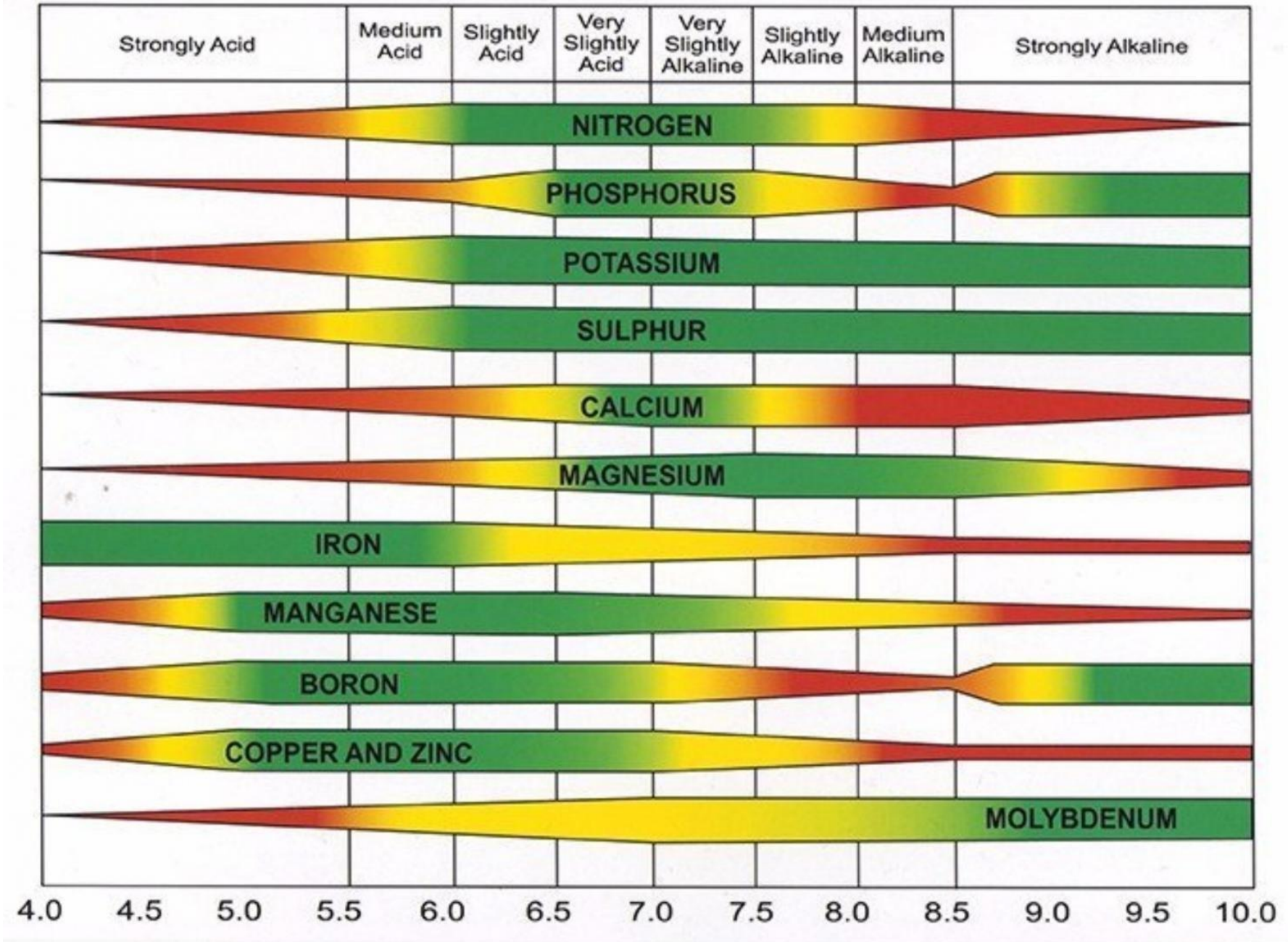
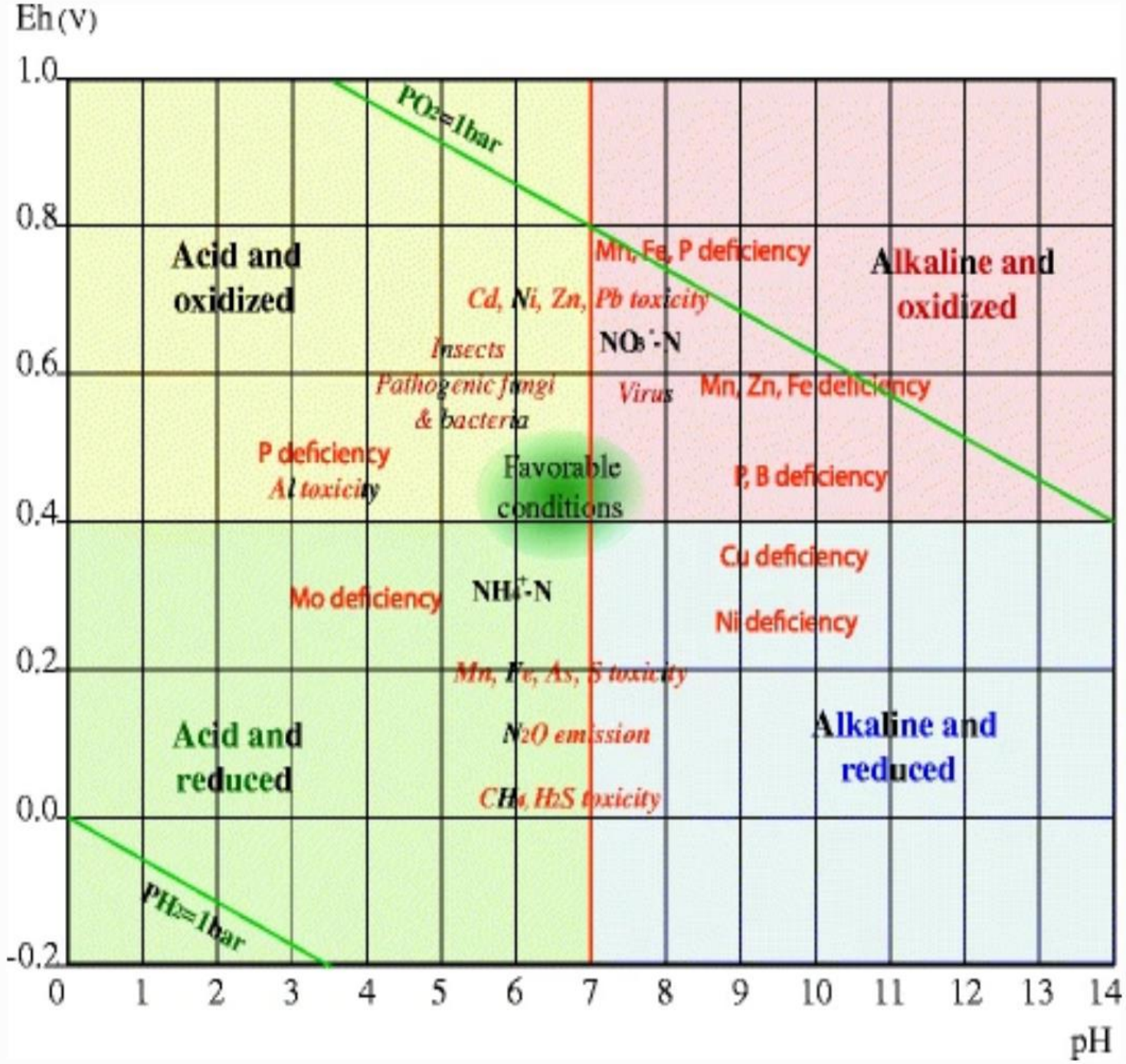
SOIL FERTILITY FUNDAMENTALS

