Objectives

1. Learn about soil testing: how to take a sample, how often to test and what test results mean.
2. Learn basics of fertilization: what your soil needs, how much to apply, how often to apply, pitfalls and safety measures to minimize pollution.
3. Learn fundamentals of soil surveys.
4. Learn how to determine soil potential using a soil survey.
5. Practice using the NRCS web-based soil survey tool (on your own).

Module 2, Lesson 2

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Activity Sheets

1. Soil Test Results Interpretation Activity Sheet
2. Organic Fertilizers Information Sheet
3. Reading the Fertilizer Bag and Fertilizer Application Rates Activity Sheet
4. Soil Survey Interpretation Activity Sheet

Supplemental Handouts

Soil Test Interpretation Guide, OSU Extension

Soil Fertility in Organic Systems, WSU Extension

Soil Management for Small Farms, WSU Extension

Fertilizing for Profit, Washington Soil and Water Conservation District, Oregon

Cover Crops for Home Gardens West of the Cascades, WSU Extension

Cover Crops for Home Gardens, OSU Extension

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Soil Test Results Interpretation Activity Sheet, page 1 of 2

Look on either the soil survey test results for soil sample(s) taken on your property or the sample soil test results attached. Please answer the questions below.

Sample number _____ Date of report _____

What is the percentage of sand?_____, silt?_____, clay?_____

What is the soil texture classification given to this sample?_____

What is the percentage of organic matter in this sample?_____

Is this an acceptable level of organic material or should you amend your soil?_____

What is the pH of this soil sample?_____ Is this pH a potential problem?_____

What is the Cation Exchange Capacity (CEC) rating for this sample?_____

Is this CEC a potential problem?_____

What is the soluble salts value for this sample?_____

Is this level of soluble salts a potential problem?_____

Nutrient levels: Please indicate the levels of the different elements shown on the soil test. Are they High (H), Moderate (M) or Low (L) for what you are growing?

MACRONUTRIENTS

Nitrogen:	H	M	L
Phosphorus:	H	M	L
Potassium:	H	M	L
Calcium:	H	M	L
Magnesium:	H	M	L
Sulfur:	H	M	L

Which, if any, of the macronutrients are problems?_____

Soil Test Results Interpretation Activity Sheet, page 2 of 2

Micronutrients

Iron:	H	M	L
Manganese:	H	M	L
Zinc:	H	M	L
Boron:	H	M	L
Molybdenum:	H	M	L
Nickel:	H	M	L
Copper:	H	M	L
Cobalt:	H	M	L
Chloride:	H	M	L

Which, if any, of the micronutrients are problems?_____

What are the problems with this soil sample and what can or should be done to aid this soil?

_____

_____

_____

_____

_____

Organic Fertilizers Information Sheet

Fertilizer	Typical NPK Analysis	Release Time*	Pros	Cons
Plant By-products				
Alfalfa meal or pellets	2-1-2	1-4 months	• Available at feed stores	• May contain seeds
Corn gluten meal	9-0-0	1-4 months	• Very high nitrogen • Does not harm established plants	• Inhibits seed germination • Some are genetically modified
Cottonseed meal	6-0.4-1.5	1-4 months	• High nitrogen	• May have pesticide residues • Some are genetically modified
Soybean meal	7-2-1	1-4 months	• High nitrogen • Available at feed stores	• Up to half of all conventionally grown soybean is genetically modified
Animal By-products				
Bat guano, high N	10-3-1	4+ months	• Stimulates soil microbes	• Cost
Bat guano, high P	3-10-1	4+ months	• Stimulates soil microbes	• Cost
Blood meal	12-0-0	1-4 months	• Available at feed stores	• Can burn • Expensive at garden centers
Feather meal	N varies, 7-12%	4+ months	• Long-term fertilizer	• Cost vs. speed of N release
Fish emulsion	5-2-2	1-4 months	• Adds needed micronutrients	• Some have foul smell
Fish meal	10-6-2	1-4 months	• N & P source	• Heat processed
Fish powder	12-0.25-1	Immediate to 1 month	• Adds micronutrients	• Heat processed
Seaweed				
Kelp meal	Negligible	4+ months	• Adds micronutrients	• Not useful as a source of N, P, and K
Kelp powder	1-0-4	Immediate to 1 month	• Adds micronutrients	• Very minor source of N and K
Liquid kelp	Negligible	Immediate to 1 month	• Adds micronutrients • Helps plants with stress	• Not useful as a source of N, P, and K
Compost and Manure				
Compost	Varies; 1.5–3.5% N 0.5-1% P 1-2%K	Releases slowly, over a period of years	• Aids in soil moisture retention • Excellent source of organic matter • Stimulates soil microbes	• Supplemental nitrogen fertilizer may be needed • If not properly composted, may contain live weed seeds or pathogens
Manure	Varies by species, age, moisture content, etc.	Releases slowly, over a period of years	• Adds micronutrients • Readily available • Improves soil texture	• Fresh manure should not be used on food crops due to potential for transmission of pathogens • Salt content can be high • If not properly composted, may contain live weed seeds or pathogens

