

Plant Nutrition & Soil Fertility

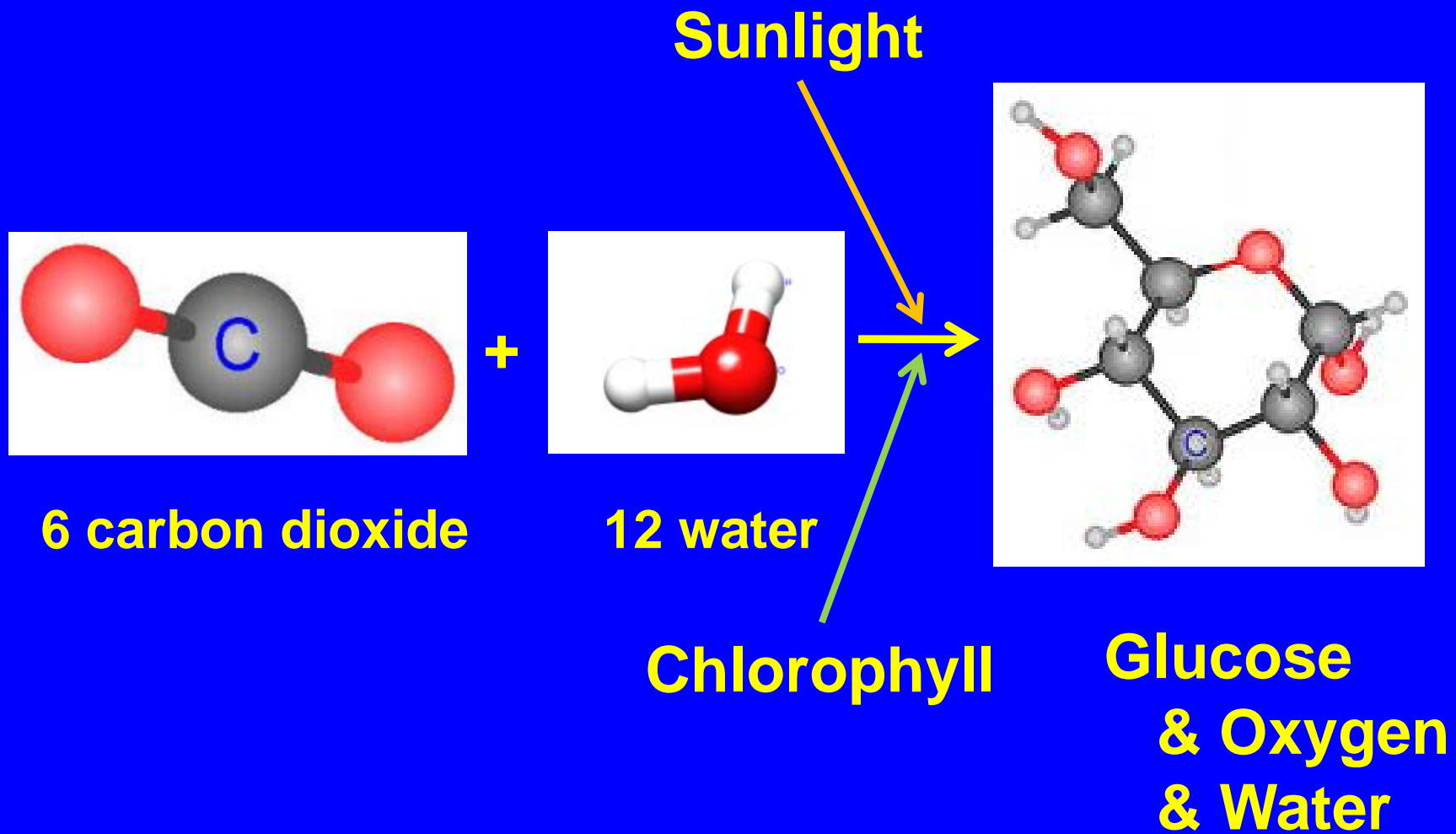
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Plant Nutrition

- 1. Plants feed themselves through photosynthesis and nutrients from soil**
- 2. In agriculture and landscapes, normally plants need fertilizer to grow properly**
- 3. Knowing which nutrients to apply and how much can save money and protect the environment**

Photosynthesis



Functions of Nutrients in Plants

- **Chlorophyll -- photosynthesis**
- **Amino acids and proteins**
- **DNA**
- **Plant hormones and enzymes**
- **Plant moisture balance**
- **Energy transfer**

How do Fertilizers Help Plants?

