Improving Your Soil Quality

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UC Agriculture & Natural Resources is celebrating the centennial of the passage of the Smith-Lever Act and the beginning of Cooperative Extension in California.

Local programs:
- Master Gardeners
- 4-H
- Viticulture
- Weed Science
- IPM
- Livestock & Natural Resources
- Watershed Management
- Food Systems
- Commercial Farming
Soils Formation

- Weatherization and Glaciation
Soil Formation

Concept:

• Parent Material → Particle Size/Density

Based on Temperature, Pressure, Weather Combined
What is Organic Matter?

- H  Hydrogen
- O  Oxygen
- N  Nitrogen
- C  Carbon

HONC Your Horn!!!
Soil Formation

Concept:
• Particle Size, Pore Size and Organic Matter → Aggregate Stability
Your Goal:
The Four Things Plants Need?
Soil is a matrix of minerals, Organic Matter, O2, H2O & living organisms.
Particle Size

Relative soil particle sizes

- **Gravel**
- **Sand**
- **Silt**
- **Clay** (invisible at this scale)

Measurement scales in mm and inches:
- 0 mm
- 1 mm
- 2 mm
- 3 mm
- 4 mm
- 5 mm
- 0 inches
- 1/16 inches
- 2/16 inches
- 3/16 inches
Porosity

• *Soil porosity* is the % of a soil that is pore space or O2/H2O.

• The average soil has a porosity of about 50%

• Sands have larger pores, but less total pore space than clays.
Concept: Think About Water & Air Movement

- Single-grain: Rapid
- Blocky: Moderate
- Platy: Slow
- Granular: Rapid
- Prismatic: Moderate
- Massive: Slow

http://ohioline.osu.edu/b905/images/006.jpg
CONCEPT: How does structure affect water movement in soils?

• Good Structure → pore space is large: Good water and air movement.

• Well-developed structure → important in clayey soils.

• Clayey soils with poor structure: Reduces water and air movement.
Physical Indicators of Soil Quality

• Color - Visual Test
• Soil Texture
  - Texture-by-Feel
  - Ribbon Test
  - Soil Suspension/Sedimentation Test: % of Sand, Silt & Clay
Soil Texture is the single most important physical property of the soil. It helps the grower recognize:
1. Water flow potential & holding capacity
2. Fertility potential
3. Suitability for urban uses like bearing capacity
Physical Indicators of Soil Quality

See Soil Suspension/Sedimentation Test Instructions
Physical Indicators of Soil Quality

Soil Texture Classification

Ratio or Relative Proportions of Sand to Silt to Clay
Chemical Indicators of Soil Quality

• pH Test (Range: 0-14)

• Electro-Conductivity Test for Soluble Salts (Unit: PPM)

• Cation Exchange Capacity
Chemical Indicators of Soil Quality

• Soil pH Scale

Soil pH - what is it?

• measure of the acidity or alkalinity of a soil
• concentration of hydrogen ions (H+) in the soil solution

Increasing acidity

NEUTRAL

Increasing alkalinity

Ideal pH for plant growth

pH Water 1:5

Battery acid
Beer
Soap sol’n
Caustic soda
Chemical Indicators of Soil Quality

$pH \sim \text{Macro/Micro-Nutrient Absorption}$
Chemical Indicators of Soil Quality

Electro-Conductivity Measures
Soluble Salts and Fertilizer Tie Up (PPM)
Chemical Indicators of Soil Quality

Cation Exchange Capacity

Soil CEC measures a soil’s negative charge!
Diagrammatic scheme showing how root hair takes in nutrients from exchangeable ions on a clay crystal and on humus, and from soil.
Concept:

Organic Matter (and Clay)

• Has a Large Surface Area
• Incorporating OM Enhances Nutrient Exchange in Root Zone

• ↑ % Organic Matter

→ ↑ Cation Exchange Capacity
Fungal networks: Threadlike fungal networks hold soil particles and micro aggregates onto the surface of crop residues as part of the formation of stable soil aggregates. Cultivation disrupts soil aggregates whereas minimum till combined with stubble retention enhances aggregate stability, stimulates microbial growth and improves soil structure.
Your Goal

- **Living organisms (<5%)**
- **Fresh residue (<10%)**
- **Stabilized organic matter (humus)**: 33% - 50%
- **Decomposing organic matter (active fraction)**: 33% - 50%
Chemical Indicators of Soil Quality

CONCEPT:

Cation Exchange Capacity (CEC) → ~SOIL FERTILITY by Affecting Water Holding Capacity & Nutrient Holding Capacity
Biological Indicators of Soil Quality

Secret:

(Soil Biodiversity)

Bacteria, Worms, Pill Bugs, Centipedes & Millipedes, etc.