*Release time refers to the amount of time needed for microbial activity to release nutrients for plant uptake. Dry and/or cold soil conditions will delay the release of nutrients.

Table adapted from Organic Fertilizers, Colorado State University, GardenNotes#234

Reading the Fertilizer Bag and Fertilizer Application Rates Activity Sheet, page 1 of 2

Micronutrients

Now that you have a rough idea of what your soil actually needs, it is time to fertilize.

Remember that the numbers on the fertilizer bag indicate the percentage of elements in a specific order: N - P - K (**N**itrogen, **P**hosphorus, **P**otassium). If there is a fourth number, it indicates the amount of sulfur. Let's make sure we understand by answering the next few questions.

Which bag has the highest percentage of phosphorus?

☐ Bag A with 16-16-16 or ☐ Bag B with 16-20-0-14?

Which bag has the highest percentage of nitrogen?

☐ Bag A with 16-16-16 or ☐ Bag B with 16-20-0-14?

Which bag has the highest percentage of potassium?

☐ Bag A with 16-16-16 or ☐ Bag B 16-20-0-14?

Which bag contains sulfur?

☐ Bag A 16-16-16 or ☐ Bag B 16-20-0-14?

Now, the tough question: how much fertilizer do we need to add? The soil test results will recommend a certain number of pounds of a certain element to add to your soil, generally on a per acre basis. But there are some things to remember about the calculation. The soil test will tell you how many pounds of a certain element to add to your soil. It is up to you to calculate the actual pounds of fertilizer to apply to achieve that concentration of a specific element. Remember that a 100-pound bag of 16-16-16 fertilizer actually contains only 16 pounds of nitrogen, 16 pounds of phosphorus and 16 pounds of potassium. The rest is inert ingredients. If your soil test suggests adding forty pounds of nitrogen per acre, you will actually have to apply 250 lbs of the 16-16-16 fertilizer per acre to get to the desired level of nitrogen. You must also remember to calculate your actual fertilizer needs based on your acreage.

Let's try some examples:

Example 1: Your irrigated pasture has been tested and it is suggested that you fertilize at a rate of 140 pound of nitrogen per acre. You are using Ammonium Phosphate Sulfate, a 16-20-0-14 fertilizer. A 50-pound bag of this fertilizer will contain 8 pounds of nitrogen. How many bags of this type of fertilizer should you apply, per acre?

Reading the Fertilizer Bag and Fertilizer Application Rates Activity Sheet, page 2 of 2

Example 1, continued

140 pounds divided by 8 = 17.5 bags. Each bag is 50 pounds, so the grand total is 875 pounds of 16-20-0-14 fertilizer per acre to actually apply 140 pounds of nitrogen per acre. What does this cost? If Ammonium Phosphate Sulfate sells for about $24 per 50 pound bag, the fertilizer cost per acre would be: 17.5 bags X $24 per 50-pound bag = $420 per acre

Do you need the phosphorus and sulfur? What does your soil test indicate? Is there a cheaper fertilizer? These questions will take some research on your part to see what is available in your area.

