Soils and Fertilizer
Objectives

- Discuss soil components, texture and chemistry
- Consider relationships between soil, water, plants and air
- Examine steps to prevent soil compaction and salt accumulation
- Identify common plant nutrient deficiencies in our region
- Calculate fertilizer requirements
- Review proper techniques in soil analysis collection
Function of Soil in the Landscape and Why We Care:

- Supports the roots and anchors the above ground plant material
- Provides the essential elements for uptake by trees and plants
- Holds and supplies water and essential elements to the plants
- Releases water vapor into the air, potentially creating a cooler microclimate

Knowing the characteristics of the soil on a particular job site can be the difference between success and failure.

Soil isn’t “Just Dirt”! It is the ecosystem that supports our landscape plants. What we do to it matters.
Arizona Desert Soils

- Mineral
- Alkaline
- Arid
- Probably some caliche
- May be rocky and shallow, particularly in foothills
- May be saline
- May be heavy
Desert soils have significantly less than 5% organic matter. Why?
Desert soils have low organic matter because there is not enough precipitation to support lush wild plant growth.
Urban Soil Challenges

Soil quality directly impacts plant life

✓ Establishment
✓ Health
✓ Growth
✓ Longevity

In general, our desert, urban soils have low organic matter and less pore space
Organic Matter

- Group of carbon containing compounds
- Originated from living material and have been deposited on or within earths structural components
- Contains minerals and trace elements
Benefits of Organic Matter

• Helps strengthen soil aggregates, thus improving soil structure
• Improve aeration and water infiltration
• Increases water-holding capacity
• Provides significant amounts of cation exchange capacity

• What do we do with organic matter in the landscape? Blow it, bag it and cart it away.

• Mulching grass clippings and leaving some leaf litter as a natural mulch can increase the organic matter content of the soil over time.
Soil Texture

*Refers to the size of particles that make up the soil: sand, silt and clay*

**USDA Standard Relative Particle Size**

- **Sand**: (2.00 - 0.05 mm)
- **Silt**: (0.05 mm - 0.002 mm)
- **Clay**: (< 0.002 mm)

‘light’ soil

‘heavy’ soils
Heavy, Light or Just Right?

Clay
- “Heavy”
- Slow infiltration
- High water-holding capacity
- High nutrient-holding capacity

Sand
- “Light”
- Fast infiltration
- Low water-holding capacity
- Low nutrient-holding capacity
Soil Texture Triangle

68% sand
18% silt
14% clay

International Society of Arboriculture, Bugwood.org
Determine your soil texture
The “Feel Method” of estimating soil texture

**Flowchart Details**

1. **Start**
   - Place approximately 25 g of soil in palm. Add water dropwise and knead the soil to break down all aggregates. Soil is at the proper consistency when plastic and moldable, like moist putty.
   - **Yes**: Add dry soil to soak up water
   - **No**: Is soil too dry?
     - **Yes**: **SAND**
     - **No**: Is soil too wet?
     - **Yes**: **SAND**
     - **No**: Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, squeezing it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight.

2. **Loamy Sand**
   - Does soil form a ribbon?
     - **Yes**: Excessively wet a small pinch of soil in palm and rub with forefinger.
     - **No**: Does soil make a weak ribbon less than 2.5 cm long before breaking?
       - **Yes**: **SANDY LOAM**
       - **No**: Does soil make a medium ribbon 2.5-5 cm long before breaking?
         - **Yes**: **SANDY CLAY**
         - **No**: Does soil make a strong ribbon 5 cm or longer before breaking?
           - **Yes**: **SANDY CLAY**
           - **No**: Loamy Sand

3. **Sandy Loam**
   - Does soil feel very gritty?
     - **Yes**: **SANDY LOAM**
     - **No**: Does soil feel very smooth?
       - **Yes**: **SILTY CLAY**
       - **No**: **SANDY CLAY**

4. **Silty Clay**
   - Does soil feel very gritty?
     - **Yes**: **SILTY CLAY**
     - **No**: Does soil feel very smooth?
       - **Yes**: **SILTY CLAY**
       - **No**: **CLAY**

5. **CLAY**
   - Neither gittiness nor smoothness predominates.

