WHY ARE WOODY PLANTS SOMETIMES YELLOW?

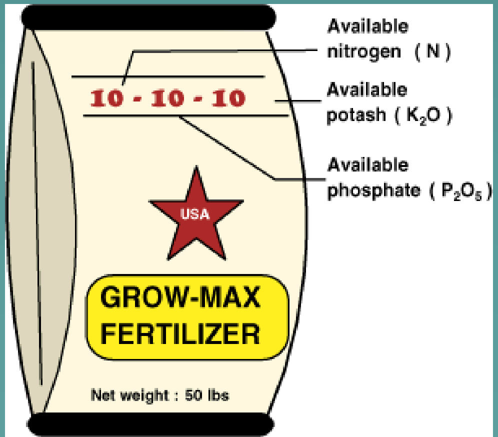
Understanding, Diagnosing, and Managing Soil Nutrient Issues

INTRODUCTION

- Factors contributing to chlorosis
- How to diagnose nutrient deficiencies
- Consequences of improper diagnosis
- Best management practices (BMP’s for nutrient deficiencies

ESSENTIAL MACRONUTRIENTS

◆ Nitrogen (N)	◆ Amino acids, proteins, DNA
◆ Phosphorus (P)	◆ Energy (ATP)
◆ Potassium (K)	◆ Regulatory enzymes
◆ Magnesium (Mg)	◆ Chlorophyll and energy
◆ Calcium (Ca)	◆ Cell division and cell walls
◆ Sulfur (S)	◆ Synthesis of proteins and hormones



ESSENTIAL MICRONUTRIENTS

- Iron (Fe)
- Manganese (Mn)
- Copper (Cu)
- Boron (B)
- Chlorine (Cl)
- Zinc Zn)
- Molybdenum (Mo)

- Chlorophyll, proteins
- Activates enzymes
- N-fixation, proteins
- Translocation, cell growth
- Stimulates auxin synthesis
- Transforms nitrate to amino acids

MOBILITY OF PLANT NUTRIENTS

Nitrogen	Mobile
Phosphorus	Mobile
Potassium	Mobile
Calcium	Non-Mobile
Magnesium	Mobile
Sulfur	Non-Mobile

MOBILITY OF PLANT NUTRIENTS

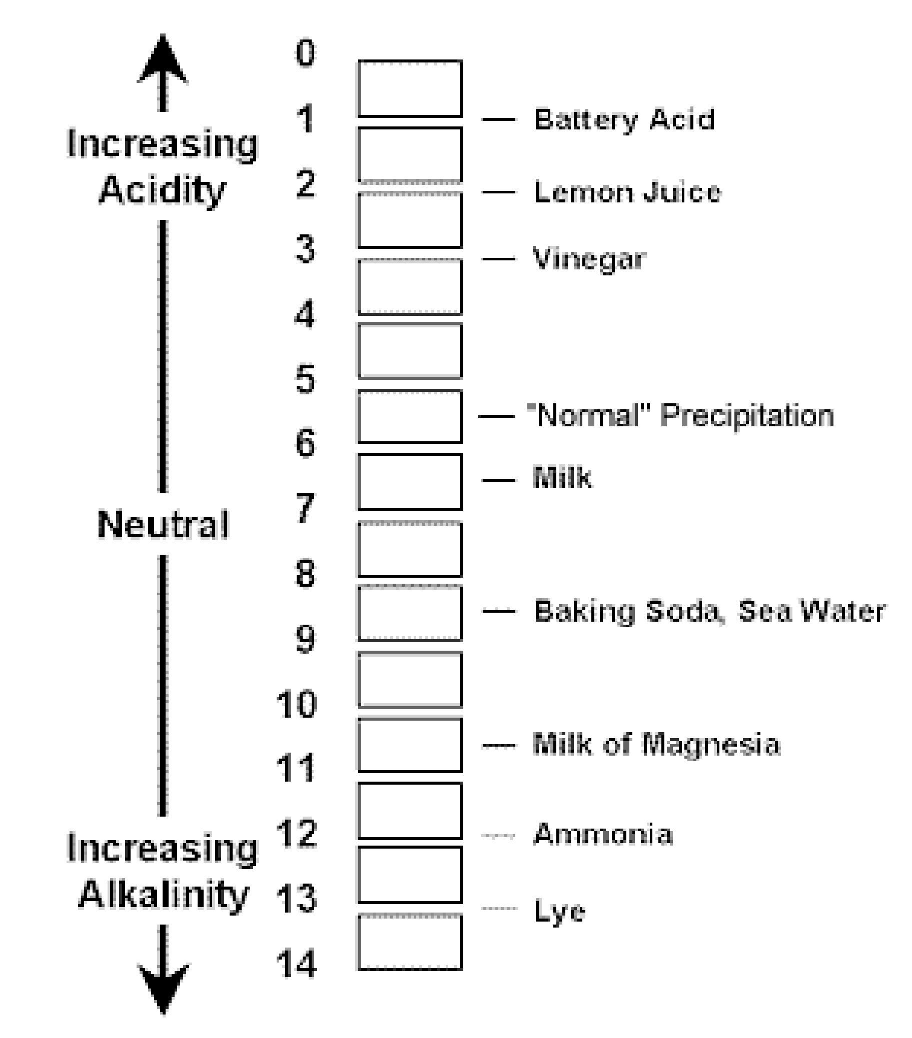
Boron	Non-mobile
Copper	Non-mobile
Iron	Non-mobile
Manganese	Non-mobile
Molybdenum	Non-mobile
Zinc	Non-mobile