- Improve the growth, yield and appearance of plants
- Plant function better: turf, shade, hedge, habitat, food production

Macro and Micro Nutrients from Fertilizers

- **Macro Nutrients**

- Nitrogen
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulfur

- **Micronutrients**

- Boron
- Iron
- Manganese
- Zinc
- Copper
- Chloride
- Molybdenum

The Fertility of the Soil Influences the Nutrition of Plants

- **Soils differ in their abilities to supply nutrients to plants:**
- **Loams and clay loams tend to be richer in nutrients than sandy loams and sands**
- **All soils can be improved by additions of organic matter (compost, aged manures, cover crops, mulches, etc)**

Key Plant Nutrients Occur as Cations or Anions

Cations

- NH_4^+ (ammonium)
- Ca^{2+} (calcium)
- Mg^{2+} (magnesium)
- K^+ (potassium)

Anions

- NO_3^- (nitrate)
- SO_4^{2-} (sulfate)
- H_2PO_4^- (phosphate)

Soil Characteristics

- **Clays and organic matter have predominantly negative charges that can hold onto cations**
- **Anions such as sulfates are retained in soil organic matter and phosphates are retained on secondary minerals as well as organic matter**
- **Nitrates are not attracted to soil and are subject to leaching with rain or excessive irrigation**

Cation Exchange Capacity CEC

meq/100grams soil

It is a measure of the soil's ability to retain cations

- **Organic Soils:** > 50
- **Clay soils:** > 25 – 50
- **Silty soils:** > 8 – 30
- **Sandy soils:** > 5 – 15

Soil Acidity or Alkalinity

- The pH of the soil is a measure of the acidity or alkalinity
- pH 7.0 is neutral
- Soil pH's greater than 7.0 are basic
- Soil pH's lower than 7.0 are acidic
- The general range of soils in this area is 5.5 to 7.5
- The preferred pH depends on the species of plant

Factors that Affect Soil pH

- Irrigation water pH
- Climate:
 - Humid areas tend to have lower pH soils
 - Arid areas tend towards alkaline soils
- Parent material:
 - High calcium may result in high pH
 - High sulfur may result in low pH
- Management
 - Fertilizers