6. **Silt Loam**
   - Does soil feel very smooth?
     - **Yes**: **SILTY LOAM**
     - **No**: **SANDY LOAM**

7. **Sandy Loam**
   - Does soil feel very gritty?
     - **Yes**: **SANDY LOAM**
     - **No**: Does soil feel very smooth?
       - **Yes**: **SILTY CLAY**
       - **No**: **SANDY CLAY**

8. **Sandy Clay**
   - Does soil feel very gritty?
     - **Yes**: **SANDY CLAY**
     - **No**: Does soil feel very smooth?
       - **Yes**: **SILTY CLAY**
       - **No**: **CLAY**

9. **Clay**
   - Neither gittiness nor smoothness predominates.
Can you alter soil texture?

• “You get what you get and you don’t throw a fit!”
• Not practical to try to alter on a large scale
• Not financially feasible on a large scale
• Better to focus on selecting plants that are more tolerant of current site conditions
Soil Structure:

Arrangement of soil particles into groups called soil aggregates.

<table>
<thead>
<tr>
<th>Granular</th>
<th>Blocky</th>
<th>Prismatic</th>
<th>Columnar</th>
<th>Flaty</th>
<th>Single Grained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.</td>
<td>Irregular blocks that are usually 1.5 - 5.0 cm in diameter.</td>
<td>Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.</td>
<td>Vertical columns of soil that have a salt &quot;cap&quot; at the top. Found in soils of arid climates.</td>
<td>Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.</td>
<td>Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.</td>
</tr>
</tbody>
</table>

desert soils
Soil Structure

Impacts water infiltration
pH is a measure of acidity/alkalinity. Desert soils tend to be high in pH.
Salinity

Sodium (Na), Calcium (Ca), Potassium (K) and salts accumulate in soils.

Peeling of the soil surface is a sign of poorly drained, salty soil and remediation is required for plants to grow.
Salts contained in irrigation water will accumulate unless adequate leaching is provided.

Excess water (more than plants require) must be added to flush salts below the root zone. This excess irrigation is called the “leaching requirement”.
How does soil become saline?

- Shallow watering
- Fertilizers
- Irrigation water quality
- Application of other salty substances to soil

Frequent, shallow irrigation is the leading cause of salt build up. Watering more deeply and less frequently helps flush salts out of the root zone of plants.
Soil Analysis Report

Project: 
Sampler: 
Date Received: 9/14/2012  
Date Reported: 9/19/2012  
PO Number: Flower Beds  
Lab Number: 906095-01  
Crop: Landscape  
Sample ID: Flower Beds  
Growth Stage:  
Description: 09/14/12

<table>
<thead>
<tr>
<th>Soil Complete Test</th>
<th>Method</th>
<th>Result</th>
<th>Units</th>
<th>Levels</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td>1.1</td>
<td>7.6</td>
<td>SU</td>
<td>Medium</td>
</tr>
<tr>
<td>Electrical Conductivity, EC</td>
<td>1.1</td>
<td>2.1</td>
<td>dS/m</td>
<td>Medium</td>
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<tr>
<td>Calcium, Ca</td>
<td>NH4OAc (pH 8.5)</td>
<td>4,300</td>
<td>ppm</td>
<td>Very High</td>
</tr>
<tr>
<td>Magnesium, Mg</td>
<td>NH4OAc (pH 8.5)</td>
<td>620</td>
<td>ppm</td>
<td>Very High</td>
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<tr>
<td>Sodium, Na</td>
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<td>Potassium, K</td>
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<td>Zinc, Zn</td>
<td>DTPA</td>
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<td>Iron, Fe</td>
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<td>Nitrate-N, NO3-N</td>
<td>Cd Reduction</td>
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<td>Olsen</td>
<td>150</td>
<td>ppm</td>
<td>Very High</td>
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<tr>
<td>Sulfate-S, SO4-S</td>
<td>Hot Water</td>
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<td>Boron, B</td>
<td>Hot Water</td>
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<td>Free Lime, FL</td>
<td>Acid Test</td>
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<td>EIP</td>
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<td>5.4</td>
<td>%</td>
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<tr>
<td>CEC</td>
<td>Calculated</td>
<td>36.2</td>
<td>meq/100g</td>
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Levels are generalized and apply to most cropping environments.
Low means a high probability that applying nutrient will elicit a growth response.
Medium means a moderate probability of plant growth from application.
High means little or no response expected from application of this nutrient.
Very High means adding the nutrient may reduce growth or cause imbalance.
Cation Exchange Capacity (CEC)

