Soil Nutrition, Fertilizers, and Cover Crops

Master Gardener Training
Sacramento County
Feb. 25, 2016
Chuck Ingels
UC Cooperative Extension, Sacramento County
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Essential Plant Nutrients

<table>
<thead>
<tr>
<th>Major Nutrients from Air &amp; Water</th>
<th>Major (Macro) Nutrients from Soil</th>
<th>Minor (Micro) Nutrients from Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>Nitrogen</td>
<td>Iron</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Phosphorus</td>
<td>Zinc</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Potassium</td>
<td>Manganese</td>
</tr>
<tr>
<td></td>
<td>Calcium</td>
<td>Copper</td>
</tr>
<tr>
<td></td>
<td>Magnesium</td>
<td>Chlorine</td>
</tr>
<tr>
<td></td>
<td>Sulfur</td>
<td>Boron</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Molybdenum</td>
</tr>
</tbody>
</table>
Roles of Nitrogen (N)

- Converts to amino acids in plant
  - Building blocks for proteins
  - Essential for cell division & plant growth
- Necessary for enzyme reactions
- Constituent of chlorophyll (photosynthesis)
- Promotes vigorous vegetative growth
Movement of Nitrogen

- Taken up by plants primarily as nitrate (NO$_3^-$)
  - Plant roots can absorb ammonium (NH$_4^+$) but it is often bound to soil and cannot move as easily to roots
- Leaching from root zone occurs easily
- Deficiency appears on older leaves first because N is mobile
Roles of Phosphorus (P)

- Plays role in photosynthesis, respiration, energy storage & transfer, cell division & enlargement
- Stimulates early growth & root formation
- Promotes flower and fruit development
- Promotes seedling root growth
- Contributes to disease resistance
- Does not easily leach
Roles of Potassium (K)

- Essential for photosynthesis
- Used for protein synthesis & sugar translocation
- Important in membrane permeability
- Opening & closing of stomates
- Helps plant use water more efficiently by promoting turgidity
- Increases disease resistance
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Cation Exchange Capacity (CEC)

- A measure of soil fertility
- Clay and humus particles have neg. charge
- Varies by soil type and % organic matter

![Diagram of Cation Exchange Capacity]

- NH₄⁺
## Typical CECs Based on Soil Texture

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Typical CEC Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>2 – 6 meq/100g</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>3 – 8 meq/100g</td>
</tr>
<tr>
<td>Loam</td>
<td>7 – 15 meq/100g</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>10 – 18 meq/100g</td>
</tr>
<tr>
<td>Clay &amp; Clay Loam</td>
<td>15 – 30 meq/100g</td>
</tr>
</tbody>
</table>
Low vs. High CEC

**CEC 1-10**
- High sand content
- N & K leaching more likely
- Less lime or sulfur needed to adjust pH
- Low water-holding capacity

**CEC 11-50**
- High clay or OM content
- Greater capacity to hold nutrients
- More lime or sulfur needed to adjust pH
- High water-holding capacity
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
pH Scale
0-14

1 Battery acid
2 Lemon juice
3 Vinegar
4 Tomatoes
5 Beer
6 Milk
7 Pure water
8 Sea water
9 Baking soda
10 Milk of magnesia
11 Ammonia
12 Lime
13 Lye
14
# Soil pH

<table>
<thead>
<tr>
<th>Acidic</th>
<th>Neutral</th>
<th>Alkaline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low pH</td>
<td></td>
<td>High pH</td>
</tr>
<tr>
<td>(4.5 to 5.5)</td>
<td></td>
<td>(7.0 to 8.0)</td>
</tr>
<tr>
<td>- Azalea</td>
<td></td>
<td>- Lilac</td>
</tr>
<tr>
<td>- Blueberry</td>
<td></td>
<td>- Clematis</td>
</tr>
</tbody>
</table>