Example 2: You have tested your dryland pasture soil and the recommendation from the testing lab is to add 40 pounds of nitrogen per acre. You would like to do this as cheaply as possible. You have access to two different fertilizers:

Ammonium Sulfate	21-0-0-24	cost = $14.00 per 50 pounds
Urea	46-0-0	cost = $18.00 per 50 pounds

Which is cheaper to use?

Ammonium sulfate: 40 pounds nitrogen required. 21% of 50 pounds = 10.5 pounds of nitrogen per 50 pound bag. 40 pounds per acre required divided by 10.5 pounds per bag = 3.8 bags per acre or 190 pounds of ammonium sulfate per acre.
3.8 bags at $14.00 per bag = $53.20 per acre

Urea: 40 pounds of nitrogen required. 46% of 50 pounds = 23 pounds of nitrogen per 50 pound bag. 40 pounds per acre required divided by 23 pounds per bag = 1.75 bags per acre or 87.5 pounds per acre of urea.
1.75 bags at $18.00 per bag = $31.5 per acre

If there is no need to add sulfur to your soil, urea is a cheaper fertilizer.

PLEASE remember that cost is not the only factor to consider in deciding on a fertilizer. Generally, the less expensive fertilizers are the quickest to dissolve, and some will flush away as water moves through your soil. Urea may even volatilize if it is not immediately worked into the soil. Slow-release fertilizers behave as the name implies. They release nutrients slowly due to an outer coating that slows the rate of release. Of course, you pay more for these types of products because they cost more to produce. They are applied less frequently and reduce pollution by reducing nutrient runoff. Weigh all the factors involved and decide on a fertilizer that best meets all your needs, goals and objectives.

Soil Survey Interpretation Activity Sheet, page 1 of 2

Have the class obtain the legal description of their property before the class begins. Example: The legal description of the piece of property you own is N 1/2 SE ¼, Sec 34 T38S, R5W

Legal description of your property _____

_____

Please find the following information on the soil survey for your property. You may use a web-based soil survey:

On what map sheet is your property found? (Hint: use the index to map sheets.) _____

_____

Soil map unit(s) for your property: _____

Is there more than one soil map unit represented on your property? If so, you will need to answer the questions for all the units represented.

Looking at the map, what features do you see? (Hint: look for a symbol legend on the map sheet.)

Read or skim the map unit descriptions for these soils. These descriptions contain valuable information about the different soil map units.

What is the depth of the soil? _____

Would this land be suitable for growing trees? (Hint: what is the effective rooting depth?)

_____

What is the USDA texture name given for this soil?_____

How well does this textural classification match your texture by feel classification?_____

What kind of traditional crops have been grown here? _____

_____

What is the capability class of this soil? (Remember to look up all units on your property.) _____

_____

How suitable would this soil be for a septic system? _____

If there are limitations for septic uses, what are they and how can they be minimized?_____

_____

How suitable would this soil be for pond development? _____

Soil Survey Interpretation Activity Sheet, page 2 of 2

How suitable is this soil for use as road fill? _____

What is the permeability of the soil? _____

Does the permeability change as you move through the soil profile? _____

Would this soil be suitable for building a dwelling with a basement? _____

Is this site prone to flooding? _____

Give a short description of your soil, in terms of its suitability for your proposed goals for your property. _____

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Acidic soil: Soils with a pH less than 7.

Alkaline soil: Soils with a pH greater than 7.

Capability class(es): A classification system developed by the U.S. Department of Agriculture to show the potential or suitability of a soil for growing crops.

Chemical fertilizer: Fertilizer manufactured from non-living materials, such as rock phosphate.

Clay: A flat or plate shaped mineral or soil grain, less than 0.002 mm across. Clay is also the name of a specific soil texture that contains 40 percent or more particles of clay size.

Compaction: Elimination of pore space in soil and destruction of soil structure, resulting in reduced soil volume and increased soil density. A decrease in soil pore space due to the physical compression of a soil. Compacted soils have poor tilth and limited production capabilities.