SSShhhhhhhhhhhhhhhhh........

Don’t scare the Micro-Ecosystems!
A root feeding nematode is trapped by a fungus; the fungus gives off a substance similar to that given off by the roots of plants.
http://organicsoilsolutions.com/education-center/the-soil-food-web/
Limiting Factor

- Limiting Factor for Plant Growth = Nitrogen
- Limiting Factor for Plant - Nitrogen Availability = Carbon
- Carbon: Nitrogen Ratios (3:1 or 2:1) (Think Compost Piles)
Soil Amendments to Improve Fertility

- Manures
- Compost
- Nitrogen (Greens): Carbons (Browns), & Nitrogen Tie-Up
- Organic Amendments: Composts & Manures
- Water Solubility & Synthetic Fertilizers
- Embedded Energy
Effects of Soil Compaction

• Reduced Root Penetration & Water Infiltration/Permeability
• Decreased Pore Size and Root Zone Soil-Temperature (Think Tomatoes)

RESPONSE: RAISED BEDS
Soil Amendments for Managing Compaction:

Mulches Of Many Kinds.....
Soil-Protection & Watering

Cover Crops, Inter-Planting & Companion Planting
Sources of Heavy Metal/Lead Exposure

• Lead **paint** hazards  
  → lead **dust** in homes; from exterior prep work & friction of windows

• Bare **soil** in yards with lead contamination from house paint or previous use of leaded gasoline

• **Take-home** lead dust from construction work or other occupations

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Understand: How do we get lead into our body while growing food?

- **Hands contaminated with leaded soil**
  
  Contaminated hands touch mouth, food, drink container, cigarette

- **Hands contaminated with leaded paint**
  
  Hands touch damaged lead paint and its dust. Then hands touch mouth, food, drink container, cigarette, etc.

- **Eating lead-containing soil or paint dust on unwashed produce, or eating produce that has lead uptake**
How Lead Toxicity Affects Health!!!

- Affects brain development
- Causes iron deficiency & anemia
- Interferes with calcium uptake, affect growth and dental health
- Harms kidneys & reproductive health
- Can impact behavior

**Children at most risk** - their brains & bodies are still developing (& fetus, because lead easily crosses placenta).

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Site History: Possible Sources of Lead Risks

- Contamination in existing soil from unknown sources—particles from previous leaded gasoline use, demolition of building, etc.

- History of Industrial Use

- Pre-1979 buildings with Chipping Paint
Best Practices to Reduce Heavy Metal Exposure from Growing Food

• Wear Gloves & Practice Good Personal Hygiene
• Garden in low-leaded soil when possible
  – Test soils to confirm lead is < 80 ppm
  – Buy Organic Materials Review Institute (OMRI)
• Don’t Let Kids Garden/Play in > 80 ppm Soils
• Be Aware of Soil Contamination →

Watch for Site Risks!!!!!!!!!!
2 Ways To Garden Using New Soil

• In Raised Beds: No Pressure-Treated Wood, or Recycled Painted Materials ☹

• 12-18” New Soil on top of the existing soil with a barrier in between, such as a weed cloth

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Other Gardening Practices

Best Practices: UC Davis ANR Publication 8424:

• Amend Soil with OM: Clean Compost, Decomposing Leaves, Well-Rotted Manure
• Maintain Neutral pH: Add Limestone if Soil too Acidic

“Cleaning” Lead-contaminated Soil:

EPA Experiment in West Oakland:

EPA is adding imported fish bones from Alaska to bind lead into large molecules (pyromorphites) that plants cannot uptake. The lead-bound molecules then remain in the soil.

• Phyto-remediation: Grow plants that are good at lead uptake, such as sunflowers and dispose of plants offsite (rather than in your site-based compost pile)

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Happy & Safe Growing!
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