FACTORS AFFECTING NUTRIENT AVAILABILITY

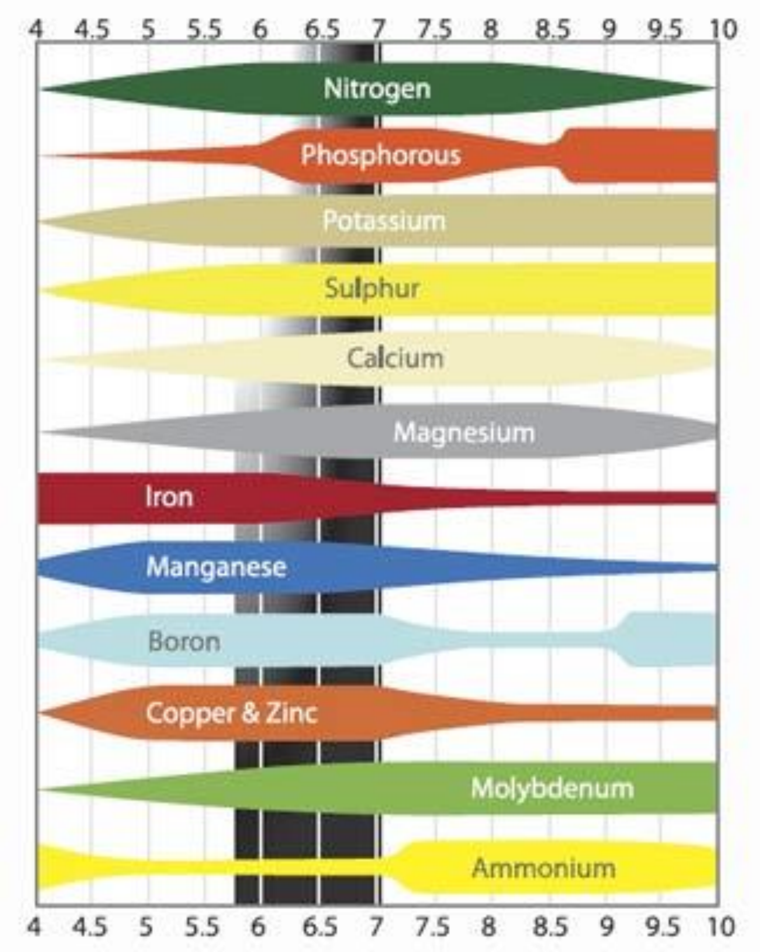
- pH
- Soil texture and structure
- Drainage
- Amount of organic matter
- Soil microbes, vegetation, animals
- Soil formation and geology
- Soil disturbance

WHAT IS pH?

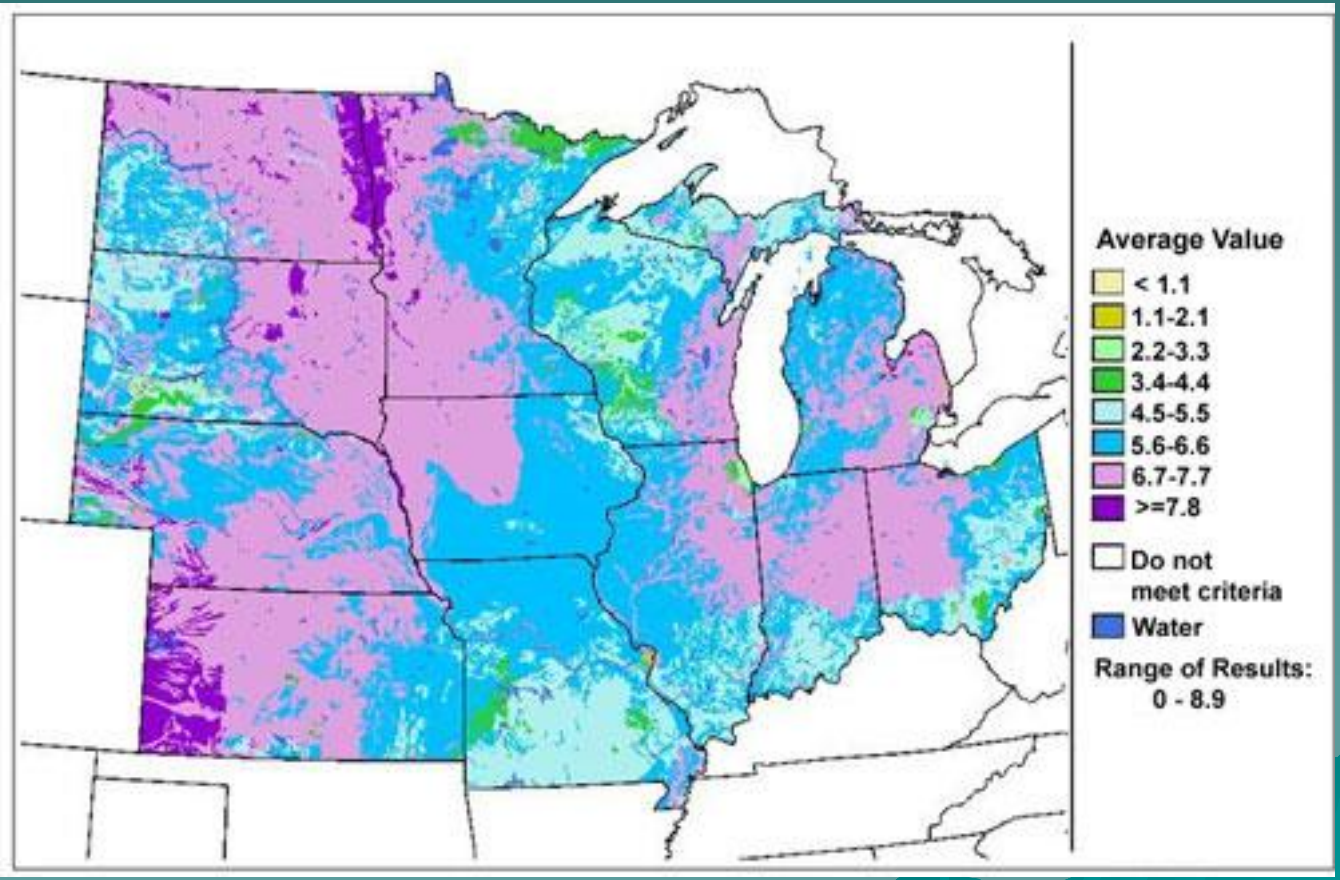
- Measure of acidity and alkalinity
- Expresses the concentration of H+ ions present in solution