The total number of cations a soil can hold—or its total negative charge—is the soil's cation exchange capacity. The higher the CEC, the higher the negative charge and the more cations that can be held.

*Cations held on the clay and organic matter particles in soils can be replaced by other cations; thus, they are exchangeable.* For instance, potassium can be replaced by cations such as calcium or hydrogen, and vice versa.
Humus and clay carry a negative charge, and so attract positively charged cations.
Cation Exchange Video

- [https://www.youtube.com/watch?v=HmEyymGXOfI&feature=youtu.be](https://www.youtube.com/watch?v=HmEyymGXOfI&feature=youtu.be)
**Sodium Adsorption Ratio (SAR)**

The ratio of ‘bad’ to ‘good’ flocculators gives an indication of the relative status of these cations:

Mathematically, this is expressed as the ‘sodium adsorption ratio’ or SAR:

\[
SAR = \frac{[Na^+]}{\sqrt{[Ca^{2+}] + [Mg^{2+}] / 2}}
\]

where concentrations are expressed in mmoles/L
An alternative to SAR is ESP (Exchangeable Sodium Percentage)

SAR and ESP are approximately equal numerically

Mathematically, this is expressed as the percentage of the CEC (cation exchange capacity) that is filled with sodium in units of charge per mass (cmolc/kg)

\[
ESP = \frac{\text{Na}^+}{\text{Cation Exchange Capacity}}
\]
# Salt-affected Soil Classification

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<td>&lt;15</td>
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<td>&gt;4</td>
<td>&lt;15</td>
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<td>&gt;15</td>
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Levels are generalized and apply to most cropping environments. Low means a high probability that applying nutrient will elicit a growth response. Medium means a moderate probability of plant growth from application. High means little or no response expected from application of this nutrient. Very High means adding the nutrient may reduce growth or cause imbalance.
Test soil to determine sodium level

Soil sodium tests:
- SAR - sodium adsorption ratio
- ESP - exchangeable sodium percentage

If SAR or ESP are $\geq 10$ the soil is likely to disperse. You should consider treating the soil.

Lower ESP and SAR numbers are always good.
Plant Salinity Tolerance

![Graph showing the relationship between relative productivity and electrical conductivity (ECe) in dS/m. The graph indicates that halophytes tolerate high salinity levels, while crop plants are unsuitable for such conditions. The graph is from Brady and Weil, Figure 9.27.]
Managing Salt

• Apply extra water to prevent excessive salt buildup
  • The amount of extra water needed is called the *leaching requirement* (LR)
    • LR is higher when using salty irrigation water
    • LR is higher when growing salt-sensitive plants

• You can save water and prevent salt buildup by using adapted plant species
Salty Soil – Saline or Sodic?

Why does it matter? The treatment is different!

