Definition of Soil

Soil: a \textit{living, dynamic system} at the \textit{interface} between air and rock. Soil forms in response to forces of \textit{climate} and \textit{organisms} that act on \textit{parent material} in a specific \textit{landscape} over a long period of \textit{time}.

What does soil do for us?

- Sustains plant and animal life
- Biological setting for water, nutrient, air, and heat exchange for living organisms.
- Controls distribution of rainfall or irrigation water. Runoff, infiltration, storage, or deep drainage.
- Nutrient cycling and plant growth.
- Acts as a filter to protect water, air, and other resources.
- Engineering medium

What we’ll cover today

- Soil Physical Properties
  - How soils are formed and classified
  - Soil texture and structure
  - Protecting soils
- Soil Biological Properties
  - Soil organisms
  - Soil organic matter
- Soil Chemical Properties
  - pH and plant nutrients
  - Collecting a soil sample and interpreting a soil test
  - Understanding fertilizers
  - When to fertilize
Interface

- The top 6.7” of soil in an acre (also known as an acre furrow slice) weighs close to 2 million lbs.

Soil Horizons

O – Litter layer
A – Mineral surface horizon, dark colored, granular structure
B – Subsoil horizon of maximum development, “brown,” blocky structure
C – Weathered “parent material”
R – Hard Bedrock

Soil Classification

- How soil scientist group soils based on their different properties.
- Soils are named and classified based on the physical and chemical properties in their horizons (layers).
- Over 20,000 different kinds of soil have been identified and mapped in the US.

- Barron coarse sandy loam – Raptor Creek Farm
- Central Point sandy loam – Pennington Farm

Capability classes

- Class I & II --good farmland with few to moderate limitations
- Class III & IV—severe to very severe limitations for growing crops
- Classes V & VI—limitations that are impractical to remove for cultivation
- Classes VII & VIII—very severe, unsuited for cultivation
Capability Subclasses

- Soil groups within one class;
  - e (erosion)
  - w (water)
  - s (shallow, droughty or stony)
  - c (climate, too cold or too dry)
- Example: Waldo silty clay loam (IIIw)
  McAlpin silty clay loam (IIw)
  Willamette silt loam (I)

Restrictive features

- Cemented pan
- Erodes easily
- Flooding
- Permeability
- Low strength
- Restrictive layer
- Shrink-swell potential

Oregon State Soil

The Jory series consists of very deep, well-drained soils in the foothills surrounding the Willamette Valley. They are named after Jory Hill, Marion County, Oregon. The Jory soils and the climate of the Willamette Valley provide an ideal setting for the production of many crops, including Christmas trees, various berries, filberts (hazelnuts), sweet corn, wheat, and many varieties of grass seed.

Four Principle Components of Soil
Properties of Soils

**Physical**: texture, structure, color

**Chemical**: nutrient availability, pH, cation exchange

**Biological**: animals, plants, fungi, bacteria

Using the Soil Textural Triangle

Soil Texture

Estimating your soil textural components at home - soil fractional analysis

- **A**: 20 min.
- **B**: 2 hrs.
- **C**: 24 hrs.
- **D**: total

Quart jar
2/3 full water
1 cup dry soil
2 tsp dish soap
Finding information about your soil
USDA Soil Survey

Estimating texture by feel

Loam is not topsoil!

• Topsoil is another name for the A horizon, where the bulk of biological activity in the soil occurs.
• Loam is a near-equal mixture of sand, silt and clay.
Why care about soil texture?

- Soil texture influences:
  - Water intake rates (infiltration)
  - Water storage capacity
  - Permeability
  - Ease of tillage
  - Amount of aeration
  - Soil fertility

Soil Structure

- Soil structure refers to the way individual particles of sand, silt and clay are bound together into larger units called **peds**.

Soil Aggregate Stability

- Influenced by:
  - Soil Organic Matter
  - Biological Activity

- Influences:
  - Water Holding Capacity
  - Erosion potential
  - Permeability
Soil Aggregate Stability Activity Part 1

3 plates on each table. Do you see any differences?