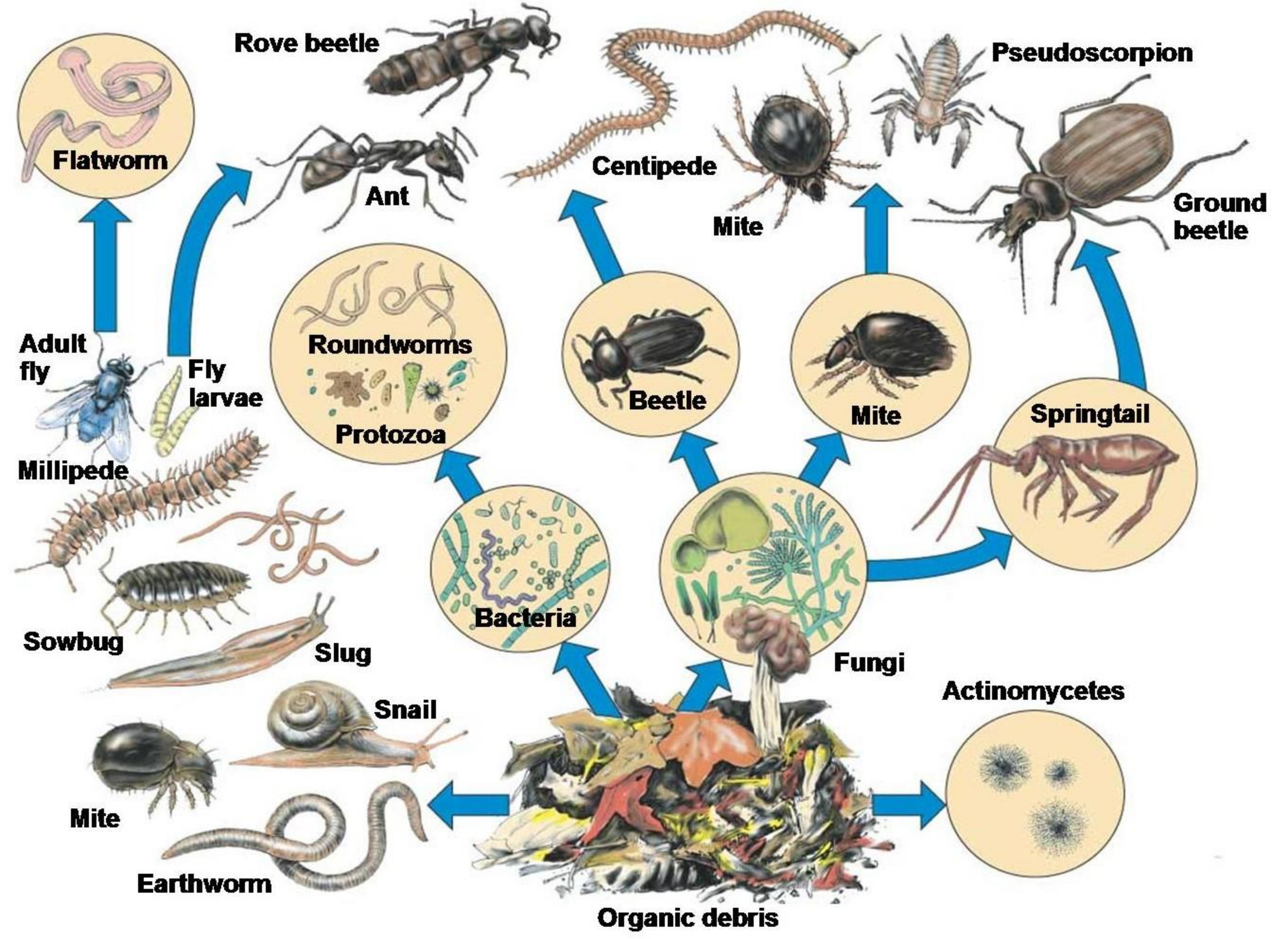
pH AND NUTRIENT AVAILABILITY



REGIONAL pH VALUES



SOIL BIODIVERSITY



EFFECTS OF DROUGHT ON BIOLOGICAL CYCLES

- Organisms involved in the first phases of decomposition switch from nutrient cycling to survival
  - Earthworms move deeper into the soil
  - Protozoa, nematodes, insects go dormant

EFFECTS OF DROUGHT ON BIOLOGICAL CYCLES

- Moisture is required for microbes for decomposition and release of N, P, K, and S for plant uptake

- Midwestern micro-organisms (bacteria, fungi) are **mesophiles**
  - Grow from 15 to 30^{o}C (58 to 88^{o}F)
  - Upper threshold is about 40^{o}C (103^{o}F)

EFFECTS OF DROUGHT ON BIOLOGICAL CYCLES

- Nucleic acids (DNA/RNA) and proteins are irreversibly denatured or damaged
- Cell membranes and walls may rupture
- Microbes can succumb to heat stress and desiccation under severe drought