- pH 6.5 to 7.0 = generally “ideal”, maximum availability of primary nutrients (N, P, & K)
pH and Nutrient Availability

- Iron
- Manganese
High pH leads to micronutrient deficiency in sensitive species
Materials for Changing pH

**Raising pH**
- Limestone
- Hydrated lime
- Oyster shell lime
- Dolomite
- Wood ash

**Lowering pH**
- Soil sulfur
- Ammonium-based fertilizers

Gypsum does not change soil pH
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Nutrient Analysis
Soil Sampling

- Doesn’t always tell what plants take up
- Good for baseline info, detecting deficiencies
- Sample in rooting zone from different areas
- Include at least 1 pint per sample in a quart plastic zip-lock bag, take to lab
  » See http://cagardenweb.ucdavis.edu
- Include: Total N, NO3-N, P, K, Ca, Mg, soil texture, pH, OM, CEC, salts(?)
Selected Home Soil Testing Kits

“Rapitest”
(Luster Leaf)

“Soil Master”
(Mosser Lee)

“Professional”
(Luster Leaf)

pH Test Winners
## Soil Nutrient Analysis
### FOHC Vegetable Garden

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Org. matter (%)</strong></td>
<td>1.8</td>
<td>4.1</td>
<td>10.1</td>
<td>9.6</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>6.6</td>
<td>6.4</td>
<td>6.7</td>
<td>6.5</td>
</tr>
<tr>
<td><strong>Nitrate-N (ppm)</strong></td>
<td>1</td>
<td>16</td>
<td>0.8</td>
<td>95</td>
</tr>
<tr>
<td><strong>Phosphorus</strong></td>
<td>21</td>
<td>49</td>
<td>48</td>
<td>37</td>
</tr>
<tr>
<td><strong>Potassium</strong></td>
<td>59</td>
<td>221</td>
<td>173</td>
<td>163</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>1,611</td>
<td>2,658</td>
<td>3,649</td>
<td>2,117</td>
</tr>
<tr>
<td><strong>Magnesium</strong></td>
<td>374</td>
<td>277</td>
<td>320</td>
<td>559</td>
</tr>
</tbody>
</table>
Nitrogen Deficiency
General Chlorosis, Older Lvs.

Orange

Sycamore

Beans
Phosphorus Deficiency
   Purpling, Bronzing
Potassium Deficiency
Chlorosis, Necrosis, Boating

Prune

Pear
Iron Deficiency
Interveinal chlorosis, green veins

Oak

Tomato
Manganese Deficiency – Grape
Excess Salt & Boron Toxicity

Necrosis on edges, tips
Chloride Toxicity – Grape

Boron Toxicity – Walnut
Chlorine Toxicity? – Redwood
Herbicide Damage

Redwood

Pittosporum (mock orange)
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
  - Fertilizing Specific Plant Types
  - Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Synthetic Fertilizers

- Commonly derived from petroleum
- A typical 40-pound bag of lawn fertilizer contains the fossil-fuel equivalent of 2.5 gallons of gasoline (Univ. of Vermont)
- Prolonged use of ammonia-based fertilizers can greatly reduce soil pH
Making of Chemical Nitrogen Fertilizers

- Natural gas = 98% methane (CH$_4$)
- Chemical reactions $\rightarrow$ hydrogen gas (H$_2$)
- Air = 78% N$_2$
- Haber-Bosch Process:
  - High pressure & heat $\rightarrow$ Makes ammonia (NH$_3$)

Anhydrous ammonia
Conversions of Ammonia to Various N Fertilizers

- Ammonia → Ammonium Nitrate
- CaCO₃ → Calcium Nitrate
- Phosphate Rock → Nitric Phosphate
- Phosphate Rock & Phosphoric Acid → Mixed Acid Phosphate
- Ammonia & Sulfuric Acid → Ammonium Nitrate-Sulfate