- O
- H
- F

Take a ped from each plate and put it in the corresponding cup. Spray with water – 5 squirts from 3” away

Water in the Soil

Soil and Water

- A productive soil is permeable to water and is able to supply water to plants.

Effect of texture on water movement
Good Porosity & Permeability Resolve Many Garden Problems

- **Porosity**: amount of space (pore space) between particles in a soil.
- **Permeability**: ability of water to move through that pore space.
- Good structure is associated with large pores (**macropores**).
- OM is essential to the formation and maintenance of good soil structure (tilth).

Myths of Soil Amendments #1

*If you have a clay soil, add sand to improve drainage and texture.*

**NO!**

Incorporating these materials leads to vertical and horizontal textural barriers to surrounding unamended soil. In containers, a perched water table can occur.

Soil Biology: The Living Soil

- **Microflora, or “microbes”**
  - Bacteria: 200 billion
  - Fungi: 100,000 meters
- **Microfauna**
  - Protozoa: 20 million
  - Nematodes: 100,000
- **Macro- and mesofauna**
  - Arthropods: 50,000
  - Earthworms: <1

A cup of soil contains... Of total organic matter, 1-8% by dry wt. living portion
Soil organisms need three things to thrive

The activity of soil organisms depends on:

- Soil moisture
- Soil temperature
  - 70°F-100°F for microorganisms
  - 50°F for earthworms
- Organic matter (food)

Critical functions of soil organisms:

- translocation and mixing of OM and mineral soil
- shred plant litter (speeds up decomposition)
- increased aeration and improved water infiltration
- population control of smaller organisms

gee whiz fact: dung beetles can bury up to 78% of the cattle feces in a pasture within weeks
Earthworms have gizzards!

- Eat organic matter and pass as much as 24,281 lbs/acre of soil through their bodies (mixing horizons) each year
- Can eat their weight each day
- Excreted casts higher in N, P, K, Ca, Mg, pH, and CEC
- Slime contains nitrogen and helps form aggregates
- Promote good soil structure and aeration

What is Soil Organic Matter?

- Cells of soil microorganisms
- Living organisms are also part of S.O.M
- Plant and animal residues in different stages of decomposition
- Substances that are so well-decomposed it’s impossible to tell what they were to begin with

Soil organic matter is the base for the Soil Food Web

Benefits of Soil Organic Matter

- Soil aggregation
- Aeration and water penetration
- Moisture holding capacity
- Cation exchange capacity
- pH buffer
- Micronutrient chelation
- Plant nutrient source
How to add organic matter

Cover Crops
Crop residue
Compost

• Compost is an excellent source of organic matter for garden soils.
• Composting also closes the recycling loop by turning waste materials into a soil amendment.
• You can make compost at home or buy commercially prepared compost.

How much S.O.M is there?

Recommended minimum 3% - 5% for agricultural soils

• Primarily due to natural factors like:
  • Temperature
  • Soil texture
  • Drainage
• Management may reduce S.O.M:
  • Frequent tillage
  • Periods of bare ground
  • Removal of crop residues

Organic Matter

Helps sandy soils retain water and nutrients
In clay soils
  • Helps with infiltration and permeability of water
  • Provides better aeration for plant roots
Too much of a good thing?
  • Maybe
  • Fresh organic material stimulates increase of microbial activity
  • Ties up available nitrogen until equilibrium is reached
  • Can result in excess salts
  • More nutrients than plants can use, especially phosphorus

Myths of Soil Amendments #2

When transplanting trees or shrubs into landscapes, amend the backfill soil with organic matter.

Initial results are positive!
What happens when roots grow and encounter the native soil?
What happens to soil-water movement?
What happens when the organic material breaks down?
Use native soil to backfill and mulch with organic material
Good quality soil has:

- Good aeration
- Good drainage
- Good tilth (easy to work)
- Lots of organic matter
- Lots of organisms

Minimize tillage for slower soil building

Negative affects of tillage:

- Reduces soil cover
- Disrupts interconnected pore space
- Compacts soil
- Reduces soil organic matter
- Reduces infiltration
- Breaks down soil aggregates

Protecting your soil from erosion

Process of Erosion
How to reduce soil erosion?