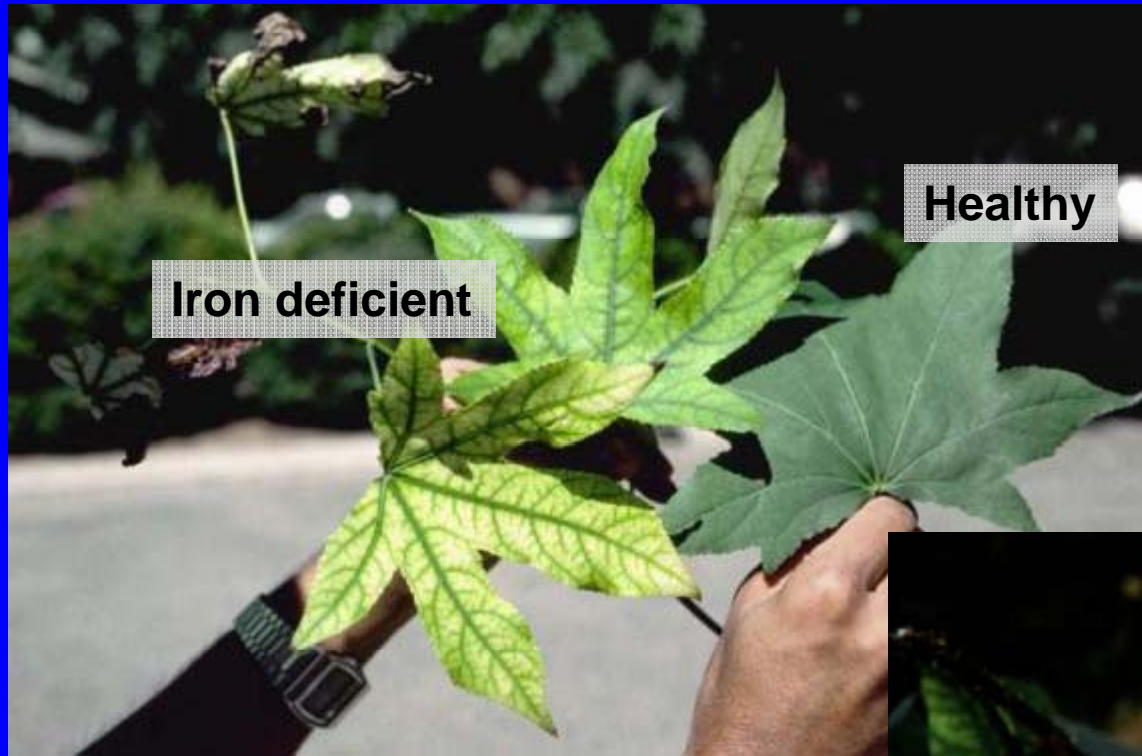
Optimal pH Ranges

- **Most garden plants grow well with pH's that range from 5.5 to 7.5**
- **Acid loving plants need soil pH at 4.5 to 5.5**
- **Soil pH affects the availability of certain nutrients – particularly phosphorus and iron**

Soil pH can be managed

- **To raise the pH**
 - **Lime (CaCO_3) supplies Ca, raises pH**
 - **Dolomite lime supplies Ca & Mg**
 - **The amount needed to raise pH can be estimated, but a good soil pH measurement is needed**
- **To lower the pH (for acid loving plants)**
 - **Soil sulfur**
 - **Aluminum sulfate**

Iron Deficiency caused by too high soil pH



Iron deficient

Healthy

Liquid Amber



Rose

Plant Nutrition



Common Plant Nutritional Problems

- **Common Deficiencies**
 - Nitrogen
 - Potassium
 - Phosphorus
 - Zinc
 - Iron
- **Common Toxicities**
 - Boron
 - Chlorine
 - Sodium

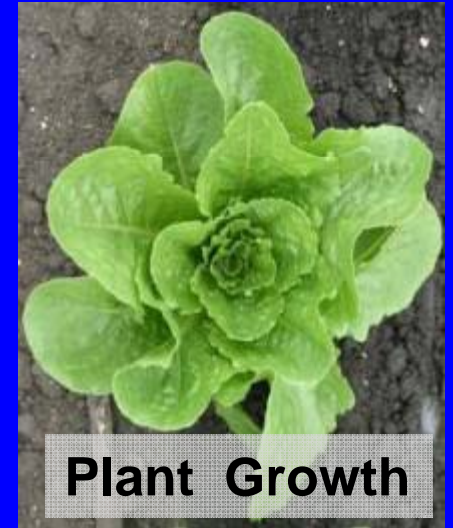
Nitrogen

- **Very important for many aspects of growth and development**
- **Taken up as NO_3^- (nitrate) and NH_4^+ (ammonium)**
- **Nitrogen in fertilizers converted to nitrate by microorganisms**
- **Deficiency: chlorosis (yellowing) of older leaves (nitrogen moves to younger tissue when limited)**
- **Excess: Dark green, excessive vegetation growth**