EFFECTS OF DROUGHT ON BIOLOGICAL CYCLES

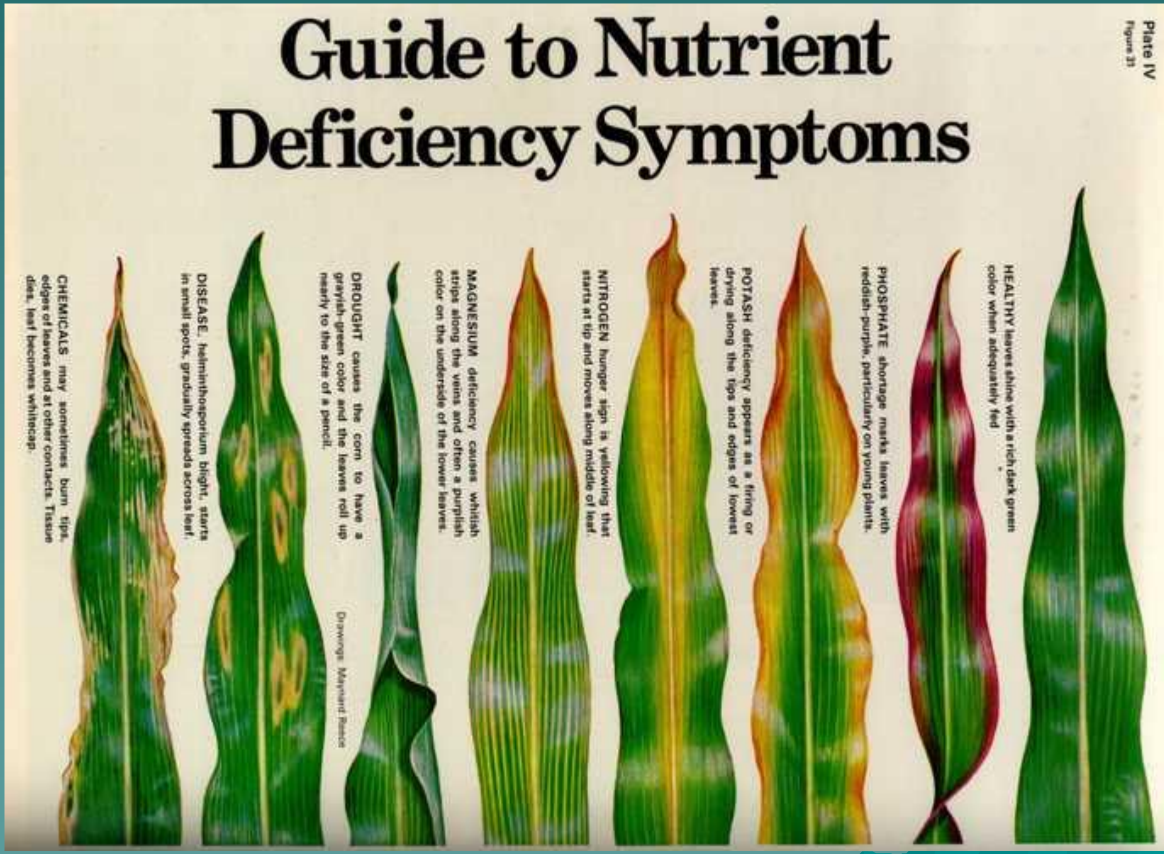
- Bare soil temperatures at Sanborn Field at UMC from 28 June to 27 July 2012 at 2-4 inches ranged from 80 to 94^{o}F

EFFECTS OF DROUGHT ON BIOLOGICAL CYCLES

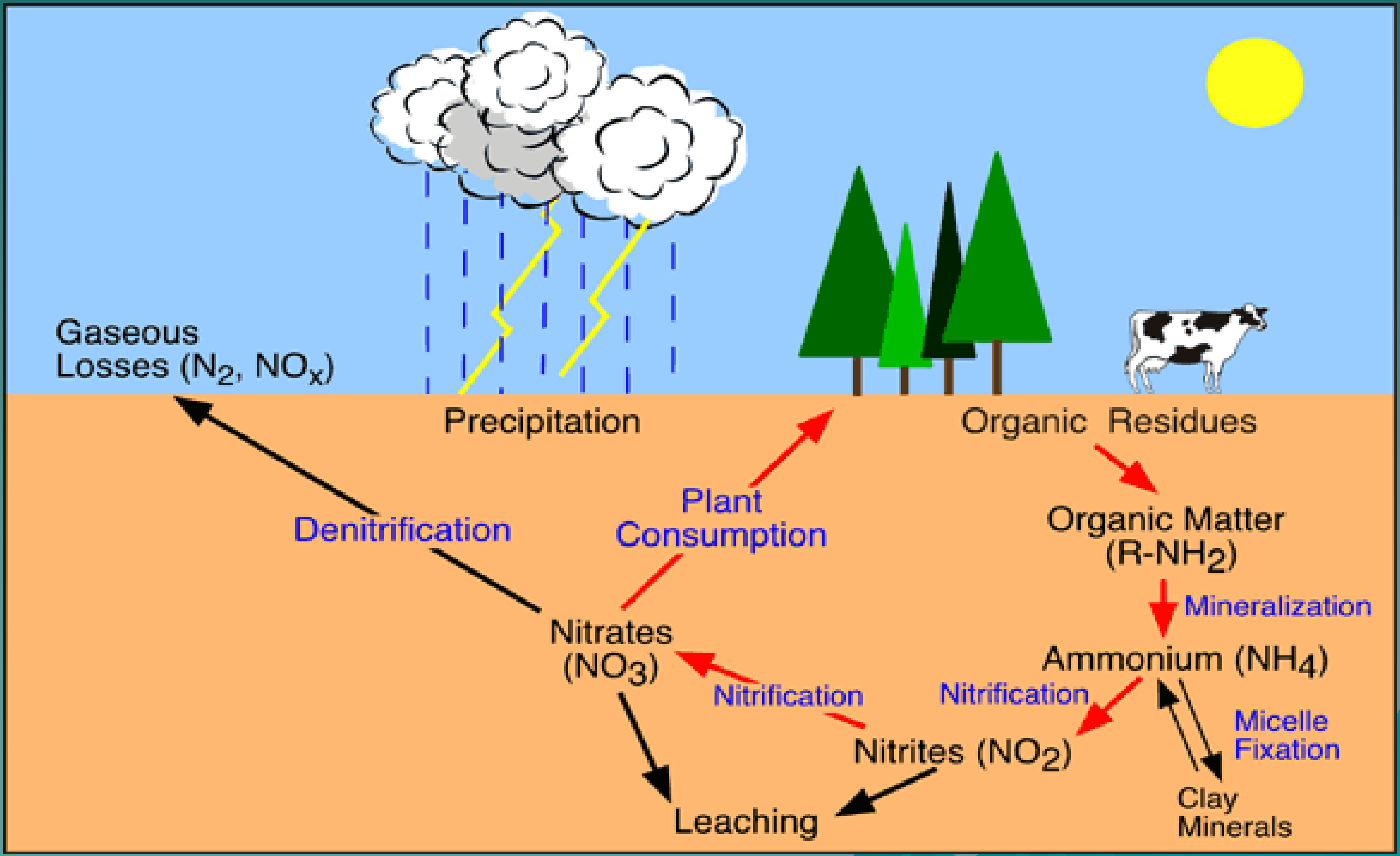
- Micro-organisms are resilient
- **N fixing bacteria are sensitive to high temperatures**
- Enzyme activity can be reduced by 80% or more for cycling nitrogen, phosphorus, and carbon