- Use common sense
- Retain existing vegetation whenever possible or add protective cover
- Cover crops
- Mulch and litter
- Time grading, construction and tillage to minimize exposure of soil to erosive forces
- Reduce tillage and number of passes

Mulching and seeding reduces erosion

Leaving soil exposed can cause compaction

- Reduces pore space and destroys soil structure.
- Rototilling or plowing wet soil can lead to long term compaction problems
- What happens to soil when you make a mud pie?
Composition of a compacted soil

Before

50% Solid
25% Air
25% Water

After

70% Solid
30% Air

Note the reduced air space in a compacted soil.

Compaction leads to loss of structure

• Tilling when soil is too wet damages soil structure.

How can I manage my soils to improve them?

• Avoid compaction by
  • Reducing tillage of wet soils
  • Reducing traffic on wet soils
• Increase the organic matter content by
  • Mulch soil surface
  • Adding compost and manure
  • Growing and tilling in cover crops (green manure)
• Maintain cover with vegetation

Myth of Soil Amendments #3

Adding Gypsum can improve your soil.

Sodic soils (excessive levels of sodium ions (Na⁺)) and some heavy clay soils can be improved by adding gypsum. The calcium in the gypsum binds to clay particles, replacing the sodium ions in sodic soils and helping to improve the structure in some heavy clay soils.

Gypsum does not improve water holding capacity, the fertility of soil, cure blossom end rot in tomatoes and peppers, or acidify soil.
Gardening with challenging soils

- High clay
- Serpentine
- Rocky

High clay

- Slow to dry out in Spring
- Compacts easily
- Increase organic matter
- Don’t work when wet
- Don’t try to change texture by adding sand
- Avoid compaction

Serpentine soils

- High in Magnesium and some heavy metals.
- Tend to be neutral or alkaline
- Many essential nutrients are unavailable or limited to plants (Ca, N, P, K)
- Health concerns (asbestos)

- Use native plants adapted to serpentine soils
- Minimize dust
- Cover gardens and yards with serpentine tolerant plants and 3”-6” layer of mulch or asbestos-free soil
- Don’t disturb serpentine rock
- Raised beds with imported soil
Soil Aggregate Stability Part 2

Fertilizers and Soil Amendments

Break – 15 minutes

Soil texture
Feel free to wet soil samples and rub them through your fingers. How do the different soils feel?

Why do we care about soil fertility?
Nutrient deficiencies can cause visual symptoms

Nutrient deficiencies can limit yield

Liebig's Law
Yield is proportional to the amount of the most limiting nutrient, whichever nutrient it may be.

So you think you need fertilizer:

- Which nutrients (elements) do you need?
- What type of fertilizer material should you use?
- How much should you apply?
- How should you apply?
- When should you apply it?
- Will you get a return on your investment?

Test your soil!

Soil testing provides an estimate of the quantity of nutrients which should become ‘available’ during the growing season.

Not the total amount of nutrients in the soil.
Soil sampling gives you information about the chemical composition of your soil

Collect 15 – 20 subsamples randomly around the management unit. Combine into one composite sample to submit to certified lab.

**Management Units**

*Use field characteristics (soil type, size, history)*

[Websoilsurvey.nrcs.usda.gov](http://websoilsurvey.nrcs.usda.gov)

If sampling a small area (one tree) combine at least four cores
Sampling depth is very important
Pick a depth and stick to it

How often should I take a soil sample?

- Prior to a new landscape or garden
- New property
- Every 2 – 5 years in home gardens/lawns/landscapes, use the same lab or testing methods
- Frequently enough to make good decisions on fertilization
- Having a problem

Time of year generally does not matter for routine chemical analysis but be consistent.

What do you do with your soil samples?