Manure, Mulches



Fertilizer
Urea, NH_4^+ , NO_3^-



Plant Growth

Organic Matter
1000 – 3000 lbs N/A

NH_4^+

NO_3^-

Nitrate Losses



Fertilizer runoff reduces water quality



Older Leaves turn yellow



**Pale Green
and Smaller
Nitrogen Deficient**

**Dark Green
Sufficient Nitrogen**

Phosphorus

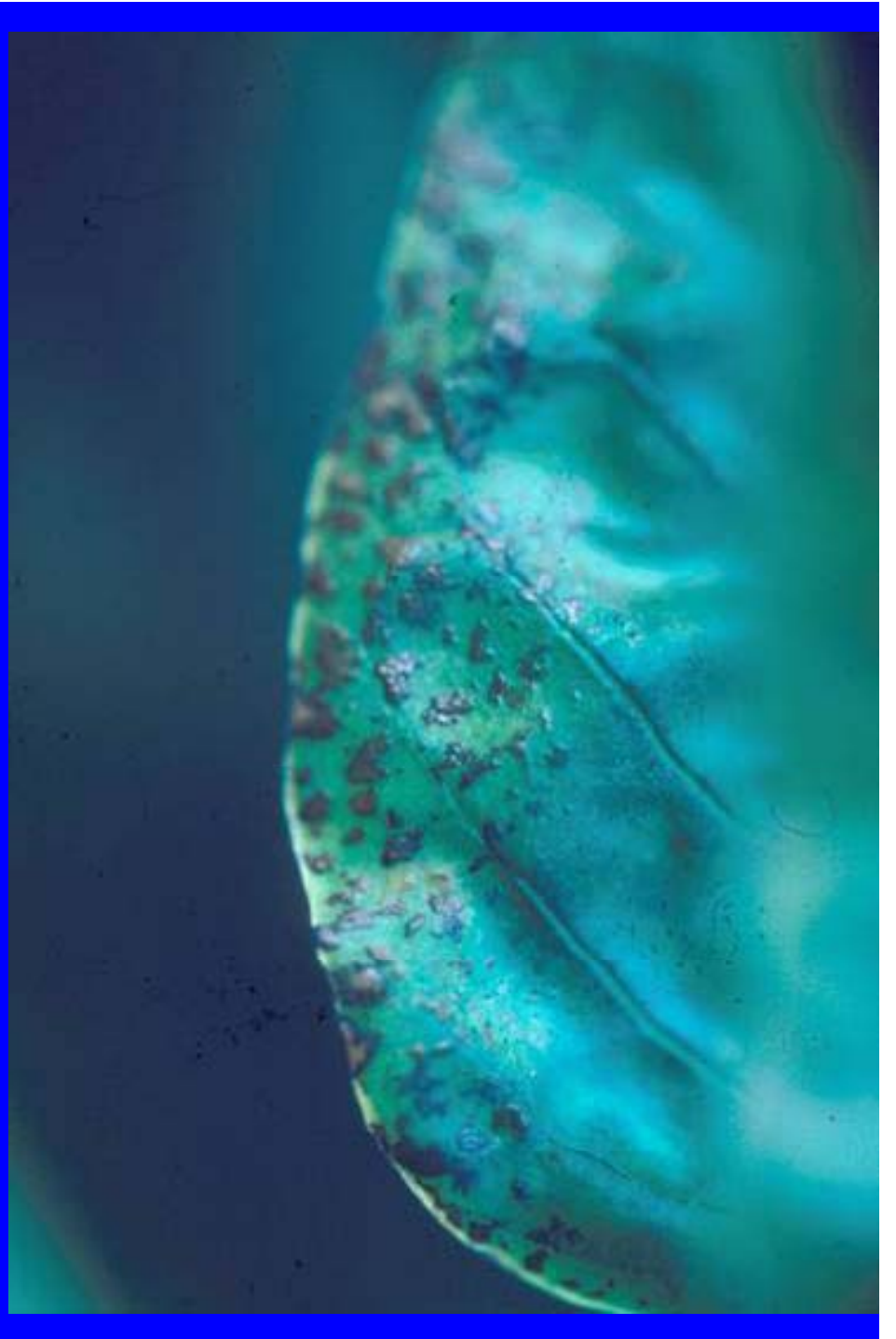
- **Stimulates early growth and root formation, promotes seed formation, important in photosynthesis**
- **Deficiency:**
 - **Causes plant stunning and purplish casts on leaves**