NUTRIENT DEFICIENCIES THAT LEAD TO CHLOROSIS IN PLANTS

- Nitrogen
- Magnesium
- Sulfur
- Iron
- Manganese



NITROGEN CYCLE



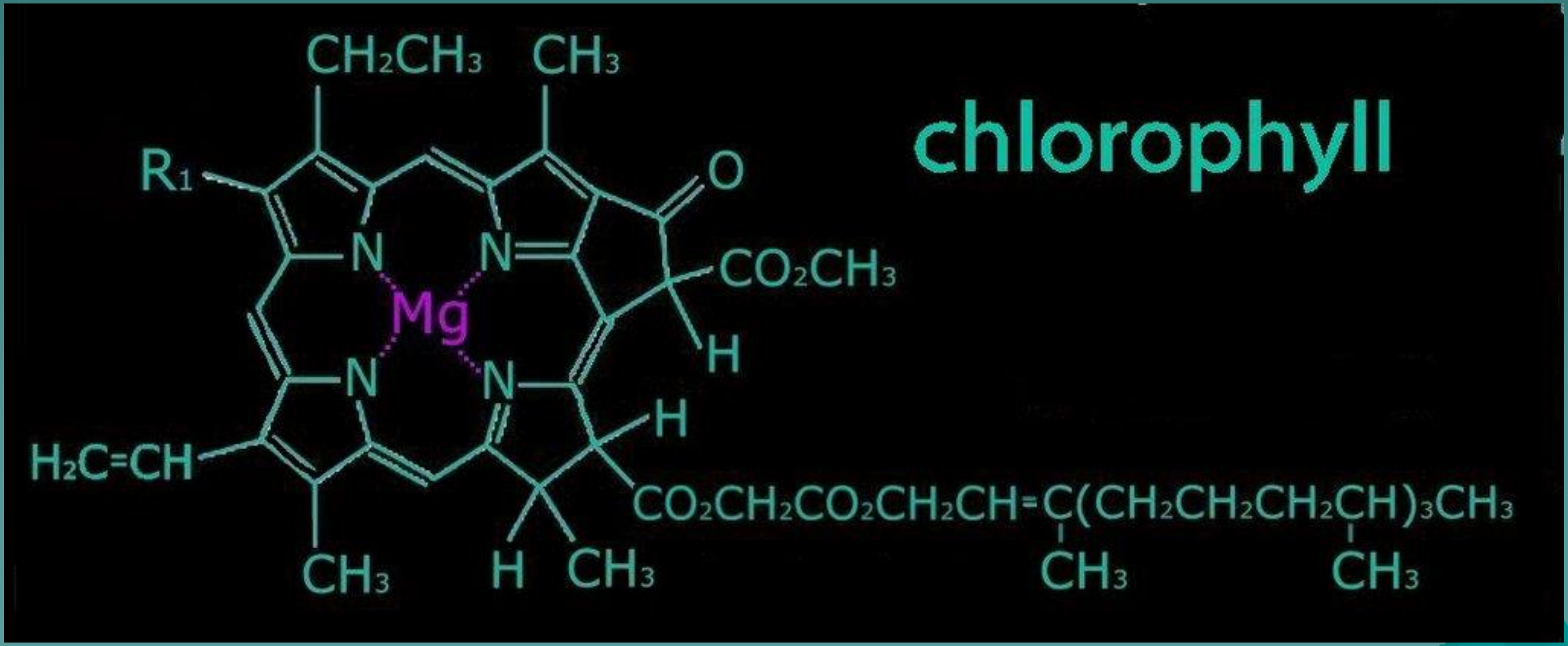
NITROGEN DEFICIENCES IN BROADLEAF WOODY PLANTS

- Chlorosis or yellowing
- Stunted leaf and shoots
  Early leaf drop
- Thin crowns
- **Older tissues will show chlorosis before younger tissues**

NITROGEN DEFICIENCES IN CONIFERS

- Short and yellow needles
- Poor needle retention
- Lower crowns yellow and upper crowns green

MAGNESIUM MOLECULE



MAGNESIUM DEFICIENCES IN BROADLEAF WOODY PLANTS

- Marginal chlorosis on older leaves followed by interveinal chlorosis
- Shoot growth affected only when severe Symptoms disappear quickly after treatment

MAGNESIUM DEFICIENCES IN CONIFERS

- Golden or yellow-tip "halo" on needles
- Sharp transition from yellow to green Symptoms more severe in moist years



SULFUR DEFICIENCES IN BROADLEAF PLANTS AND CONIFERS

- Symptoms similar to N deficiency
- Younger foliage yellow-green or yellow
- Older leaves usually not affected

IRON DEFICIENCES IN BROADLEAF PLANTS

- Interveinal chlorosis of young leaves
- Leaves yellow upon emergence (oaks)
- Interveinal necrotic spots
- Leaves curl, wither, and die



IRON DEFICIENCES IN CONIFERS

- New growth stunted and chlorotic
- Older needles and lower crown green

MANGANESE DEFICIENCES IN CONIFERS

- Symptoms similar to iron
- New needles chlorotic and pale green
- Tip necrosis may be present

MANGANESE DEFICIENCES IN BROADLEAF WOODY PLANTS

- Marginal leaf chlorosis extending beyond major veins
- Bands of green along veins and midrib
- Necrotic spots in chlorotic areas
- Reduced shoot growth



RED MAPLE NUTRIENT STUDY (Objectives)

- To determine the efficacy of Verdur Mn micro-nutrient versus macro-infusion tree injections for alleviation of chlorosis in red maple

- To determine optimum dosage rates and application timing

MEAN SPAD LEAF READINGS FOR RED MAPLES

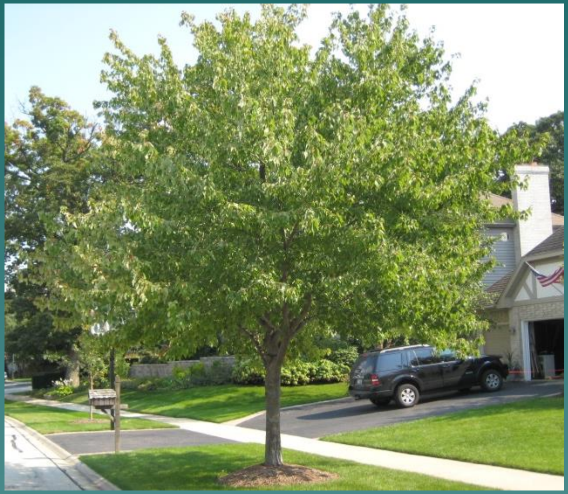
TREATMENT	2008	2009
Mn at high rate prior to leaf drop	----	42b
Mn + Fe at high rate prior to leaf drop	----	41b
Mn + soil tablets prior to leaf drop	----	41b
Mn at low rate at bud break	38c	38b
Mn + soil tablets at bud break	37c	41b
Mn at low rate with macro-infusion	37c	37b
Mn + Fe at low rate with macro-infusion	33b	39b
Mn + soil tablets with macro-infusion	33b	34b
Untreated Control (UTC)	28a	20a
Significance	$P<0.001$	$P<0.001$

WHAT DO SPAD READINGS MEAN?