- Send them to a lab for chemical analysis
- Soil test methodologies are calibrated

Use this (Olsen P) for East-side soils

More OM is generally better
N, P, S & B are supplied as OM breaks down

Low Bray P may limit yield & root growth

pH is the first thing you should look at

Target K > 150 ppm

The buffer pH or SMP measures how much lime is needed
Let’s talk pH

pH = measurement of the concentration of free hydrogen (H+) ions in a solution

As pH increases, the concentration of H+ decreases

pH is measured on an inverse logarithmic scale (power of 10) from 0-14

What makes soils acidic?

- Acidic soils: pH is below 7
- Soils become acidic because of heavy rainfall that weathers soils quickly
- Basic elements such as calcium, magnesium, sodium and potassium are used or leached from the soil
- This natural weathering process makes soils acidic
- The addition of some fertilizers can also cause soil acidification (ammonium and sulfur).
Lime Applications

- Average pH range in Western Oregon is 4.9 to 6.5
- Most vegetables thrive with pH of 6.2 to 6.8
- Acid-loving plants like blueberries or rhododendrons like 4.5 to 5.5

### Different types of liming materials are available

<table>
<thead>
<tr>
<th>Material</th>
<th>Calcium carbonate equivalent (CCE) (%)</th>
<th>Lime score (%)</th>
<th>Ca (%)</th>
<th>Mg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common mined products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone (CaCO₃)</td>
<td>90–100</td>
<td>90–100</td>
<td>12–39</td>
<td>below 1</td>
</tr>
<tr>
<td>Dolomite (CaCO₃ + MgCO₃)</td>
<td>95–110</td>
<td>95–110</td>
<td>18–23</td>
<td>8–12</td>
</tr>
<tr>
<td>Specialty oxides and hydroxides</td>
<td></td>
<td>120–135</td>
<td>120–135</td>
<td>54</td>
</tr>
<tr>
<td>Beet lime or calcium oxide (CaO)&lt;i&gt;</td>
<td>150–175</td>
<td>150–175</td>
<td>71</td>
<td>0</td>
</tr>
</tbody>
</table>

**By-products**

- Sugar beet lime: 70–75<br>
- Pepper mill lime: 10–100<br>
- Cement plant dust: 110–120<br>
- Shrimp and crab waste: 30–40<br>
- CA lime (controlled atmosphere storage): 100<br>
- Wood ash: 2–30

### A real-life application:

How lime raises pH (lowers acidity) --

$$\text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2 + \text{Ca}^{2+}$$

### Table 11.—SMP lime requirement—gardens.

<table>
<thead>
<tr>
<th>If the SMP lime requirement test is</th>
<th>Apply this amount of lime (lb/1,000 ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 or below</td>
<td>250</td>
</tr>
<tr>
<td>5.5–6.0</td>
<td>150–250</td>
</tr>
<tr>
<td>6.0–6.5</td>
<td>100–150</td>
</tr>
<tr>
<td>above 6.5</td>
<td>0</td>
</tr>
</tbody>
</table>

Table is from OSUEC EC1478: Soil Test Interpretation Guide
Soil pH is often the most important measurement on a soil test report.

Plants need nutrients to grow

Macronutrients
- Primary - Nitrogen (N), Phosphorus (P), Potassium (K)
- Secondary – Calcium (Ca), Magnesium (Mg), Sulfur (S)

Micronutrients
- Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn), Boron (B), Molybdenum (Mo), Chlorine (Cl)

NPK- What do they do?

N (ammonium – NH$_4^+$ or nitrate – NO$_3^-$)
- important for healthy plant growth, protein formation, root growth, chlorophyll, carbohydrate use.

P (phosphate – HPO$_4^{2-}$)
- essential for vigorous growth of seedlings, especially in cool, wet, spring weather. Key role in photosynthesis, energy storage and transfer, and cell division. Vital to flowering, seed formation, and maturation.

K (Potassium – K$^+$)
- important for disease resistance and starch formation. Helps plants adapt to environmental stress. Essential for photosynthesis, protein synthesis, starch formation, and translocation of sugars.