Compost: Organic material, rich in humus, formed by decomposed plant material and other organic matter. Compost is used as a soil amendment or improver and as a mulch.

Cover crop: A crop planted to protect the soil by reducing or stopping erosion.

Droughty soil: A soil that is unable to store enough water to meet plant requirements. Sandy and gravelly soils are droughty because they have low water-holding capacities.

Electrical conductivity (EC): A measurement of the readiness or ease with which a soil transmits electricity. This number directly correlates to soil salinity or salt concentration, since salts ions conduct electricity.

Exchangeable sodium percentage (ESP): The percentage of available absorption sites on soil particles filled with sodium.

Fertilizer: Any material of natural or synthetic origin (other than liming materials) that is added to a soil to supply one or more elements essential to the growth of plants.

Fertilizer grade: The guaranteed analysis of the contents of a fertilizer bag, generally given as a string of three or four numbers. By convention, the first three numbers represent the percentage of nitrogen, phosphorus and potassium in the fertilizer; if there is a fourth number, it indicates the percentage of sulfur.

Green manure, green manure crop: Crop that is grown and then plowed into the soil or left to decompose for the purpose of soil improvement. A green manure crop helps put organic material into the soil and keep nutrients from leaching away.

Horizon: A layer of soil that is roughly parallel to the earth's surface and has distinct characteristics formed by the soil formation process.

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Humus: A product of microbial decomposition of plant and animal residues that resists further decomposition and accumulates in the soil as organic matter. Humus has a dark color and darkens the A horizon in soils layers. It improves soil texture, moisture-holding capacity, and fertility.

Infiltration: The rate at which water enters the soil. Infiltration depends on the texture, structure and the depth of the soil.

Loam: A specific class of soil texture that contains a balanced mixture of sand, silt and clay**.** Clay must not exceed 27 percent. Loams have enough sand to feel some grit and enough clay to give the soil some body, but the properties and behavior of the soil is dominated neither by sand nor clay.

Macronutrients: The essential nutrients needed by plants in large quantities; generally they include hydrogen, oxygen, carbon, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur.

Microorganisms or microbes: Tiny, microscopic living organisms, including bacteria, fungi, algae, protozoa, and viruses. Microbes live in the soil and decompose dead plant and animal residues, converting them into humus. Some microbes help make soil nutrients more available for plant use.

Micronutrients: The essential nutrients needed by plants in small quantities; generally they include iron, manganese, zinc, boron, molybdenum, nickel, copper, cobalt and chlorine.

Nitrogen: One of the three major nutrients in a complete fertilizer and the first one listed in the formulation on a fertilizer label (as **10**-8-6, for example).

Nutrients: Substances required by plants for growth; see macronutrients and micronutrients.

Organic fertilizer: Fertilizer made from materials derived from living things, such as manure, bone meal, and blood meal.

Organic matter: The sum of all plant and animal material, living or dead, that is mixed into the soil. Living microorganisms are part of soil organic matter, and so is the humus they produce. Living and dead plant roots are also part of the soil organic matter. Organic matter promotes good soil structure, reduces compaction, improves rates of movement of air and water through the soil, increases the water storage capability for plant use and provides nitrogen and other elements needed by plants.

Parent material: The original geologic material from which the horizons of soil are formed. This can be bedrock, sediments, windblown material or volcanic ash.

pH: The symbol for the logarithm of the reciprocal of hydrogen ion concentration, used to indicate an acid or alkaline condition. On a scale from 1 to 14, a pH of 7 indicates neutral condition, less than 7 indicates acidic conditions, and greater than 7 indicates alkaline conditions.

Phosphorus: A nutrient required by all organisms for the basic processes of life. Phosphorus is a natural element found in rocks, soils and organic material. It clings tightly to soil particles and is used by plants, so its concentration in clean waters is generally very low. However, phosphorus is used extensively in fertilizer and other chemicals, so it can be found in higher concentrations in areas of human activity. It is the second number contained in a complete fertilizer (such as 10-**8**-6.)

