Soil is the Key
(Chapter 3)
Soils 101

- Soil profile
- Soil sources, texture, chemistry, physical properties
- Soil Amendments
- Identifying your soil
- Soil Testing
- Fertilizers
Soil Profile

• Vertical distribution
  ➢ A = topsoil
  ➢ B = subsoil
    (accumulates iron & clay)
  ➢ C = rock

Makes a difference following disturbance or construction
• Created by disintegrating rocks & organic matter
• Components are minerals, organic matter, air & water
• Influenced by “parent material”
  – “weathered from metamorphic & sedimentary rock”
  – “weathered from ultrabasic & serpentinitic rock”
Soil Texture

- Particles are divided by size:
  
  **Sand > Silt > Clay**

- Use flowchart for analyzing texture: “feel method”
Texture is Important

• Sand
  – Warms faster in spring, drains better, good aeration
  – Low water-holding & nutrient storage

• Clay
  – Surface area million times that of coarse sand
  – Negatively charged particles that attract positive particles that are essential elements to plant
  – Has high exchange rate that makes elements available to plants
  – Has high water holding capacity, but holds water tightly

• Mix of textures = loam
Soil Porosity

- Spaces between solids
- Provides space for roots
- Convey air, water, dissolved minerals
  - Roots & soil organisms need oxygen
  - In waterlogged soils, the pores fill up with H$_2$O
  - In compacted soils, pores are gone
    - Don’t work soil when wet
    - Avoid heavy machinery
    - Add organics
Soil Water Availability

- Soil has a chemical & physical attraction to water
- Plants “pull” water away from soil
- Clay has greater water holding capacity, but holds water tighter
Organic Matter

- Decomposing OM (available to plants)
- Living Matter: Worms, bacteria, fungi, algae, etc
  - Churn soil, improve soil structure (usually)
  - Mychorrhizae
    - Association between plant roots & soil fungi
      - Roots provide carbon to fungi
      - Fungi promote better absorption of phosphorus by roots
• **Endotropic (within cells)**
  – Arbuscular
    • About 80% of plant species, including crops
    • Inoculation increases crop production 2-6X
  – Ericoid
  – Orchidaceous

• **Ectotropic (external to roots)**
  – 3% of plant species
  – mostly pines
  – inoculation of new forestry plantations

**Takeaway:**

Usually not needed in home garden unless new

Use in burned areas & native plant restoration
Soil Fertility & Plant Nutrition

• Plants need 14 elements from soil
  – Primary: nitrogen (N), phosphorus(P), potassium(K)
  – Secondary: Calcium, magnesium, sulfur
  – Micro: boron, chlorine, copper, iron, manganese, molybdenum, nickel, zinc

• Most commonly needed is **Nitrogen**
• Other deficiencies are phosphorus, potassium, zinc and iron
• In excess (toxic) are boron, chlorine & sodium
Soil pH

- pH: measure of acidity or alkalinity of soil
- Ranges from 1 (acid) to 14 (alkaline), 7 is neutral
- Most crops grow in a range from 5.5 to 7.5
  - Nutrients are in a form that plant roots can absorb
  - Influences toxicity
Soil Amendments

- Used to improve physical properties
  - Increase water holding capacity, decrease compaction, adjust pH, add microorganisms, decrease toxicity
  - Not necessarily the same as fertilizer
- Mixed into soil (not mulch)
Add Organic Matter!!!!

- Multiple benefits! Increases water holding, provides nutrition, lowers pH……..
- Add 2” per year, can’t add too much over long haul since it decays
- BUT – may have short term consequences and may not improve soil fertility immediately, depending on C:N ratio
Carbon:Nitrogen Ratio