• **Saline**
  
  • *Non-sodic soil containing sufficient soluble salt to adversely affect the growth of most crop plants with a lower limit of electrical conductivity of the saturated extract (ECe) being 4 deciSiemens / meter (dS/m), which is equivalent to a value of 4 mmhos/cm*

• **Sodic**
  
  • *Non-saline soil containing sufficient exchangeable sodium (Na) to adversely affect crop production and soil structure under most conditions of soil and plant type. The sodium adsorption ratio of the saturation extract (SARe) is at least 13*
Salty Soil Treatments

- **Sodic soils**
  - Gypsum applications (replaces Na with Ca)
  - Leaching program

- **Saline soils**
  - Leaching program (best way)
  - Elemental sulfur applications (soil incorporation is best)

- **Sodic-saline soils**
  - Gypsum applications
  - Leaching program
Caliche

- Layer of soil where soil particles have been cemented together by lime (calcium carbonate, CaCO$_3$)
- Common in arid areas due to low precipitation
- Light in color
- Thickness of layers vary, few inches to several feet thick
- May be more than one layer of caliche in the soil profile
Caliche

- Reduces water movement through soil profile
- Restricts root growth to upper levels of soil (may reduce growth)
- Leads to salt accumulation and reduced aeration in soil
- High pH can cause nutrient deficiencies in plants, especially iron
Caliche Management

- Keep roots out of the caliche zone
- Physically remove caliche layers if possible to allow for water drainage out of root zone
- Check drainage on property prior to planting by performing a percolation test
  - Dig plant hole, fill with water and confirm drainage is at rate of 4” per 4 hours
- Utilize chimney drainage holes to provide drainage
Soil Amendments

Used to modify soil chemistry in our region

- **Gypsum** (Calcium sulfate)
  - temporarily removes Na from soil, helps break apart hardened soils
- **Soil sulfur**
  - may eventually reduce pH after repeated applications
- **Organic matter**
  - Microbial degradation and production of organic acids
  - Large amounts are required
- **Fertilizers**
  - Ammonium products (especially ammonium sulfate)
How do you know if you need to apply gypsum?

Observe the soil:
- Soil cracks when dry
- Soil won’t absorb water
- Rainwater soaks in more slowly than irrigation water
Soil Amendments

Elemental Sulfur

- Slow reaction- may take many months to change pH
- Dependent on microbial action (*Thiobacillus*)
- Soil incorporation is necessary
- Sulfur neutralizes the free calcium carbonate
- Not practical to change soil pH over large areas, but may be appropriate for directed applications to specific plants
- Monitor results with soil sample to confirm desired pH is achieved

Sulfur is oxidized by bacteria to form sulfuric acid

\[ S + O_2 + H_2O = H_2SO_4 \]

(elemental S + oxygen + water + soil microorganisms + time = sulfuric acid)
Soil Texture Affects Water Movement

- **Large Pore Space**
  - Gravitational Pull
  - Sandy Soil
  - Depth: 12”, 24”, 36”, 48”, 60”, 72”
  - 15 min, 40 min, 1 hour, 24 hours

- **Small Pore Space**
  - Capillary Action
  - Clayey Soil
  - Depth: 24”, 12”, 0”, 12”, 24”
  - 4 hours, 24 hours, 48 hours
Capillary Action

- **Cohesion** – “like sticking to like”
  - Water molecules stick together
- **Adhesion** – “sticking to unlike”
  - Water molecules stick to certain surfaces
- **Capillary action** – drawing of water in a narrow tube
Which soil texture warrants the greatest number of drip emitters to wet an area?
Water Infiltration

Rate which water enters the soil surface
Soil Compaction

*Increased density of soil by packing the soil particles closer together causing a reduction in the volume of air.*

Compaction reduces pore space:
Restricts H$_2$O and O$_2$ = Poor root development
Soil Percolation

Movement of water through the soil profile
Soil Moisture Levels

Saturated soil: all pores are filled.

Field capacity: about 1/2 of pores are filled.

Wilting point: plants can’t extract the remaining water.