COLOR	SPAD READING
Bright yellow to gold	<10
Light yellow to pale green	10-25
Ivory to light green	26-35
Moderate or “normal” green	36-50
Dark green	50 +

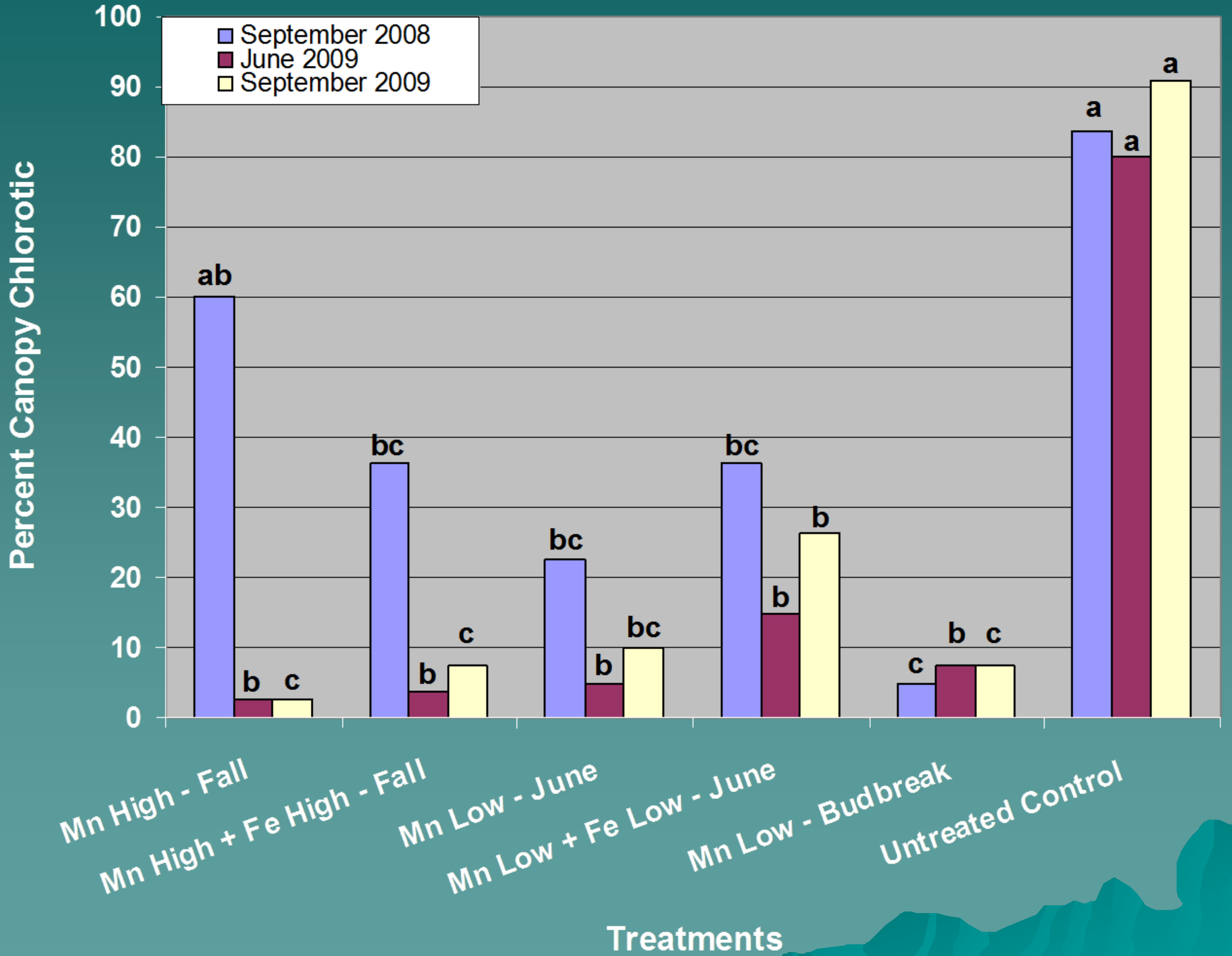
UNTREATED CONTROL (SPAD READING= 0-15)

TREATMENTS 1-8
(SPAD READINGS=35-50)




Leaf Greenness - Naperville
SPAD Index
45
40
35
30
25
20
15
10
5
0
2008
2009
b
b
b
c b
c b
c b
b b
b b
a a
Mn (High) - Fall
Mn+Fe (High) - Fall
Mn (High)+Soil Tablets - Fall
Mn (Low) - Budbreak
Mn (Low)+Soil Tablets - Budbreak
Mn (Low) - June
Mn+Fe (Low) - June
Mn (Low)+Soil Tablets - June
Untreated Control
Treatments

Canopy Chlorosis Ratings - Northbrook



DETERMINING NUTRIENT REQUIREMENTS

- Visual observations and symptoms
- Soil sampling and testing
- Foliar tissue testing
- **Put it all together**

CORRECTING FOR NUTRIENT DEFICIENCIES

- “Right plant – Right place”
- Foliar applications
- Trunk injections and implants
- Fertilizer applications
- Soil acidifying treatments

"Right Plant – Right Place"

- Know your local soils
- Select plants that tolerate alkaline soils

FOLIAR NUTRIENT TREATMENTS FOR IRON AND MANGANESE

- Use chelated iron and ferrous sulfate for iron
- Chelated manganese or manganese sulfate
- Provides quick "green up" and quick fix
- Only affects treated leaves