**Phosphorus deficiency can show purpling,
but most common symptom is stunting**



Potassium

- Important for stomate opening/closing, cell division, starch and protein synthesis, size and quality of fruit and disease resistance
- Taken up as K^+
- Can be tied up in soil minerals
- Deficiency: Symptoms include scorching along leaf margins, slow growth, weak stems, poor roots



**Poor root growth caused by nematodes
caused potassium deficiency on peppers**



Calcium

- Essential component of plant cell walls and membranes
- Young tissues show deficiencies first
- Excess calcium lead to high pH
- Deficiency:
 - Reduced terminal growth of shoots
 - Blossom end rot of tomatoes
 - Tip burn on lettuce, cabbage



Iron

- **Essential component of chlorophyll synthesis**
- **Deficiency:**
 - **Due to high pH,**
 - **Common when acid-loving plants are in alkaline soils**

**Blueberry with Interveinal
chlorosis caused by iron
deficiency from too high
soil pH**



Fertilization of Garden Soils

- **Nutrition management in gardens is relatively simple in California**
- **Most soils have sufficient levels of essential nutrients**
- **Mostly garden soils require small amounts of supplemental nitrogen fertilizer to achieve good growth**
- **The use of composts and manures typically provide sufficient quantities of the other essential macro and micro nutrients**



Sources of Nitrogen

- **Organic matter - manure, compost, prior crop residues, mulches**
- **Cover crops**
- **Organic fertilizers**
 - **Recycled nutrients (slaughter house by products, mined guano, fish, seed meals)**
- **Commercial fertilizers**
 - **Salts of ammonium & nitrate as well as urea**

Common Dry Organic Fertilizers

Fertilizer	Nitrogen	Phosphorus	Potassium
Feather Meal	12	0	0
Blood Meal	13	0	0
Meat Meal	8	5	1
Bone Meal	2	5	0
Fish Meal	10-11	6	2
Chicken Manure	2-3	1.5	1.5
Alfalfa Meal	4	1	1
Kelp	<1	0	4



Nitrogen Availability from Dry Organic Fertilizers

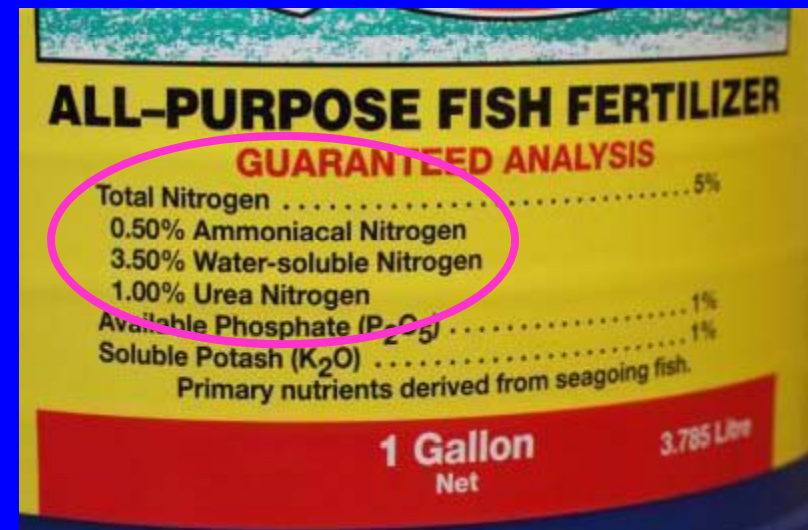
- In general nitrogen release from organic materials is a two stage process where 50-60% of the N is released in the first two weeks mostly by hydrolysis**
- This is from the breakdown of simple compounds such as urea and proteins**

Nitrogen Availability from Dry Organic Fertilizers

- **There is then a slower release that is accomplished by microbial degradation of more complex molecules that may extend over a period of several months**

Nitrogen Availability from Liquid Organic Fertilizers

- These materials generally have rapid N availability
 - 70-80% in 1st 2 weeks
- Their cost per unit of nitrogen can be much higher than other sources of organic N