Runoff → Infiltration → Drainage → Water table: depth where soil is always saturated.

Evaporation Transpiration

Rain

Sweet spot after a few days after weeks of drought
Evapotranspiration (Et)

Evaporation + Transpiration = Evapotranspiration
Factors that Affect ET

- Temperature
- Relative humidity
- Wind speed
- Light intensity
- Type of plant
Stomata

Factors affecting opening and closing:

- Light, especially blue light
- Water
- Temperature
- CO₂
1-2-3 Rule of Irrigation

Watering depth
1 ft - Flowers, vegetables and other small annuals
2 ft – Shrubs
3 ft – Trees
FERTILIZING
Essential Plant Elements

Macronutrients

• Needed in larger amounts
  • Primary macronutrients
    • Nitrogen (N)
    • Phosphorus (P)
    • Potassium (K)
  • Secondary macronutrients
    • Calcium
    • Sulfur
    • Magnesium

Micronutrients

• Needed in smaller amounts
  • Iron
  • Boron
  • Manganese
  • Zinc
  • Copper
  • Chlorine
  • Molybdenum
  • Nickle*

* recently added

• Other essential plant elements include Hydrogen, Carbon & Oxygen
Essential and Beneficial Elements for Plants

<table>
<thead>
<tr>
<th>Essential Mineral Element</th>
<th>Essential Non-mineral Element</th>
<th>Beneficial Mineral Element</th>
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<tbody>
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Soil Testing

- **Find a local, reliable lab** – see AZ Cooperative Extension Publication AZ1111 in the resources

- **Collect a representative sample** – ask your lab for specifics or see AZ Coop Ext Publication AZ1412

- **Make decisions based on the results** - pay extra for the recommendations – worth it unless you are very experienced
Nitrogen (N)

- Originates from decomposing organic material, from rainfall and from nitrogen-fixing bacteria
- Generally, in short supply in western (desert) soils
- Required in large amounts by plants
- Readily lost through leaching & microbe activity
To get quick ‘greening’, use a fertilizer with nitrogen in the ammonic form

Examples: Ammonium Sulfate (21-0-0)  
Ammonium Nitrate (33-0-0)
Nitrogen Deficiency

- Nitrogen (N)
- Yellowing of older leaves, bottom of plant
- Rest of the plant is often light green
- Stunted growth
- Foliage may drop early in fall
- Mobile in plants so overwatering can cause deficiency

- Treatment
  - Ammonium, Urea, Nitrate, manures, blood meal
Nitrogen-Fixing Bacteria on the roots of Acacia
Phosphorus Deficiency

- Phosphorus (P)
  - Leaf tips look burnt
  - Older leaves turning a dark green or reddish purple
  - Stunting
  - Loss of lower leaves
  - Poor root growth
  - Mobile in plants

- Treatment
  - Phosphate products
  - Bone meal
  - Greensand
Phosphorus Deficiency
Iron Deficiency

- Iron (Fe)
  - Interverinal chlorosis (yellowing leaf with green veins)
  - Found on newer growth
  - Leaves may be small
  - Immobile in plants

- Treatment
  - Iron chelates
  - Ferrous sulfate
Zinc Deficiency

- Zinc (Zn)
  - New leaves interveinal chlorosis, thicker green pattern around veins
  - Necrotic spots on margins or tips
  - Dwarfed new leaves, cupped upward or distorted

Deficiency on citrus, normal leaf on right
Zn deficiency  Fe deficiency
Micronutrient deficiencies may be caused by multiple minerals lacking. Application of micronutrient packages will help broaden the spectrum. Foliar testing to confirm mineral deficiency.
pH is a measure of acidity/alkalinity
Understanding Soil pH

https://www.youtube.com/watch?v=7Z15h189LCc
Treating Plants in Alkaline Soils

- Metal nutrients are insoluble in alkaline soils (iron, manganese, zinc)
- Apply nutrients directly to plant foliage
  - use sulfate salts
    - iron sulfate
    - copper sulfate
    - zinc sulfate
- Use chelated forms
  - more soluble than un-chelated forms
  - stay in solution longer
  - more available to plants
    - EDTA
    - DTPA
    - others
Chelates