- Sulfuric Acid → Ammonium Sulfate
- Phosphoric Acid → Ammonium Phosphates
- Carbon Dioxide → Urea
Examples of Chemical Nitrogen Fertilizers

- Ammonium sulfate (21-0-0-24S)
- Ammonium nitrate (34-0-0)
- Urea (46-0-0)
  - Highest %N; protein substitute in animal feeds
Slow-Release N Fertilizers

- **Synthetic**
  - UF (urea formaldehyde), MU (methylene urea), IBDU (isobutylidenediurea)
    - (uncoated; short & long-chain polymers)
  - Polymer-coated (e.g., Osmocote)
  - Longer lasting, not readily leached
  - Label says “Slow Release Nitrogen”
    - Water Insoluble Nitrogen (W.I.N.)
- **Natural** (e.g., compost, feather meal)
Polymer-Coated Fertilizer
Potash
(Potassium)

- Historically used for bleaching textiles, making glass, making soap (lye)
- Originally, came from extraction of $\text{K}_2\text{CO}_3$ by leaching ashes and evaporating the solution in iron pots, leaving a white residue ("pot ash")
- Now potash is the common term used for the fertilizer forms of potassium
- Standard measurement is potassium oxide ($\text{K}_2\text{O}$)
K attaches to soil particles
- K concentrated, so extra K leaches down

- Broadcasting K (or P) on ground has little effect – nutrients are locked up in top 1-2” of soil
  - Must be banded or incorporated
Mining of Potassium Fertilizers

- World reserves deposited when water from ancient inland oceans evaporated
  - K salts crystallized into beds of potash ore
  - Covered by thousands of feet of soil
- Most deposits chloride (KCl), some sulfate (K₂SO₄)
- From Canada (#1), Russia, Belarus, US (#7)
  - New Mexico, Utah, Canada
Rock Phosphate

- Source: Natural deposits in N. America, China, Morocco, & former Soviet Union
- N. America – Florida, Idaho/Mont./Utah/Wyoming, N. Carolina, Tennessee
- Soft-rock phosphate
  - 16% P and 19% Ca, many micronutrients
  - Form that plants can use more easily
  - Breaks down very slowly
By law, guaranteed content of fertilizer must be stated on bag

Expressed as % of each plant nutrient applied

N - P - K
‘Complete’ Fertilizers

Contain at least:

- **Nitrogen (N)**
  - % nitrogen (N)
- **Phosphorus (P)**
  - % phosphoric acid $P_2O_5$
- **Potassium (K)**
  - % potash $K_2O$
Example of Fertilizer Label

Miracle-Gro® All Purpose Plant Food 15-30-15

GUARANTEED ANALYSIS

Total Nitrogen (N) ............. 15%
5.8% Ammoniacal Nitrogen
9.2% Urea Nitrogen
Available Phosphate (P₂O₅) .... 30%
Soluble Potash (K₂O) ........... 15%
Boron (B) ...................... 0.02%
Copper (Cu) .................... 0.07%
0.07% Water Soluble Copper (Cu)
Iron (Fe) ...................... 0.15%
0.15% Chelated Iron (Fe)
Manganese (Mn) ............... 0.05%
0.05% Chelated Manganese (Mn)
Molybdenum (Mo) ........... 0.0005%
Zinc (Zn) ..................... 0.06%
0.06% Water Soluble Zinc (Zn)
Derived from Urea, Ammonium Phosphate, Urea Phosphate, Potassium Chloride, Boric Acid, Copper Sulfate, Iron EDTA, Manganese EDTA, Sodium Molybdate, and Zinc Sulfate.
Information regarding the contents and levels of metals in this product is available on the internet at:
http://www.regulatory-info-sc.com

Scotts Miracle-Gro Products, Inc., 14111 Scottslawn Road, Marysville, OH 43041
**GUARANTEED ANALYSIS**

Scotts® All Purpose Flower & Vegetable Continuous Release Plant Food 10-10-10 F643