TRUNK IMPLANTS AND INJECTIONS OF IRON AND MANGANESE

- Requires drilling holes into trunk base or stem
- Effects show up in about one month and may last up to 2 years
- Late spring-early summer recommended

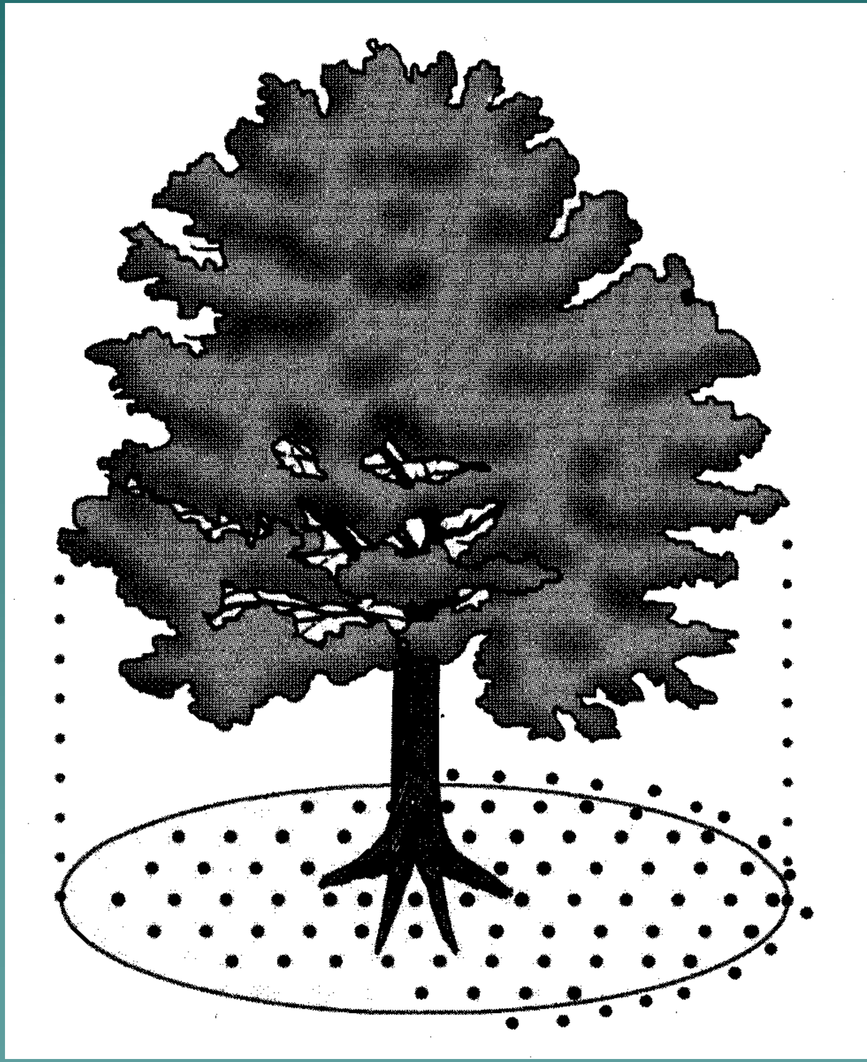
SOIL FERTILIZERS FOR IRON AND MANGANESE DEFICIENCIES

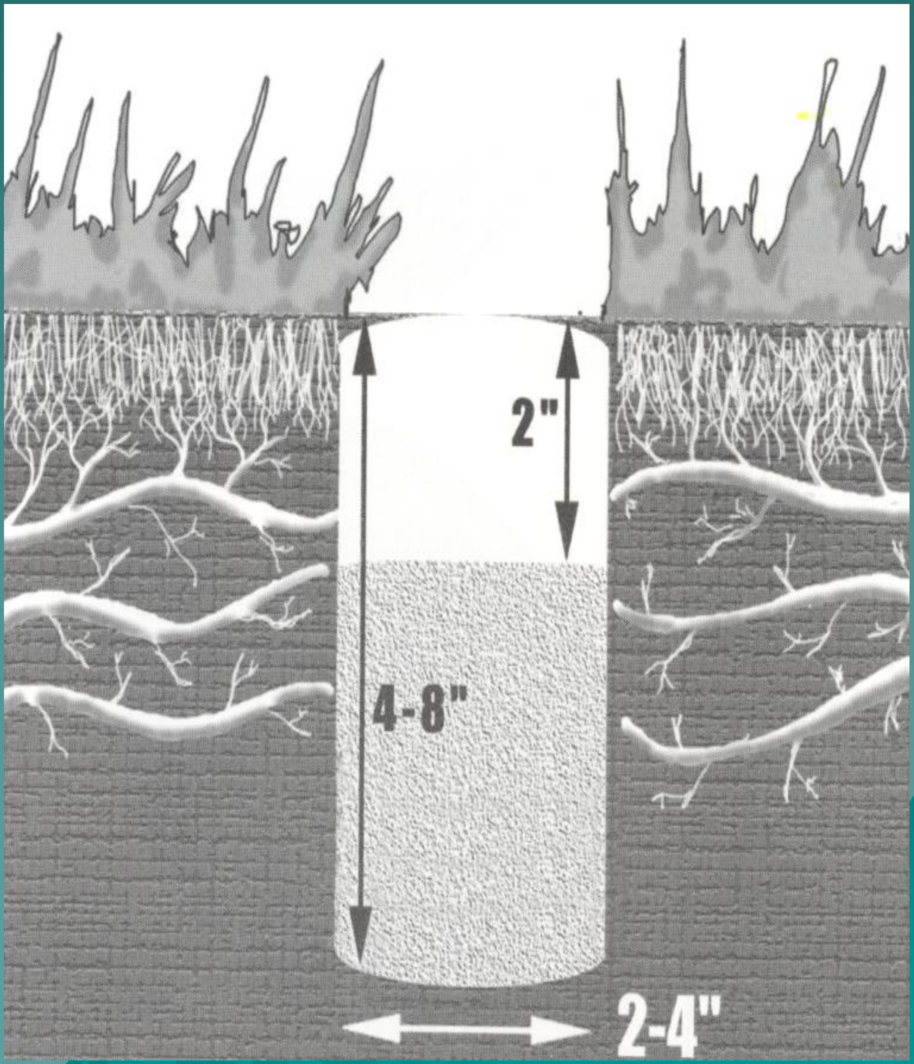
- Chelated iron fertilizers for neutral and high pH soils
- Annual applications in top 1 to 2 inches of soil in spring
- Chelated iron placed in augered holes in a grid pattern under drip line