Chelated Iron
Fe -EDTA
## Other Factors Affecting Uptake

<table>
<thead>
<tr>
<th>Raises Fertility</th>
<th>Lowers Fertility</th>
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<tbody>
<tr>
<td>High clay content</td>
<td>High sand content</td>
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<tr>
<td>High humus content</td>
<td>Loss of organic matter</td>
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<td>Good structure</td>
<td>Compaction</td>
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<td>Warm soil</td>
<td>Cold soil</td>
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<td>Deep soil</td>
<td>Shallow soil</td>
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<td>Moist soil</td>
<td>Dry or wet soil</td>
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<tr>
<td>Good drainage</td>
<td>Excess irrigation or drainage</td>
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<tr>
<td>Fertilization</td>
<td>Erosion</td>
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<tr>
<td>Desirable microbes</td>
<td>Root damaging pests</td>
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<tr>
<td>Near neutral pH</td>
<td>pH too acid or alkaline</td>
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</table>
Fertilizers

- Add nutrients to the soil
- Organic and inorganic forms
- Usually salts
- Can burn plants
- Must be watered in
Fertilizer analysis

\[ \text{N-P}_2\text{O}_5\text{-K}_2\text{O} \]
(nitrogen-phosphate-potash)

- **Complete** fertilizer
  - 21-7-14 (contains N-P-K)
- **Incomplete** fertilizer
  - 21-0-0 (contains only N)
- **Slow release** fertilizers
  - Coated to promote slow release of minerals
## Organic vs. Chemical Fertilizers

<table>
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<tr>
<th><strong>Organic</strong></th>
<th><strong>Chemical (Inorganic)</strong></th>
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<tr>
<td>Often recycle waste materials</td>
<td>Can be energy intensive to make</td>
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<td>May be resource intensive</td>
<td>Lighter weight</td>
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<td>Can be bulky, heavy</td>
<td>Less material required</td>
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<tr>
<td>Micronutrients</td>
<td>Minerals in formulations readily available for plants</td>
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<td>May contain pathogens, weeds</td>
<td>Must be purchased</td>
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<tr>
<td>Salt</td>
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<tr>
<td>Requires more fertilizer to get the same amount of N as chemical fertilizer</td>
<td>May provide more predictable results</td>
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<tr>
<td>Generally slow-release</td>
<td>More risk of over fertilization</td>
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<td>Can improve soil structure as they break down</td>
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Organic vs. Chemical Fertilizers

**Organic**
- Manure
- Compost
- Fish emulsion
- Guano
- Milorganite
- Bone meal, blood meal
- Cottonseed meal

**Chemical/ Inorganic**
- Ammonium nitrate
- Ammonium sulfate
- Urea
- Superphosphate
- Potassium nitrate
- Calcium nitrate
Organic vs Chemical Fertilizers

https://worcesterallotment.wordpress.com/page/25/
Fertilizer Application Methods

**Solid**
- Broadcast
- Placement

**Liquid**
- Foliar
- Soak
- Fertigation
Fertilizer Labeling

Yes but where is the rate?
Determining the amount of a fertilizer for a given area

1. Take the measurements (in feet) of the area in question

2. Multiply the length by the width; this gives you the area in square feet (sq ft.)

3. Read the label. Determine how much product is required per 1000 sq. ft. Measure the amount fertilizer needed

4. Calibrate your spreader, load and distribute
Example #1

A lawn is 100 by 50 ft. How much fertilizer is necessary if the label states that you need 1 lb. of the product per 1000 square feet?

Determine the area. 100 ft. X 50 ft. = 5000 sq. ft.