- Yellowing of older leaf material – N is mobile in plants
- Stunted growth, reduced plant vigor
- General chlorosis of entire plant

**NITROGEN (N) Deficiency**
Table 1. Nitrogen requirement for vegetable crops (lb/1000 ft²) Based on seasonal nitrogen uptake (adapted from Gaskell et al. 2007). From PNW 646, pg. 4

<table>
<thead>
<tr>
<th>Low: 3 lb/1000 ft²</th>
<th>Med: 4 lb/1000 ft²</th>
<th>High: 5 lb/1000 ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby greens</td>
<td>Carrot</td>
<td>Broccoli</td>
</tr>
<tr>
<td>Bean</td>
<td>Corn, sweet</td>
<td>Cabbage</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Garlic</td>
<td>Cauliflower</td>
</tr>
<tr>
<td>Radish</td>
<td>Lettuce</td>
<td>Celery</td>
</tr>
<tr>
<td>Spinach</td>
<td>Melon</td>
<td>Potato</td>
</tr>
<tr>
<td>Squash</td>
<td>Onion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pepper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tomato</td>
<td></td>
</tr>
</tbody>
</table>

Multiply values by 44 to approximate the conversion of lb/1000 ft² to lb/acre.

PHOSPHORUS (P) Deficiency

- Purpling of leaves, especially in leaf veins. Mobile in plants so symptoms show in older leaves first.
- May result because of cold soil temperatures
- Sparse flowering, poor fruit and seed development

PHOSPHORUS (P) soil test categories and suggested fertilizer rate recommendations.

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10</td>
<td>10-20</td>
<td>&gt; 20</td>
</tr>
<tr>
<td>0-30</td>
<td>30-60</td>
<td>&gt; 60</td>
</tr>
</tbody>
</table>

Table from OSU Publication EC 1476, Soil Test Interpretation Guide

POTASSIUM (K) deficiency

- Light green color or uneven chlorosis of young leaves, tip burn on mature or new leaves, distorted new growth.
- Blossom-end rot on tomatoes, peppers and eggplants?

CALCIUM Deficiency

- Usually only a problem in very acidic soils. Can occur in serpentine soils (high Mg) with adequate pH.
• Interveinal chlorosis on older leaves, proceeds to younger leaves with more severity
• Curling of leaves upward along margins
• Magnesium (Mg) deficiency

### Soil Test Report: Other items

- Nitrogen (N) and Sulfur (S)
  - Very mobile in soil so regular soil tests not reliable
  - Tissue analysis for S and N better than soil test for S and N

### Boron (B)

- Not routinely provided in soil tests
- Check with lab, you may have to request it
- Crops susceptible to B deficiency: cabbage, broccoli, cauliflower, cane berries, strawberries, beets, carrots
- Many soils in western OR are deficient
- If test results indicate less than 1ppm, add Boron. See pg. 4 of Fertilizing your garden for recommendation
- Be careful – don’t over apply, too much can be toxic to plants!

### Soil Test Report: Other items

- Cation Exchange Capacity (CEC)
  - Indicates potential to hold plant nutrients
  - Capacity of soil to exchange cations (Ca, Mg, K, Na, H, Al)
  - Highest in clay soils and high organic matter soils
- **Base saturation**
  - Percentage of exchange sites occupied by basic cations (Ca, Mg, K, Na)
  - If 100% saturated with bases, there is no exchangeable acidity (acidic cations H and Al)
- Neither used in OSU fertilizer recommendations
  - Not very precise
  - Lack evidence for agronomic response
Basic Fertilizing Principles

Nitrogen, Phosphorus, Potassium most limiting nutrients
pH often most limiting factor

Fertilizer and Soil Amendments

A natural or synthetic material that provides useful quantities of nutrients in forms soluble in soil

- Most soluble nutrients become immobilized in soil (adsorbed, incorporated into humus):
- This is GOOD. It increases soil reserves
- Increased soil reserves → increased concentration in soil → greater availability to plants

Types of fertilizers

Synthetic fertilizers (urea, diammonium phosphate, potassium chloride, etc.)
Organic fertilizers (bone meal, compost, crab or fish meal, manure, etc.)

Fertilizer Mixes

- Listed as N - P - K
- Numbers are %
- Example:
  - Fifty pound bag contains how much nitrogen, phosphorus and potassium?