CHEMISTRY IS FOUNDATIONAL

How soil pH affects availability of plant nutrients.



SOURCE: https://www.emporiumhydroponics.com/what-is-ph-1-to-14


Eh (V)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
PO2=1bar
PH2=1bar
Acid and oxidized
Alkaline and oxidized
Acid and reduced
Alkaline and reduced
Favorable conditions
Mn, Fe, P deficiency
Cd, Ni, Zn, Pb toxicity
NO3--N
Insects
Pathogenic fungi & bacteria
Virus
Mn, Zn, Fe deficiency
P deficiency
Al toxicity
P, B deficiency
Cu deficiency
Mo deficiency
NH4+-N
Ni deficiency
Mn, Fe, As, S toxicity
N2O emission
CH4, H2S toxicity
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
pH

Calcium: Ca++

Functions

- Cell wall construction
- Cell division
- Cell membrane function and material transfer in and out of cells
- Soil structure
- Immobile

- Desired value: ~60-70% of base saturation (CEC dependent)

Calcium: Ca++

Deficiency

- Terminal buds die
- Young leaves hooked
- Blossom end rot on fruit

Excess

- Tie up off other nutrients
- Symptoms of other nutrient deficiencies

Calcium: Ca++

Sources

- High Calcium lime – ~30-38% Ca, minimal Mg
- Dolomite lime – ~20-24% Ca, ~10-12% Mg
- Gypsum - ~22-24% Ca, ~15-18% Sulfur
- Marl - ~30-38% Ca + clay impurities
- Oyster shell lime – ~30-38% Ca
- Rock Phosphates - ~ 20 Ca, ~20% P
- Layer manure - Variable
- Industrial byproducts – Variable (i.e. kiln dust, sugar beet waste)