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen (N)</td>
<td>10%</td>
</tr>
<tr>
<td>7.9% Urea Nitrogen*</td>
<td></td>
</tr>
<tr>
<td>2.1% Ammoniacal Nitrogen</td>
<td></td>
</tr>
<tr>
<td>Available Phosphate (P₂O₅)</td>
<td>10%</td>
</tr>
<tr>
<td>Soluble Potash (K₂O)</td>
<td>10%</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>2%</td>
</tr>
<tr>
<td>2% free Sulfur (S)</td>
<td></td>
</tr>
</tbody>
</table>

Derived from: Urea, Polymer-coated Sulfur-coated Urea, Potassium Chloride, and Ammonium Phosphate.

*Contains 5.3% slowly available Urea Nitrogen from Polymer-coated Sulfur-coated Urea.
Examples of Fertilizer Blend Ratios

Ratio

1-1-1 (e.g., 16-16-16): General purpose
2-1-1: Orn. & fruit trees, estab. lawns, leafy veggies
1-2-2: New lawns
1-2-1: Vegetables, seedlings, flowers, bulbs
0-1-1: Woody plants in fall
Fertilizer Blends

- N-P-K numbers not always the same
- “Complete” fertilizer = Contains N, P, & K
- “Balanced” fertilizer = Equal amounts of N-P-K
- Examples: 16-16-16 (multi-purpose), 12-4-8 (fruit tree & vine), 5-10-10 (tomato & veg.), 4-8-5 (camellia/azalea), 25-6-4 (lawns)
- Blends are not standardized!
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Should I Use Fertilizers?

- Garden soils rarely contain all nutrients in optimal amounts
- Equally rare for garden soil to be deficient in several nutrients
- When appropriate, add only N or the nutrients that are deficient
Vegetable Fertilization
Veg. Gardening Basics, UC Pub. 8059

- **Preplant:** N-P or N-P-K
  - Use 1/3 lb. N per 100 sq. ft.
  - Dry steer manure: 100 lb. per 100 sq. ft.
  - Chicken manure: 20 lb. per 100 sq. ft.

- **Side dressing when plants 3-4” high**
  - 0.4 lb. N per 100 sq. ft.
  - Banded application
Total lbs. of N/year to correct a deficiency:
- Large fruit tree: 1 lb.
- Small fruit tree: 0.5 lb.
- Large nut tree: 2 lbs.
- Small nut tree: 1 lb.

Deciduous trees: Late spring and summer

Citrus: Jan. or Feb. just before bloom, then in May and perhaps in June
“Adding fertilizer, soil amendments, or root stimulants to the planting hole or backfill soil is not recommended. Most nursery-grown trees are well fertilized during production and seldom respond to fertilizing at planting except in the most infertile soils.”
Tree Fertilization
Points to Remember

- Trees adapted to low soil N levels!
- Routine N-P-K fertilization unjustified unless deficiency exists
- High N wasteful, polluting, and may increase pest problems
- Trees in turf may not require fertilization
- Use compost, wood chip mulch
- Use slow release fertilizers
FERTILIZING

“Adding fertilizer, soil amendments, or root stimulants to the planting hole or backfill soil is not recommended. Most nursery-grown trees are well fertilized during production and seldom respond to fertilizing at planting except in the most infertile soils.”
Nutrient Deficiencies are Rare in Woody Ornamentals

- **N** – Sandy, overwatered, or sub soils
- **P** – Deficient in foothills
- **Ca, Mg** – Acidic or sandy soils
- **Fe, Mn, Zn, B** – High-pH or waterlogged soils
Lawn Fertilization
Practical Lawn Fertilization, UC Pub. 8065

- Cool-season grass: 4 lbs. actual N/1,000 sq. ft./year
- Low N-using species (buffalo, Zoysia): 2 lbs. N/year
- Slightly less where grasscycling is used
- Split applications: Up to 1 lb. N/application
- Organic and slow-release fertilizers:
  - Can use higher rate & fewer applications
Topics to be Covered