Fertilizer Mixes

WAY TO GROW FERTILIZER
8 - 8 - 8
GUARANTEED ANALYSIS

- Product name
- NPK formula
- Nitrogen content
- Phosphorus content
- Potassium content
- Specific sources

Total nitrogen 8%
Available phosphoric acid 8%
Soluble potash 8%
Derived from sulfur-coated urea, etc.
### Comparing organic and synthetic fertilizers

<table>
<thead>
<tr>
<th></th>
<th>Organic Fertilizers</th>
<th>Synthetic Fertilizers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
<td>Natural materials, little to no processing</td>
<td>Manufactured or extracted from natural materials; often undergo extensive processing</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>Manure, cottonseed meal, rock phosphate, fish by-products, ground limestone</td>
<td>Ammonium sulfate, processed urea, potassium chloride</td>
</tr>
<tr>
<td><strong>Nutrient Availability</strong></td>
<td>Usually slow-release; nutrients are released by biological and chemical processes in soil</td>
<td>Nutrients usually are immediately available to plants</td>
</tr>
<tr>
<td><strong>Nutrient Content</strong></td>
<td>Usually low</td>
<td>Usually high</td>
</tr>
</tbody>
</table>

### Commercial Organic Fertilizers

### Fertilizing with manures

- Watch out for weeds and pathogens
- Consider application method and timing
- Rule of thumb: 5 gallon bucket of cow manure per 50 square feet.
- Why would composted manure a better source?
### Nutrient value of manures

<table>
<thead>
<tr>
<th>Animal</th>
<th>N (lbs/ton)</th>
<th>P₂O₅ (lbs/ton)</th>
<th>K₂O (lbs/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>11.3</td>
<td>8.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Chicken</td>
<td>27.3</td>
<td>23.5</td>
<td>13.2</td>
</tr>
<tr>
<td>Goat</td>
<td>22.0</td>
<td>5.4</td>
<td>15.1</td>
</tr>
<tr>
<td>Horse</td>
<td>12.1</td>
<td>4.6</td>
<td>9.0</td>
</tr>
<tr>
<td>Sheep</td>
<td>22.5</td>
<td>7.6</td>
<td>19.5</td>
</tr>
</tbody>
</table>

### Using manure

- Nutrient content can be variable
- Should be tested for best results
- Often over supplies P & K to get amount of N needed for crop needs
- Do not over apply
- Nitrogen availability not guaranteed

### Manure vs. Compost

- Compost is the active management of manure and bedding
- Composts are lower in plant-available N
- Composting kills weeds seeds & pathogens
- More uniform material, can be easier to handle

### Herbicides in manure and compost

- Clopyralid and aminopyralid herbicides can persist in manure and compost
- Active at very low concentrations
- Do not use manure or compost from animals fed forages treated with these herbicides in vegetable or home gardens (kills broadleaf plants)
Food safety considerations with fertilizers

- Raw manure
- Composted manure*
- Compost made with no manure
- Commercial organic or chemical fertilizers

* Compost needs to be properly heat-treated.

How to minimize risk from fertilizers

- Do not use non-composted manure in your edible garden.
- If you do use manure:
  - Incorporate it into the top 8" of soil.
  - Apply at least 90 or 120 days before harvest.
  - Be aware of potential from cross contamination
  - Be very careful when using manure or compost teas for foliar feeding.

Other Soil Amendments

- Leaves, plant materials, food wastes and other composted materials
- Sawdust, wood shavings
- What about using stall waste from a horse farm on your garden?

What About Wood Ashes?

- Readily available K, Ca, and Mg
- Increase soil pH
- Salt injury could be a problem if too much is applied
- Avoid direct contact with plant roots
Benefits of Cover Crops to Soil Fertility

- Nutrient cycling
- Nitrogen additions by Rhizobium associated with legumes
- Enhanced phosphorus availability
- pH buffering
- Energy and food source for soil biota

Nutrient cycling

Nitrogen additions by Rhizobium associated with legumes

Enhanced phosphorus availability

pH buffering

Energy and food source for soil biota

http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_050219.jpg

Calculating how much fertilizer to use based on soil test

Table 2—Recommendations for fertilizer mix—organic and chemical.