• Material with high C:N ratio (sawdust, straw, leaves AKA “browns”) compete with plants for nitrogen. Browns as mulch – OK.
• Material with C:N ratio less than 20:1 (grass clippings, rotted manures) have enough nitrogen to decompose. But release N quickly.
• Best source – mix like compost
<table>
<thead>
<tr>
<th>Material</th>
<th>C:N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass clippings</td>
<td>19:1</td>
</tr>
<tr>
<td>Rotted manure</td>
<td>20:1</td>
</tr>
<tr>
<td>Vegetable trimmings</td>
<td>25:1</td>
</tr>
<tr>
<td>Oak leaves</td>
<td>26:1</td>
</tr>
<tr>
<td>Leaves</td>
<td>varies from 35:1 to 85:1</td>
</tr>
<tr>
<td>Peat moss</td>
<td>58:1</td>
</tr>
<tr>
<td>Corn stalks</td>
<td>60:1</td>
</tr>
<tr>
<td>Straw</td>
<td>80:1</td>
</tr>
<tr>
<td>Pine needles</td>
<td>60:1 to 110:1</td>
</tr>
<tr>
<td>Farm manure</td>
<td>90:1</td>
</tr>
<tr>
<td>Sawdust weathered 3 yrs</td>
<td>142:1</td>
</tr>
<tr>
<td>Newspaper</td>
<td>170:1</td>
</tr>
<tr>
<td>Douglas fir bark</td>
<td>491:1</td>
</tr>
<tr>
<td>Sawdust weathered 2 mnths</td>
<td>625:1</td>
</tr>
</tbody>
</table>
Organic Soil Amendments

• Compost – yes!
  – Contains organics, microorganisms, some nutrients
  – Doesn’t add salts
• For clay soils that need structural improvement – add fibrous organics like straw or wood chips
• Worm castings (poop) – good source of water soluble nutrients, enzymes & beneficial microorganisms
Commercial Bagged Compost

- Commercial compost can be made from forest products, municipal yard waste, manure, coconut husks and a variety of other organic materials.

- Look for:
  - Appearance of coarse soil, with a loose & crumbly texture
  - No big identifiable chunks (i.e. shredded wood or bark)
  - An earthy smell, but definitely NOT an obvious ammonia smell
  - Color should be dark brown or black, which indicates organic matter

- Some compost has added ingredients and is marketed as a “soil conditioner”, with worm castings, bat guano, beneficial microbes, humic acid, chicken manure, kelp meal, or rice hulls.
Other Soil Amendments

• Manures
  – Contain more salts than plant compost
  – Sometimes contain pathogens
  – Often contain weed seeds (i.e. horse)
    • Need to compost at high temperature (135°F)
    • Use for non-food crops?
  – Vary greatly in nutrient content
    • Steer manure good for organics, not good for nutrients
  – Can be “hot” (poultry)
    • Can harm plants due to high ammonia levels
    • Use aged or composted manure
Other Soil Amendments

• Lower pH for acid-loving crops
  – Organic matter lowers pH slightly over time
  – Add sulfur to lower pH if soil is basic due to calcium salts
  – If the pH is high due to sodium salts, then you need to flush with water

• Increase pH if needed (not typical in CA)
  – Add lime (calcium carbonate) or dolomite (Ca-Mg carbonate) in fall
Other Soil Amendments

• Wood ashes make soil more basic (increase pH) and more “salty”
• Adding clay to sand makes cement (and vice versa) – make sure to add organics also
• Vermiculite (heat-expanded silica)
  – Increases pore space
  – High water holding capacity
Amending Serpentine Soils

• Are high in Magnesium, but low in Calcium
• High in heavy metals like Nickel
• Low in nutrients
• Issues with natural asbestos
• Consider raised beds for gardens
Identifying your Soil


• Soil Survey of Trinity County, California, Weaverville Area
  – Includes Hayfork, Douglas City, Lewiston, Junction City (not northern Trinity)

• Call Natural Resources Conservation Service in Weaverville (623-3991)
Soil Testing

• DIY test kits for rough values (pH, N, P, K)
  – Use fresh reagents
  – Tricky to use and interpret

• Send soil samples to lab for N, P, K or micronutrients
  – See list of soil labs
  – Lab readings for tests for zinc, manganese, iron, copper and boron in addition to organic matter, estimated nitrogen release & nitrate nitrogen, phosphorus (weak bray & sodium bicarbonate P), extractable cations (potassium, magnesium, calcium, sodium), hydrogen, sulfate sulfur, pH & cation exchange capacity and percent cation saturation and excess lime.
  – Need information on interpreting results

• Composite of ~10 samples
  – https://www.youtube.com/watch?v=U1C_AAEf3IE
  – Use stainless, wooden or hard plastic trowel
  – Dry & mix
# Soil Test Report