● Plant Nutrients
● Cation Exchange Capacity
● Soil pH
● Nutrient Analyses and Nutrient Deficiencies
● Fertilizers
● Fertilizing Specific Plant Types
● Calculating Fertilizer Amounts
● Organic Matter and Natural Fertilizers
● Synthetic vs. Natural Fertilizers
Calculating Fertilizer Amounts

Divide the amount of N needed by the %N

- Ammon. sulfate (21-0-0)
  1 lb. N/1,000 sq. ft. ÷ 0.21 = 4.8 lbs.

- Multi-purpose (16-16-16)
  0.5 lb. N/tree ÷ 0.16 = 3.1 lbs.

- Fruit tree fert. (12-4-8)
  0.75 lb. N/1,000 sq. ft. ÷ 0.12 = 6.3 lbs.
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Soil Organic Matter

- Serves as energy source (food) for microorganisms, which promote stable aggregation of the soil particles
- Essential nutrients are obtained by plants as organic matter decomposes
- Enhanced by OM additions but destroyed by cultivation
Humus

- What’s left over after organic matter decomposes
- Cannot be seen by naked eye
- Very reactive (CEC)
- In equilibrium with organic matter additions
Animal-Based Organic Fertilizers

- By-product of animal slaughter
  - Blood meal
  - Bone meal
  - Feather meal
  - Fish products

- Manures
  - Bat guano
  - Livestock manure
Blood Meal
13-1-0.6 (80% protein)

- Bovine blood collected from processing plants, agitated, dried, granulated
- Quick N release – ammonia can burn plants
Bone Meal
1-13-0 to 4-12-0, + 22% Ca

- **Uses**
  - Blooming bulbs (P)
  - May help prevent blossom-end rot (Ca)
  - Also useful for root growth of transplants (P)
- Bone meal is alkaline, so apply to soils of pH < 7
  - Need acidic soil to convert to plant-available P
Feather Meal
Usually 12-0-0

- Made from feathers of slaughtered poultry by hydrolyzing under high heat and pressure and then grinding
- Slow release of plant-available N
**Fish Products**

- Many forms, have some P, K, & micronutrients
- Fish emulsion, liquid fish (4-5% N)
  - Derived from fermented remains of fish
  - Has a fishy smell
- Hydrolyzed fish powder (11% N)
  - Mixed with water and sprayed on plants
- Fish meal (powder) (10% N)
  - Applied to soil
Bat/Seabird Guano

- Poop from bats and seabirds – Islands in Pacific & other oceans
  - From caves – loss of bats & biodiversity
- Bat guano: 3-10% N, up to 12% P, 1% K
- Seabird guano: Up to 12% N & P, 0-2% K
- More expensive than land-animal manures
Manures
Characteristics and Uses

- Poultry, dairy, feedlot, steer, rabbit, sheep/goat
- May contain salts and weed seeds
- N content varies greatly
  - Poultry may have >3% N (ammonia smell)
  - Aged feedlot manure may have <1% N
<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh broiler / rice hulls</td>
<td>3.9</td>
<td>2.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Fresh layer</td>
<td>4.0</td>
<td>6.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Aged layer</td>
<td>2.2</td>
<td>8.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Fresh dairy corral</td>
<td>2.4</td>
<td>1.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Aged steer corral</td>
<td>1.3</td>
<td>1.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Broiler / rice hulls compost</td>
<td>1.9</td>
<td>4.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Dairy compost</td>
<td>1.4</td>
<td>1.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Dairy / steer compost</td>
<td>1.7</td>
<td>0.8</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Compost
Characteristics and Uses

- Contains most nutrients required by plants
- May contain weeds & plant pathogens
- N content usually about 1-1.5%, very slow release
- Considered a soil amendment, not fertilizer
Available N from Manures, Compost Decay Series