<table>
<thead>
<tr>
<th>Soil Test Type</th>
<th>NH&lt;sub&gt;4&lt;/sub&gt; (ppm)</th>
<th>PO&lt;sub&gt;4&lt;/sub&gt; (ppm)</th>
<th>K (ppm)</th>
<th>S (ppm)</th>
<th>N (ppm)</th>
<th>P (ppm)</th>
<th>K (ppm)</th>
<th>S (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>4-20</td>
<td>10-30</td>
<td>50-100</td>
<td>8-10</td>
<td>20-40</td>
<td>5-10</td>
<td>20-40</td>
<td>8-10</td>
</tr>
<tr>
<td>Medium</td>
<td>20-40</td>
<td>30-60</td>
<td>100-200</td>
<td>10-20</td>
<td>40-80</td>
<td>10-20</td>
<td>40-80</td>
<td>10-20</td>
</tr>
<tr>
<td>High</td>
<td>40-80</td>
<td>60-120</td>
<td>200-400</td>
<td>20-40</td>
<td>80-160</td>
<td>20-40</td>
<td>80-160</td>
<td>20-40</td>
</tr>
</tbody>
</table>

Table from EC 1503 Fertilizing Your Garden

You need to know how big your garden is!

Applying fertilizers

- Nitrogen in chemical fertilizers is highly soluble, do not need to mix into soil but do need to irrigate.
- Organic sources of N should be mixed into top 2-3 inches
- Phosphorous moves slowly in the soil. Mix in or band below seeds.
- Potassium fertilizers should be worked into the soil. Do not allow K fertilizers to contact plant roots.
**Nutrient mobility & placement**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mobility in soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Mobile as nitrate; Immobile as ammonium</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Immobile</td>
</tr>
<tr>
<td>Potassium</td>
<td>Somewhat mobile</td>
</tr>
<tr>
<td>Calcium</td>
<td>Somewhat mobile</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Immobile</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Mobile</td>
</tr>
</tbody>
</table>

**Broadcast** (incorporate or topdress)

**Band**

**Side dress**

See page 3 of “Fertilizing your Garden”

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**Best Practices: 4Rs of Nutrient Management**

**Right Source**
- Matches fertilizer type to crop needs.

**Right Rate**
- Matches amount of fertilizer type crop needs.

**Right Time**
- Makes nutrients available when crops need them.

**Right Place**
- Keep nutrients where crops can use them.

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**Best Management of Nutrients**

- Apply fertilizer in small doses
- Keep fertilizer application rates in balance with crop utilization rates
- Use soil tests to evaluate trends
- Protect water sources
- Prevent erosion & runoff
- Use conservation tillage

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**Take home message**

- Soil is alive and complex
- Soil is more than “dirt”
- Adding organic matter is the best way to improve difficult soil texture
- Keep the soil covered
- Apply lime and fertilizer based on soil test results
- Correct pH is essential for nutrient availability
NRCS Soil health lessons in a minute: how healthy soil should look

- [https://www.youtube.com/watch?v=2JZJ4zM3Y44&list=PL4j8PxoprpLbKt3gzrJWN0dGD8bnnq3wM](https://www.youtube.com/watch?v=2JZJ4zM3Y44&list=PL4j8PxoprpLbKt3gzrJWN0dGD8bnnq3wM)

Understanding the Basics: Buz's 'Fab-Five Facts of Healthy Soil'

- [https://www.youtube.com/watch?v=4BTW28oeKJw&list=PL4j8PxoprpGa3wFySXFucUW_smAtJt0&index=30](https://www.youtube.com/watch?v=4BTW28oeKJw&list=PL4j8PxoprpGa3wFySXFucUW_smAtJt0&index=30)

The Science of Soil Health: Changing The Way We Think About Soil Microbes

- [https://www.youtube.com/watch?v=EyKfpOso8q8](https://www.youtube.com/watch?v=EyKfpOso8q8)