Out of the 5% in the fish Emulsion:

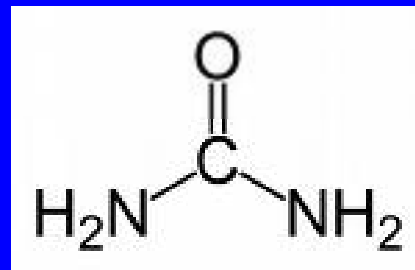
- 1.5% is ammonical & urea
- 3.5% is water soluble (probably amino acids and proteins which are rapidly broken down)

For further information on organic fertility management

- <http://anrcatalog.ucdavis.edu/>
 - Go to free publications
 - Soil Fertility Management for Organic Crops
 - Publication Number: 7249
- <http://cemonterey.ucdavis.edu/>
 - Search “Crop Notes” newsletter for articles on organic fertilizers

Conventional Nitrogen Fertilizers

- The nitrogen comes as ammonium and nitrate salts or as urea
- Examples include ammonium sulfate, calcium nitrate, urea
- Urea and needs to be broken down enzymatically to ammonium and is most slowly available of these three forms



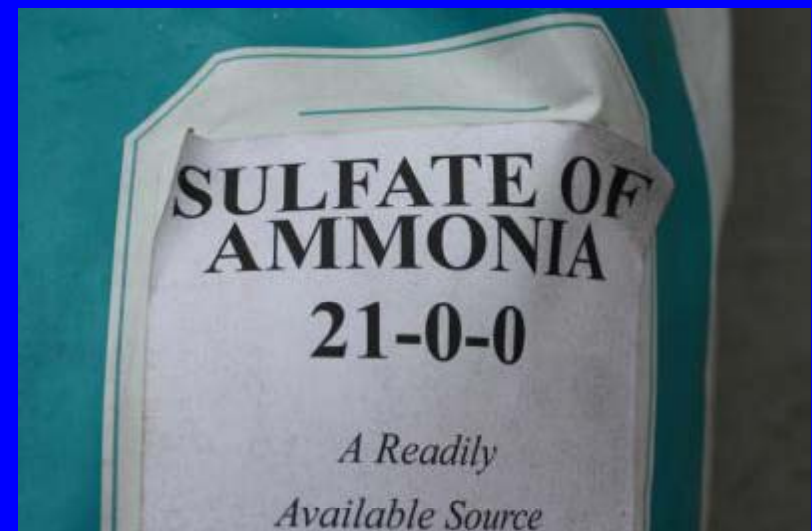
Urea

Miracle-Gro® Water Soluble All
GUARANTEED

Total Nitrogen (N)	24%
3.5% Ammoniacal Nitrogen	
20.5% Urea Nitrogen	
Available Phosphate (P ₂ O ₅).....	8%
Soluble Potash (K ₂ O)	16%
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)	

**A fertilizer with N,P,K & micros
expensive per unit of N**

**Thinking about the
source of N
for your needs**



**Ammonium sulfate
inexpensive source of N**

Nitrogen Conventional Fertilizers

- Some plants are sensitive to large quantities of ammonium in their tissue
- Urea and ammonium fertilizers can build up high ammonium in the soil, especially when soil temperatures are cool (<50 °F)



Nitrogen Conventional Fertilizers

- Some plants are not sensitive to ammonium
- Ammonium and urea are commonly found in azalea and citrus fertilizers
- Ammonium mineralizes rapidly to nitrate in warm soils (>60 °F)



Phosphorus and Potassium Fertilizers

- **P & K can be supplied by composts and mulches**
- **Many fertilizers contain all three of these nutrients, but you have to carefully decide if all three are necessary**
- **A soil analysis is a good way to determine if P & K are necessary**

Organic materials can contain 0.5 to 3.0% of Phosphorus and Potassium and can supply all Of the needed micronutrients



Commercial Compost



Household Compost



Manure



Mulches

Thank you for your attention

- **Any questions?**