- UC research, 1970s
- Average plant-available N over 3 years (years 1, 2, and 3):
  - Chicken (90%, 10%, 5%)
  - Dairy (75%, 15%, 10%)
  - Feedlot (35%, 15%, 10%)
  - Compost (~10% in year 1)
## Plant Available Nitrogen

### Organic Fertilizer Calculator (Oregon Tilth, OSU)

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Total % N</th>
<th>PAN, 28 days</th>
<th>PAN, season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa meal (2.5-0.5-2)</td>
<td>2.5</td>
<td>11</td>
<td>26</td>
</tr>
<tr>
<td>Bat guano—high N (10-3-1)</td>
<td>10.0</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Blood meal (12.5-1.5-0.6)</td>
<td>12.5</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Corn gluten meal (9-0-0)</td>
<td>9.0</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Cottonseed meal (6-0.4-1.5)</td>
<td>6.0</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Feather meal (12-0-0)</td>
<td>12.0</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Fish meal (10-6-2)</td>
<td>10.0</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Nutri-Rich (4-3-3)</td>
<td>4.0</td>
<td>36</td>
<td>51</td>
</tr>
<tr>
<td>Soy meal (6.5-1.5-2.4)</td>
<td>6.5</td>
<td>60</td>
<td>75</td>
</tr>
</tbody>
</table>
Plant-Based Organic Fertilizers

- Alfalfa meal
- Cottonseed meal
- Soybean based
- Kelp/seaweed
Alfalfa Meal
(About 2-1-2)

- From alfalfa plants, pressed into pellets
- Also contains micronutrients
- Especially good for roses, also vegetables
- Fairly quick N release
Cottonseed Meal
(About 6-2-1)

- Derived from the seed in cotton bolls
- Some people have concerns about heavy pesticide use on cotton and remaining in the seed oils, so they choose organic
- Very slow N release
Kelp/Seaweed

- Derived from sea plants off Norway, N. Calif.
- Available as liquid, powder, or pellet
- Applied to the soil or as a foliar spray
- Little N-P-K, mainly used for micronutrients, hormones, vitamins, and enzymes
- “Can help increase yields, reduce plant stress from drought, and increase frost tolerance”
Topics to be Covered

- Plant Nutrients
- Cation Exchange Capacity
- Soil pH
- Nutrient Analyses and Nutrient Deficiencies
- Fertilizers
- Fertilizing Specific Plant Types
- Calculating Fertilizer Amounts
- Organic Matter and Natural Fertilizers
- Synthetic vs. Natural Fertilizers
Synthetic Fertilizers

- No C-H linkage, so not used as energy source by soil microbes
- Nutrients in synthetic fertilizers are attached directly together with ionic bonding, which separates or dissociates readily in water
- Because of the lack of carbon, fertilizers “feed the plant but not the soil.”
Natural Fertilizers

- Carbon-hydrogen linkage in natural fertilizers slows the release of the nutrient ions
- Carbon forms covalent bonds with carbon and other elements – allows the formation of complex chemicals and structures
- Slow release, low leaching and burning potential
- “Feed the plant and feed the soil”
Synthetic vs. Natural Fertilization

- Plants take up nutrients from natural and synthetic sources (no preference)
- Natural fertilizers feed soil microbes and require them for breakdown
- Microbes (and roots) release compounds like organic acids, enzymes, and chelates $\rightarrow$ convert nutrients from organic form into a plant-available (soluble) form
Advantages of Synthetic Fertilizers

- Nutrients available to plants immediately
- Produce exact ratio of nutrients desired
- Ratios and chemical sources easy to understand
- Inexpensive
Disadvantages of Synthetic Fertilizers

- Made from nonrenewable sources (fossil fuels)
- May not promote soil health
  - No decaying matter for improving soil structure
  - Most do not replace micronutrients
- Nutrients readily available → chance of overfert.
- Tend to leach faster than organic
- Long-term use can change soil pH, harm soil microbes, increase pests
Advantages of Natural Fertilizers