## Soil Analysis Report

**REPORT NUMBER:** 00-336-047  
**CLIENT NO.:** 9999-D  
**SUBMITTED BY:**  
**GROWER:** EXAMPLE REPORT  
**DATE OF REPORT:** 04/30/04

### Soil Analysis Table

<table>
<thead>
<tr>
<th>SAMPLE ID</th>
<th>LAB NUMBER</th>
<th>Organic Matter</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Magnesium</th>
<th>Calcium</th>
<th>Sodium</th>
<th>pH</th>
<th>Hydrogen</th>
<th>Cation Exchange Capacity</th>
<th>CEC (meq/100g)</th>
<th>PERCENT CATION SATURATION (COMPUTED)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weaken Bray</td>
<td>Olsen Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>K %</td>
<td>Mg %</td>
<td>Ca %</td>
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<tr>
<td>130-1</td>
<td>55931</td>
<td>4.0 H</td>
<td>110</td>
<td>23M</td>
<td>14**</td>
<td>110L</td>
<td>992VL</td>
<td>104L</td>
<td>4.7</td>
<td>6.2</td>
<td>9.7</td>
<td>19.1</td>
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<tr>
<td>130-2</td>
<td>55932</td>
<td>1.5 L</td>
<td>60</td>
<td>27H</td>
<td>6**</td>
<td>41VL</td>
<td>569M</td>
<td>1154VL</td>
<td>185M</td>
<td>4.6</td>
<td>5.9</td>
<td>13.3</td>
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<tr>
<td>12-1</td>
<td>55933</td>
<td>3.5 M</td>
<td>100</td>
<td>12L</td>
<td>11**</td>
<td>64L</td>
<td>471VL</td>
<td>841VL</td>
<td>87L</td>
<td>5.2</td>
<td>6.5</td>
<td>4.5</td>
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<tr>
<td>12-2</td>
<td>55934</td>
<td>2.8 M</td>
<td>86</td>
<td>8VL</td>
<td>9**</td>
<td>29L</td>
<td>553VL</td>
<td>865VL</td>
<td>80M</td>
<td>5.3</td>
<td>6.6</td>
<td>3.7</td>
</tr>
</tbody>
</table>

**NaHCO₃-P unreliable at this soil pH**

### Particle Size Analysis

<table>
<thead>
<tr>
<th>SAMPLE NUMBER</th>
<th>Nitrogen NO₃-N ppm</th>
<th>Sulfur SO₄-S ppm</th>
<th>Zinc ppm</th>
<th>Manganese ppm</th>
<th>Iron ppm</th>
<th>Copper ppm</th>
<th>Excess Lime Rating</th>
<th>Soluble Salts mmhos/cm</th>
<th>Chloride Cl ppm</th>
<th>SAND %</th>
<th>SILT %</th>
<th>CLAY %</th>
<th>SOIL TEXTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>130-1</td>
<td>5L</td>
<td>5L</td>
<td>0.3V</td>
<td>3M</td>
<td>53VH</td>
<td>0.2VL</td>
<td>0.1VL</td>
<td>L</td>
<td>0.3L</td>
<td>44</td>
<td>25</td>
<td>31</td>
<td>CLAY LOAM</td>
</tr>
<tr>
<td>130-2</td>
<td>3VL</td>
<td>41VH</td>
<td>0.1V</td>
<td>1VL</td>
<td>14M</td>
<td>0.2VL</td>
<td>0.1VL</td>
<td>L</td>
<td>0.6L</td>
<td>60</td>
<td>16</td>
<td>25</td>
<td>SANDY CLAY LOAM</td>
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<tr>
<td>12-1</td>
<td>2VL</td>
<td>5L</td>
<td>0.1V</td>
<td>2L</td>
<td>50VH</td>
<td>0.1VL</td>
<td>0.3VL</td>
<td>L</td>
<td>0.2VL</td>
<td>42</td>
<td>36</td>
<td>23</td>
<td>LOAM</td>
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<tr>
<td>12-2</td>
<td>2VL</td>
<td>4L</td>
<td>0.1V</td>
<td>1VL</td>
<td>53VH</td>
<td>0.1VL</td>
<td>0.2VL</td>
<td>L</td>
<td>0.1VL</td>
<td>40</td>
<td>35</td>
<td>25</td>
<td>LOAM</td>
</tr>
</tbody>
</table>