Since you need 1 lb. of fertilizer/1000 sq. ft. Divide 5000 sq.ft. by 1000

This tells you how many 1000 sq. ft. units there are in the lawn. This is 5.

5 x 1 lb/1000 = 5 lbs per 5000 sq.ft. Answer is 5 lbs.
Example # 2

How many lbs. of 16-20-0, applied to a 50’ by 20’ lawn, requiring 1 lb. of nitrogen per 1000 sq. ft.?

Step 1: Determine the area
50’ X 20’ = 1000 sq. ft.

Step 2: Calculate how many pounds of 16-20-0 it takes to get one pound of nitrogen (N)

Divide 100 by 16 (10 ÷ 1.6 or 1 ÷ 0.16 same results)
100 ÷ 16 = 6.25 lbs. of 16-20-0
Step 3: Since you have 1000 sq. ft., you’ll need

6.25 lbs. of 16-20-0 for the lawn
Example 3:

How many pounds of 16-20-0 should be applied to a lawn measuring 50’ by 40’ that requires 2 lbs of phosphorus per 1000 sq. ft.?

Step 1: Determine the area.

50 ft. X 40 ft. = 2000 sq. ft.

Step 2: Determine the number of lbs. of 16-20-0 to get 1 lb of Phosphorous. 100 divided by 20 = 5 lbs.

(5 lbs of 16-20-0 has 1 lb of Phosphorus)
Step 3: Calculate the number of lbs of 16-20-0 that supplies the rate of 2 lbs. of phosphorus per 1000 sq. ft.

*Remember that 5 lbs of 16-2-0 has 1 lb of phosphate*

\[
2 \times 5 \text{ lbs} = 10 \text{ lbs of ammonium phosphate}
\]

Your rate of 16-20-0 is:

10 lbs/1000 sq ft to apply 2 lbs of P per 1000 sq ft
Please ask questions! Then go calibrate your equipment and get the job done!
Spreader Calibration

https://www.youtube.com/watch?v=BT4kzNq7750

You can apply these principals to calibrating a drop spreader and handheld belly-grinder.
Resources

• Laboratories Conducting Soil, Plant, Feed, or Water Testing
  • https://extension.arizona.edu/pubs/laboratories-conducting-soil-plant-feed-or-water-testing

• Fertilizing Home Gardens in Arizona
  • http://extension.arizona.edu/pubs/fertilizing-home-gardens-arizona

• Soil Sampling and Analysis
  • http://extension.arizona.edu/pubs/soil-sampling-and-analysis

• Using Gypsum and Other Calcium Amendments in Southwestern Soils
  • https://extension.arizona.edu/pubs/using-gypsum-other-calcium-amendments-southwestern-soils

• Diagnosing Nutrient Deficiencies Quick-Reference
  • https://extension.arizona.edu/pubs/diagnosing-nutrient-deficiencies-quick-reference

• Nitrogen in Soil and the Environment
  • https://extension.arizona.edu/pubs/nitrogen-soil-and-environment

• Recognizing and Treating Iron Deficiency in the Home Yard
  • https://extension.arizona.edu/pubs/recognizing-treating-iron-deficiency-home-yard

• University of Arizona publication search
  • https://extension.arizona.edu/pubs
Soil Testing Laboratories

Local
IAS Laboratories
2515 E. University Dr. Phoenix, AZ
602-273-7248

Motzz Laboratory, Inc.
3540 E. Corona Ave. Phoenix, AZ
602-454-2376

National
AgSource/ Harris Labs
402-476-0300
harrislabs.agsource.com
harrislabs@agsource.com
Thank you to those who contributed to this program:

Rebecca Senior  
University of Arizona Cooperative Extension  
Maricopa County  
602-827-8276  Office  
602-509-6719  Cell  
rsenior@cals.arizona.edu

Kasey Billingsley  
Harmony Horticultural Consulting, LLC