- May also improve soil structure
- Most are slow-release; not easy to overfertilize
- Renewable and biodegradable
- Can make your own from waste (compost, worm castings) or locally (manure)
Disadvantages of Natural Fertilizers

- May not release nutrients as they are needed
- Nutrient content of manure & compost often unknown
- % nutrients usually lower than chemical fertilizers
- Tend to be bulkier, requiring more fossil fuels and producing more GHG; more expensive
How Much Does it Cost?

- 2-lb. box with 12% nitrogen = ?
- 2-lb. box with 12% nitrogen = 0.24 lbs. N
- $6 a box / 0.24 lb. N = ?
- $6 a box / 0.24 lb. N = $25.00/lb. N
## Nutrient Costs of Selected Fertilizers
Local Sacramento Nursery, April 201

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight</th>
<th>Analysis</th>
<th>Price</th>
<th>$/Lb. of N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SYNTHETIC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azalea/Camellia</td>
<td>5 lbs.</td>
<td>10-10-6</td>
<td>$7.50</td>
<td>$15.00</td>
</tr>
<tr>
<td>Rose</td>
<td>“</td>
<td>10-12-6</td>
<td>$7.50</td>
<td>$15.00</td>
</tr>
<tr>
<td>All-Purpose</td>
<td>“</td>
<td>16-16-16</td>
<td>$7.50</td>
<td>$9.38</td>
</tr>
<tr>
<td>Citrus</td>
<td>“</td>
<td>14-4-8</td>
<td>$7.50</td>
<td>$10.71</td>
</tr>
<tr>
<td><strong>“NATURAL” BRAND</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azalea/Camellia</td>
<td>4 lbs.</td>
<td>5-5-3</td>
<td>$7.50</td>
<td>$37.50</td>
</tr>
<tr>
<td>Rose</td>
<td>“</td>
<td>5-6-3</td>
<td>$7.50</td>
<td>$37.50</td>
</tr>
<tr>
<td>All-Purpose</td>
<td>“</td>
<td>5-5-5</td>
<td>$7.50</td>
<td>$37.50</td>
</tr>
<tr>
<td>Citrus</td>
<td>“</td>
<td>7-3-3</td>
<td>$7.50</td>
<td>$26.79</td>
</tr>
</tbody>
</table>
### Nutrient Costs of Selected Fertilizers
#### Local Nursery vs. Farm Supply Co.

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight</th>
<th>Analysis</th>
<th>$/Lb. N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LOCAL NURSERY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa meal</td>
<td>3 lbs.</td>
<td>2-0-3</td>
<td>$108</td>
</tr>
<tr>
<td>Blood meal</td>
<td>3.5 lbs.</td>
<td>13-0-0</td>
<td>$20</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>3.5 lbs.</td>
<td>6-2-1</td>
<td>$31</td>
</tr>
<tr>
<td>Bat guano</td>
<td>1.5 lbs.</td>
<td>9-2-1</td>
<td>$70</td>
</tr>
<tr>
<td><strong>FARM SUPPLY CO.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa meal</td>
<td>40 lbs.</td>
<td>3-0-2</td>
<td>$25</td>
</tr>
<tr>
<td>Blood meal</td>
<td>50 lbs.</td>
<td>14-0-0</td>
<td>$14</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>50 lbs.</td>
<td>5-2-1</td>
<td>$18</td>
</tr>
<tr>
<td>Bat guano</td>
<td>25 lbs.</td>
<td>9-3-1</td>
<td>$25</td>
</tr>
</tbody>
</table>
## Nutrient Costs of Selected Fertilizers