* CODE TO RATING: VERY LOW (VL), LOW (L), MEDIUM (M), HIGH (H), AND VERY HIGH (VH).  
** ENR - ESTIMATED NITROGEN RELEASE  
*** MULTIPLY THE RESULTS IN ppm BY 2 TO CONVERT TO LBS. PER ACRE OF THE ELEMENTAL FORM  
**** MULTIPLY THE RESULTS IN ppm BY 4.6 TO CONVERT TO LBS. PER ACRE P₂O₅  
***** MULTIPLY THE RESULTS IN ppm BY 2.4 TO CONVERT TO LBS. PER ACRE K₂O  
MOST SOILS WEIGH TWO (2) MILLION POUNDS (DRY WEIGHT) FOR AN ACRE OF SOIL 6-23 INCHES DEEP

This report applies only to the sample(s) tested. Samples are retained a maximum of thirty days after testing.

Mike Buttriss, CPAg  
A & L WESTERN LABORATORIES, INC.
**Graphical Soil Analysis Report**

**DATE OF REPORT:** 12/07/18

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Organic Matter %</th>
<th>Nitrogen NO₃-N ppm</th>
<th>Phosphorus Weak Bray ppm</th>
<th>Phosphorus NaHCO₃-P ppm</th>
<th>Potassium K ppm</th>
<th>Magnesium Mg ppm</th>
<th>Calcium Ca ppm</th>
<th>Sodium Na ppm</th>
<th>Sulfur SO₄-S ppm</th>
<th>Zinc Zn ppm</th>
<th>Manganese Mn ppm</th>
<th>Iron Fe ppm</th>
<th>Copper Cu ppm</th>
<th>Boron B ppm</th>
<th>Chloride Cl ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>12.9</td>
<td>20</td>
<td>97</td>
<td>51</td>
<td>320</td>
<td>390</td>
<td>2503</td>
<td>16</td>
<td>14</td>
<td></td>
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<td></td>
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</tbody>
</table>

**Cation Saturation (computed)**

<table>
<thead>
<tr>
<th>Percent</th>
<th>Potassium K %</th>
<th>Magnesium Mg %</th>
<th>Calcium Ca %</th>
<th>Sodium Na %</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9</td>
<td>19.4</td>
<td>75.3</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

**ECe**

- **0.5**
  - INCREASING SALINITY

**CEC**

- **16.6**
  - **L**
    - Ex. Lime

**pH**

- **7.0**
  - INCREASING NEED FOR LIME
Fertilizers

• “Complete” contains N, P, K (vs incomplete)
• Percentage stated on bag, i.e. 8-2-6
• Inorganic source
  – Usually fast-acting, cheaper, leachable
  – Can be slow-release (coated)
• Organic source
  – Manures, bone meal, cottonseed, fish emulsion, bat guano, blood meal, etc
  – More expensive/lb nutrients, but have other benefits
• All the same to the plant, as a nutrient!
Fertilizer application

• To soil surface, subsurface, foliage & water
• Use soil test, plant need, or symptoms of nutrient deficiency to determine rate of fertilizer application
• Broadcast vs Banding vs Sidedressing
Mulch

- Mulch is placed on **TOP** of the soil.
- It holds in the soil moisture, can inhibit weeds, reduces runoff, moderates soil temperatures, and creates an attractive appearance. Place mulch 2-3” deep.
- Mulch reduces evaporation by up to 50%, which reduces the need for irrigation. On the downside, mulches can hide small rodents & pests like snails and sowbugs.
- Many organic mulches are high in carbon. If mixed **into** the soil, they can tie up nitrogen. Left on top of soil, they obtain nitrogen from the air. Let decompose or add N before incorporating into soil.
In order of decreasing flammability:

Pine Needles
Shredded Western Red Cedar
Medium Pine Bark Nuggets
Fresh Wood Chips
Composted Wood Chips

From: The Combustibility of Landscape Mulches, U of Nevada Cooperative Extension, Publication SP-11-04
Mulch Placement around Trees

Don’t pile the mulch against the tree trunk
Questions?