SOIL FERTILIZER TREATMENT FOR IRON AND MANGANESE

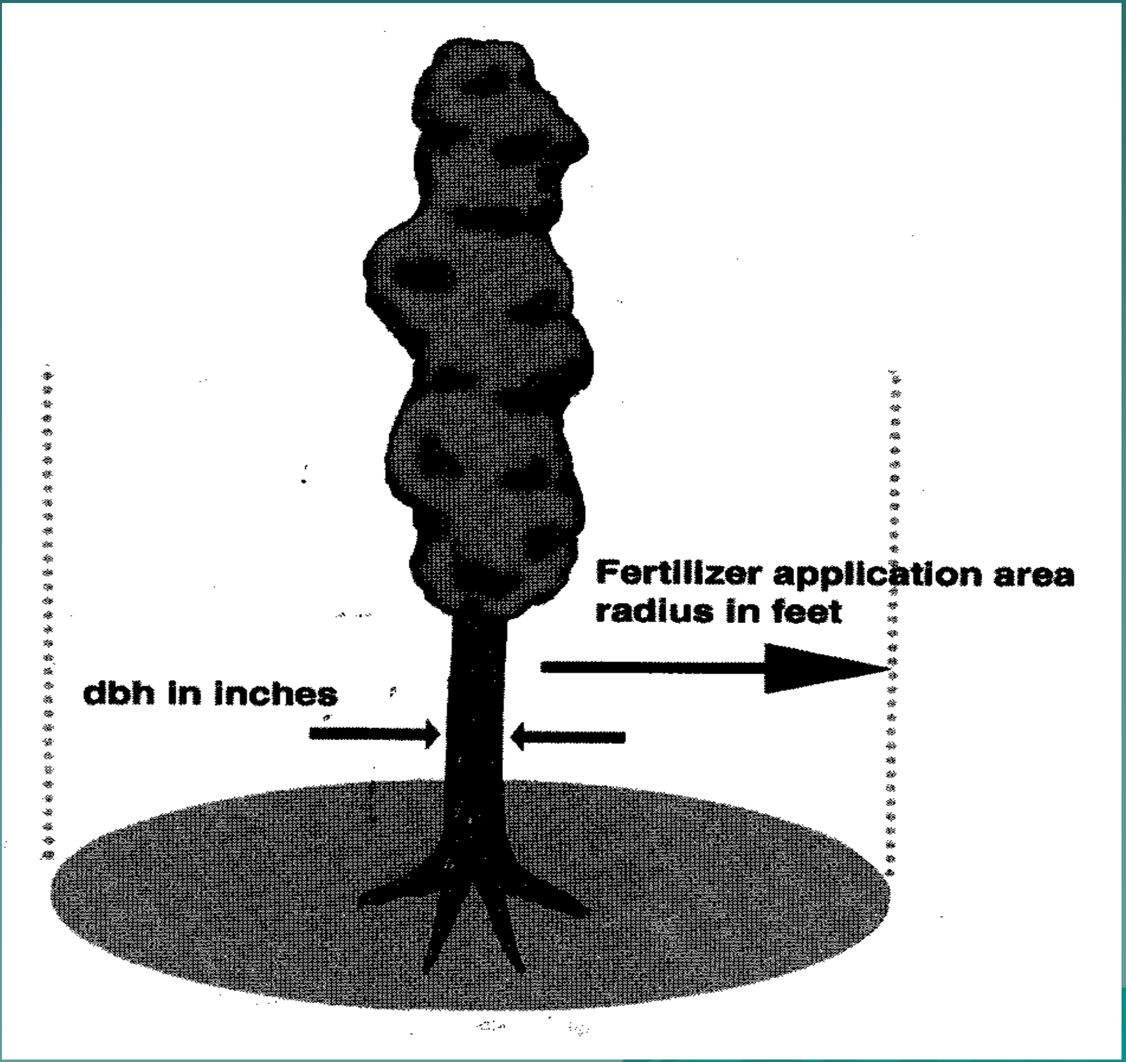
- Common chelated iron fertilizers
  - EDTA (soluble form up to 6.3)
  - DPTA (effective up to 7.5)
  - EDDHA (effective from 4.0 to 9.0)

SUB-SURFACE DRILL HOLE APPLICATION





SUB-SURFACE DRILL HOLE APPLICATION



HOW TO ACIDIFY THE SOIL

- **pH is the real issue**
- Soil acidification treatments are temporary and will need to be repeated at regular intervals
- Soil acidifiers are worked into the top 6-12 inches of soil
- Only practical for shrubs and small trees

HOW TO ACIDIFY THE SOIL

- Elemental sulfur is the most economical
  - Takes 3-4 months for full effect

- Iron sulfate acts quickly
  - Acts in 3-4 weeks
  - Requires higher rates and more expensive

- Avoid ammonium sulfate and aluminum sulfate

NITRATE LEACHING PROBLEM

- Contributes to an impoverished ecosystem

- Causes serious environmental concerns
  - Contaminates drinking water
  - Causes **eutrophication**

“TAKE HOME MESSAGE” (Per Dr. Bob Kremer)

- **“Amendments with organic materials increases soil organic matter, which influences physical, chemical, and biological properties, all which work together to maintain high soil quality.”**

- **“High soil quality under sustainable management would seem to withstand the effects of drought.”**

SUMMARY

- N and plant growth
- Origin and distribution of N
- Nitrogen cycle
- Immobilization and mineralization
- Soluble organic N
- Ammonium fixation by clay minerals
- Ammonia volatilization
- Nitrification

SUMMARY

- Nitrate leaching problem
- Gaseous losses by de-nitrification
- Biological N fixation
- Symbiotic fixation with legumes
- Symbiotic fixation with non-legumes
- Non-symbiotic N fixation
- Reactions of N fertilizers
- Practical management of soil N