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight</th>
<th>Analysis</th>
<th>$/Lb. N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feather meal</td>
<td>50 lbs.</td>
<td>13-0-0</td>
<td>$8</td>
</tr>
<tr>
<td>Nutri-Rich:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Farm Supply</td>
<td>50 lbs.</td>
<td>4-3-2</td>
<td>$7</td>
</tr>
<tr>
<td>- Local</td>
<td>50 lbs.</td>
<td>4-3-2</td>
<td>$10</td>
</tr>
<tr>
<td>Soybean meal:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Farm Supply</td>
<td>40 lbs.</td>
<td>7-2-1</td>
<td>$20</td>
</tr>
<tr>
<td>- Modesto Milling</td>
<td>50 lbs.</td>
<td>7-2-1</td>
<td>$10</td>
</tr>
</tbody>
</table>
Pelleted chicken manure

Pelleted feather meal

Org. soybean meal
Organic Soybean Meal

Farm Supply Co.
40 lb. bag, $70

Modesto Milling
50 lb. bag, $37
Organic Fertilization of FOHC Garden
Early Years
Fertilization of FOHC Garden
Currently

Pelleted chicken manure
Cover Crops
Cover Crops
Definitions

Cover crop
- A non-harvested crop planted to provide any of a number of benefits, such as improving soil quality, reducing erosion, adding N, and/or attracting beneficial insects

**Green manure**
- A crop grown & plowed under for its beneficial effects to the soil and subsequent crops
Cover Crops

Benefits

- Lowest energy use: On-site production of N
  - May still need additional N
- Add organic matter
- Improve soil tilth and water penetration
Cover Crops
Problems

- Seed can be difficult to find
- Cannot grow winter crop in that space
- Requires chopping and rototilling in spring
Cover Crops
C/N Ratio

- Low ratios (legumes) – rapid decomposition, net release of N
- High ratios (grasses) – slow decomposition, & net tie-up of N
<table>
<thead>
<tr>
<th>RESIDUE</th>
<th>C/N RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legume</td>
<td>15:1 to 20:1</td>
</tr>
<tr>
<td>Brassica</td>
<td>20:1 to 30:1</td>
</tr>
<tr>
<td>Grass</td>
<td>40:1 to 80:1</td>
</tr>
</tbody>
</table>
Cover Crops
Species

- Standard winter green manure legume mix:
  - High N mix: Bell beans, vetch, and field peas
  - Add for soil tilth (or use alone): Oats or barley
- Annual reseeding mix (orchards & vineyards):
  - Crimson, rose, subclover + bur medic
- Summer:
  - Cowpeas, buckwheat
Grass alone may require N

Avoid N fertilizers on legumes
  » High soil N → legumes fix little N

Max. N contribution is at early flowering (incorporate in March)

>80% of N is in above-ground parts; <20% in roots
**Cover Crops**

**Nitrogen Fixation of Legumes**

- Atmosphere = 78% N; only legumes can use
- Rhizobium bacteria in roots use N in soil air
  - Store N in nodules on roots
  - Resemble root-knot nematodes
- Most N translocated to foliage
Nodules Created by Rhizobium Bacteria

Berseem clover
Bell Bean vs. Fava (Horse) Bean

- Bell beans smaller, cheaper to plant
- Fairly easy to cut & rototill
- Harvest fava beans → less N
Annual Clovers

- Self reseeding
- For orchards and vineyards
Cover Crops
Planting and Incorporation

- Good seedbed preparation; inoculate seed
- Scatter seed and rake in
- Rototill 3-4 weeks before planting spring crop
  - Soil-borne diseases may be worse
  - Tie-up of soil N
Inoculating Legume Seeds

- Insures that N fixation will occur
- Use at least 1 oz./10 lbs. of seed
- To help inoculant adhere to the seed:
  - Mix 9:1 hot water (non-chlor.) + corn syrup
  - Let cool, add a small amount to seeds
- Not essential to inoculate for same soil in year 2
- Good to inoculate garden peas & beans too
Questions?