Pores or pore spaces: Space between the mineral grains of a soil. The size, shape and arrangement of soil pores determine the rates of water and air movement into and through the soil. They also control the amount of available water that a soil can store for plant use.

Porosity: The total amount of pore space in a soil. Porous soils have plenty of pore space; compact, dense soils have low total porosity.

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Potassium: Referred to as “potash,” potassium is one of the three major nutrients in a complete fertilizer and is the third listed in the formulation on a fertilizer label (10-8-**6**, for example).

Restrictive features: A general term for a host of soil features that restrict or limit the use of that soil for a specific purpose. Restrictive features tend to assist users in identifying soil features important for use and management.

Sand: A specific grain size in the soil. Sand grains range in size from 0.05 to 2.0 mm in diameter. Sand grains are big enough to see with the naked eye and they feel gritty. Sand is also the name a specific soil texture that has 90 percent or more sand and almost no clay.

Silt: A specific grain size in the soil. Silt grains range in size from 0.002 to 0.05 mm in diameter. The grains of silt are too small to see with the naked eye and they feel smooth, like flour, cornstarch or talcum powder.

Soil aggregation: Formation of soil structure when soil particles loosely or tightly stick together into peds. Organic matter (humus) and soil clays are important agents of soil aggregation.

Soil ped: A single unit of soil structure. Ped shapes include granular, platy, blocky and prismatic. Ped sizes can range from 1-mm granules to 10-cm prisms.

Soil structure: The arrangement of individual grains of sand, silt and clay into larger units, called peds or aggregates. Plant roots, humus and clay minerals all help to hold the grains together. Soil structure is characterized by the type, or shape, of the peds and their degree of development.

Soil texture: The amounts of sand, silt and clay that make up a soil sample. Names are given to specific combinations of sand, silt and clay to form textural classes, such as loam, silty loam, sandy loam, etc.

Soluble salts: A measure of inorganic chemicals that are more soluble than gypsum, such as sodium, calcium, magnesium, chloride, sulfate and bicarbonate.

Suitability ratings: Values given to identify the degree to which a soil is favorable to a given use; they are generally given in the terms “good,” “fair,” or “poor.”

Tilth: The physical condition of the surface soil. Good tilth requires plenty of organic material, good soil structure, and good porosity for air and water movement into and through the soil. Soils in good tilth are easy to work. Seedlings easily emerge from and plant roots grow well into soils that have good tilth.

Topography: Relief characteristics of a landscape, including steepness of slope, elevation, aspect and landform.

Websites For Further Information

Soil Testing and Nutrient Management by Craig Cogger, Slideshow at: http://conferences.wsu.edu/forms/biosolids/2009/Cogger_Monday.pdf

WSU Extension Puyallup Soil Testing and Soil Biology: http://puyallup.wsu.edu/soils/soils/

NRCS Web soil survey: http://websoilsurvey.nrcs.usda.gov/app/

National Soil Survey Handbook: http://soils.usda.gov/technical/handbook/

NRCS How to Use Web Soil Survey
http://websoilsurvey.nrcs.usda.gov/app/Help/WSS_HomePage_HowTo.pdf

Soil and Water Conservation Society: http://www.swcs.org/

Soil and Water Conservation Society Soil Survey Fact Sheet:
http://www.swsc.org/t_resources_survey_fact.htm

Soil Science Society of America: http://www.soils.org/

Soil Terms Glossary: https://www.soils.org/publications/soils-glossary

USDA-NRCS Soil Quality: http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/

USDA-NRCS Soil Quality Indicators:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=stelprdb1237387

Washington State University Small Farms Team, http://smallfarms.wsu.edu/soils-compost/

OSU Small Farms: Soils: http://smallfarms.oregonstate.edu/soils

USDA-NRCS Washington Soils Program, http://www.nrcs.usda.gov/wps/portal/nrcs/main/wa/soils/

Clark County Maps Online, http://gis.clark.wa.gov/mapsonline/index.cfm

SARE Building Soils for Better Crops, http://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition