SOILS

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TEACHING (35%)

- Introductory Soils & Labs
- Environmental Soils
- Soil Fertility & Labs
- Soil Microbiology & Labs
- Soil-Plant Relationships

RESEARCH (65%)

- NM Agricultural Experiment Station
- Nutrient cycling, reclamation/restoration, organic amendment, traditional agriculture
We look at soil in a different manner than we did 100 years ago. Soil is not solely a medium to be manipulated for crop production but as part of the environment that describes the present and past.
Parent Material

Climate

Organisms

Topography

Time

SOIL
SOILS ARE A PRODUCT OF THE ENVIRONMENT
Soil Layers

- O Horizon (humus)
- A Horizon (topsoil)
- E Horizon (eluviation layer)
- B Horizon (subsoil)
- C Horizon (regolith)
- R Horizon (bedrock)
SOILS ARE DIFFERENT

Humid Temperate Soils
Arid/Semiarid Soils
Humid Tropical Soils
Alfisols  Mollisols  Spodosols  Ultisols

HUMID TEMPERATE SOILS
HUMID TROPICAL SOILS

Oxisols and Ultisols
Aridisols | Alfisols | Entisols

ARID REGION SOILS
SOILS ARE COMPLEX

Chemistry
Physics
Biology
Geology
In Las Cruces with about 1% organic matter (or less), 1 Acre of soil about the depth of a plow furrow deep weights about 2,000,000 pounds (completely dry).

- Mineral Matter makes up most of the weight.
- Mainly oxygen, silicon, aluminum, iron, calcium, inorganic carbon, etc.
- Small amounts (parts per million) of lead, arsenic, boron, uranium, etc.
- Organic matter (living organisms, humus) accounts for 20,000 lbs or less.
- A day after an irrigation, the soil may hold 600,000 pounds of water. Just before an irrigation, the soil may hold 300,000 pounds of water (even though plants are wilting).
CRITICAL SOIL PROPERTIES

- **Texture** - mineral particle size (% sand, silt, clay)
- **pH** - acid, neutral, alkaline
- **Organic matter** - living organisms and humus
- **Aggregation** - clumping of particles together
SOIL TEXTURE

- The amount of sand, silt, and clay
- The soil property that affects most all other properties including chemical and biological as well as physical properties
- Gritty = sandy
- Smooth and sticky = clayey;
- Smooth and non-sticky = silty
- Loamy means moderate amounts of sand, silt, and clay
- Sandy loams, clay loams, silt loams, loams, silty clays, loamy sands, etc.
- Nothing to do with organic matter
LOAMY SANDS ON UPLANDS

• Sandy (loamy sands, sandy loams, etc.)
• Water infiltration into the soil and through the soil is quick (inches per hour)
• Good aeration
• Organic matter is low (less than 0.5%)
• Low nutrient level and holding capacity
• Often, well supplied with potassium
• Micronutrient deficiencies are evident (iron)
• Organic matter amendment improves soil by holding nutrients and water
• Soil aggregation/structure is not an issue
• Caliche and rock are an issue
• Formed from underlying rock/alluvium
CLAY LOAMS IN THE VALLEY

- Clayey (clay loams, silty clay loams, loams, clays, etc.)
- Water infiltration into the soil and through the soil is slow (tenths of an inch per hour)
- Can be poorly aerated if aggregation is poor
- Organic matter is a little better (0.75 – 1.5%)
- Nutrient level and holding capacity are better
- Often, well supplied with potassium
- Micronutrient deficiencies are less evident
- Organic matter amendment improves soil by encouraging aggregation and structure
- Salinity can be an issue because of poor drainage
- Formed from sediment from distant sources
FIGURE 5.20 Comparative rates of irrigation water movement into a sandy loam and a clay loam. Note the much more rapid rate of movement in the sandy loam, especially in a downward direction. [Redrawn from Cooney and Peterson (1955)]
Example 1: 3, 4, and 5 acre-feet of water are needed to grow a cotton, alfalfa, and pecans, respectively. River water has an EC of 0.9 dS/m and well water has an EC of 1.4 dS/m. Both sources of water have a typical distribution of salts.

A. How much salt is contained in the river and irrigation water?

River: \(0.9 \text{ dS/m} \times 640 = 576 \text{ mg/L (ppm)}\)

Well: \(1.6 \text{ dS/m} \times 640 = 1,024 \text{ mg/L (ppm)}\)

B. How much salt is applied growing all 3 crops from river water?

Cotton: \(576 \text{ mg/L} \times 2.72 \times 3 \text{ acre-feet} = 4,700 \text{ lbs salt/acre}\)

Alfalfa: \(576 \text{ mg/L} \times 2.72 \times 4 \text{ acre-feet} = 6,267 \text{ lbs salt/acre}\)

Pecans: \(576 \text{ mg/L} \times 2.72 \times 5 \text{ acre-feet} = 7,834 \text{ lbs salt/acre}\)
Plants on side of row nearest the irrigated side receive even less salt as salt moves towards other side of row, resulting in good plant growth.

Plants under sprinkler irrigation receive the least salt as salt moves down and does not accumulate in row, resulting in best plant growth. Note even salt distribution.

Drip emitters placed on top of row flush water and salts down and away from surface. The deeper the emitter, the more water wicks toward surface (evaporates) without leaching and thus the more salt accumulation.
SOIL pH

- Second to texture in importance, pH (how acid or alkaline a soil is) greatly affects physical, chemical, biological, and fertility properties.
- In Las Cruces, soil pH is generally between 7.8 and 8.1 (alkaline) and doesn’t vary unless something unusual has happened.
- Ideal pH for many plants is around 6.5-7 (slightly acid to neutral).
VERY LOW SOIL pH (<5)

- Metal toxicities of aluminum, manganese, and occasionally iron and other metals

- Severe phosphorus and other nutrient deficiencies

- Lime (tons per acre) is used to raise pH to 6.5-7.0 and is a very common agricultural practice in humid areas
HIGH SOIL pH (7.8-8.1)

- Micronutrient deficiencies, particularly iron, zinc, manganese, copper, nickel
- Moderate phosphorus deficiencies
- Lowering pH is usually not an option; apply nutrients, particularly iron
SOIL ORGANIC MATTER

• One of the soil properties a home owner can influence
• Responsible for many beneficial properties
• Raw organic matter is particularly beneficial to aggregate formation
• Humified organic matter (humus) is the end-product of decomposition
BENEFITS TO SOIL

Chemical Properties

• high nutrient holding power against leaching
• reservoir of nitrogen, phosphorus, and sulfur
• chelator of nutrients that protects them from chemical precipitation
• buffers pH, salinity, and elemental toxicities
• binds pollutants

Physical Properties

• aggregation, water stable aggregates, structure
• fluid exchange, water holding capacity
• density, crusting, erodibility
Biological Properties

- energy and nutrient source
- supports microbial diversity
SOIL AGGREGATION

• The clumping of individual sand, silt, clay, and organic matter together to form an aggregate
• Good aggregation encourages fluid exchange and root penetration
• More important with clayey textured soils
Poorly aggregated soil without organic amendment.

Well aggregated soil with organic amendment.
SOIL BIOLOGY

- The diversity of soil life is enormous. Whereas a forest might have a few hundred different species of plants and animals, a gram of soil may have 10,000 different species of bacteria alone.
Soil Bacteria

Soil Fungi
Soil Nematodes

Soil Viruses
<table>
<thead>
<tr>
<th>Organism</th>
<th>Range</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td>100,000,000 - 1,000,000,000</td>
<td>/g soil</td>
</tr>
<tr>
<td>Fungi</td>
<td>100,000 - 1,000,000,000</td>
<td>/g soil</td>
</tr>
<tr>
<td>Algae</td>
<td>10,000 - 100,000</td>
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<td>Protozoa</td>
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<tr>
<td>Nematodes</td>
<td>100 - 1,000</td>
<td>/g soil</td>
</tr>
<tr>
<td>Other fauna</td>
<td>1,000 - 1,000,000,000</td>
<td>/sq yd</td>
</tr>
</tbody>
</table>
SOIL BIOLOGY

- Decomposition of natural organic substances
- Decomposition of synthetic substances such as fuels, solvents, pesticides, etc.
- Nutrient cycling
- Aggregation
- Symbiotic relationships
- 99.9% are beneficial and not dangerous to plants, animals, or humans
Many plant pathogens (mainly fungi, some bacteria) and parasites (nematodes) spend much of their life between hosts in soil.
SOIL FERTILITY

- 17 essential elements required by plants
- Plants absorb nutrients primarily in the inorganic form
- Organic fertilizers are broken down by microorganisms and the inorganic nutrient released for plant uptake
NUTRIENT CYCLES – PLANT UPTAKE

Organic-Nitrogen → Decomposition → Ammonium/nitrate → Plant Uptake

Manure/compost → Inorganic nutrient →
FERTILIZER NUTRIENTS

• 3 numbers must be on a fertilizer bag
• Additional numbers indicate the presence of other nutrients that you may or may not need
• Iron is the only additional nutrient needed in Las Cruces

Nitrogen - expressed as N
Phosphorus - expressed as $\text{P}_2\text{O}_5$
Potassium - expressed as $\text{K}_2\text{O}$
SOIL AND YOU

How Dependent Are We On Soil?

❖ Most food and fiber comes directly from soil
❖ Most of the water you drink has flowed over or drained through soil
❖ What is the largest problem facing soil sustainability?
Wind and Water (sheet and rill) Erosion from US Cropland

43% decrease in erosion between 1982 and 2007

Source = USDA/NRCS 2007 National Resources Inventory
Famine is 6 inches away (topsoil). Topsoil contains most of nutrients for plant life.
THE MOST IMPORTANT PRACTICES THAT MAINTAIN SOIL SUSTAINABILITY

Maintenance of soil organic matter
Maintenance of soil cover
MULCHES and MULCHING
WHY MULCH?

- Conserve soil moisture; slow soil water evaporation
- Control weeds (that remove soil moisture)
- Lower soil temperature in summer
- Use plant debris/compost
- Solarization (kill nematodes, pathogens, weed seed)
MULCH CHARACTERISTICS?

- Cover bare soil
- Porous to allow good aeration to roots and soil microbes
- Porous to allow water to move into soil but not too absorbent
- Organic mulches should be course textured
WHAT YOU SHOULDN’T IT DO?

• Put mulches on too early around warm season plants
  → keeps soil from warming in spring
• Incorporate organic mulches into the soil
  → ties up soil nutrients during decomposition
• Use too much
  → prevents water from reaching soil and results in poor aeration
LANDSCAPING WITH ROCK

• Major mistake is not killing grass/weeds before putting down plastic and rock
• Water well and then kill weeds with weed killer; maybe several cycles
• Solarization works well if weed killer is undesirable
SOLARIZATION

- When temperatures are hot and solar radiation is great (May-June)
- Water well
- Cover with clear plastic
- Leave covered for at least a month
- Check temperatures at various depths
Solarization or Biofumigation
FREE CITY MATERIALS

• Yard waste mulch from the east side facility off of Sonoma Ranch.

• Glass mulch from the recycling center on west Amador

• Composted biosolids at the sewage treatment plant on west Amador – as an amendment not a mulch