Magnesium: Mg++

Functions

- Part of the chlorophyll molecule
- Actively involved in photosynthesis
- Aids in Phosphate metabolism
- Activates several enzyme systems
- Soil Structure
- Mobile

- Desired value: ~10-20% of base saturation (CEC dependent)

Magnesium – Mg++

Deficiency

- Yellowing/mottling of older leaves

Excess

- Can be similar to deficiency symptoms

Magnesium: Mg++

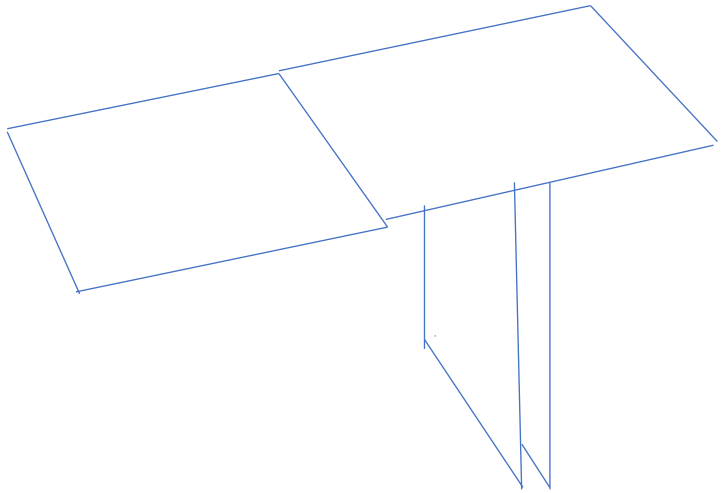
Sources

- Dolomite lime - ~20-24% Ca, ~10-12% Mg
- Sul-Po-Mag/K-Mag – 22% K2O, 11% Mg, 20-22% S
- Magnesium Sulfate – ~9-11% Mg, 11-14% S
- Kieserite – 15-16% Mg, 20-22% S
- Magnesium Oxide – 33-36% Mg

Soil Structure

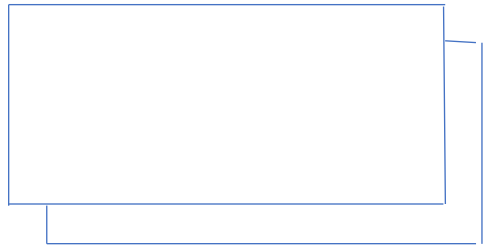
Calcium

- Flocculates the soil colloids
- Increases pore space



Magnesium

- Flocculates the soil colloids
- Decreases pore space
- Can also disperse soil colloids



Potassium: K+

Functions

- Processes that produce stalk strength
- Regulation of leaf transpiration and gas exchange
- Water use efficiency
- Winter hardiness
- mobile

Potassium: K+

Deficiency

- Scorched/yellow leaf margins usually on older leaves

Excess

- Luxury consumption can lead to other cation deficiencies

Potassium: K+

Sources

- Potassium Sulfate - 50-52% K2O, 17-18% S
- Sul-Po-Mag/K-Mag – 22% K2O, 11% Mg, 20-22% S
- Potassium Nitrate – 14-15% N, 46% K20
- Greensand – ~6-9% K2O
- Granite dust – ~4-6% K2O
- Animal manures – ~0.5-3% K2O
- Kelp (seaweed) – ~5-16% K2O
- Wood ashes - ~7-9% K2O

Sodium: Na+

Function

- Required for proper growth of Barley and crops in the Goosefoot family (i.e. Beets, Spinach, Swiss Chard)
- Coloring of fruit

Sodium: Na+

Deficiency

- Poor growth/yield of Na requiring crops

Excess

- Substitution for K potentially resulting in cell rupture/damage

Sodium: Na+

Sources

- Sodium Nitrate – 16% N, 26% Na
- Rock salt – Variable
- Sea minerals – Variable
- Kelp – Variable

Soil Structure

Potassium

- Disperses soil colloids
- Reduces porosity

Sodium

- Disperses soil colloids
- Reduces porosity

Nitrogen: NH_4^+, NO_3^-

Functions

- Vegetative growth
- Protein and enzyme formation
- Chlorophyll production
- Mobile

Nitrogen: NH_4^+, NO_3^-

Deficiency

- Weak growth
- Small leaves
- Pale green
- Yellowing of older leaves

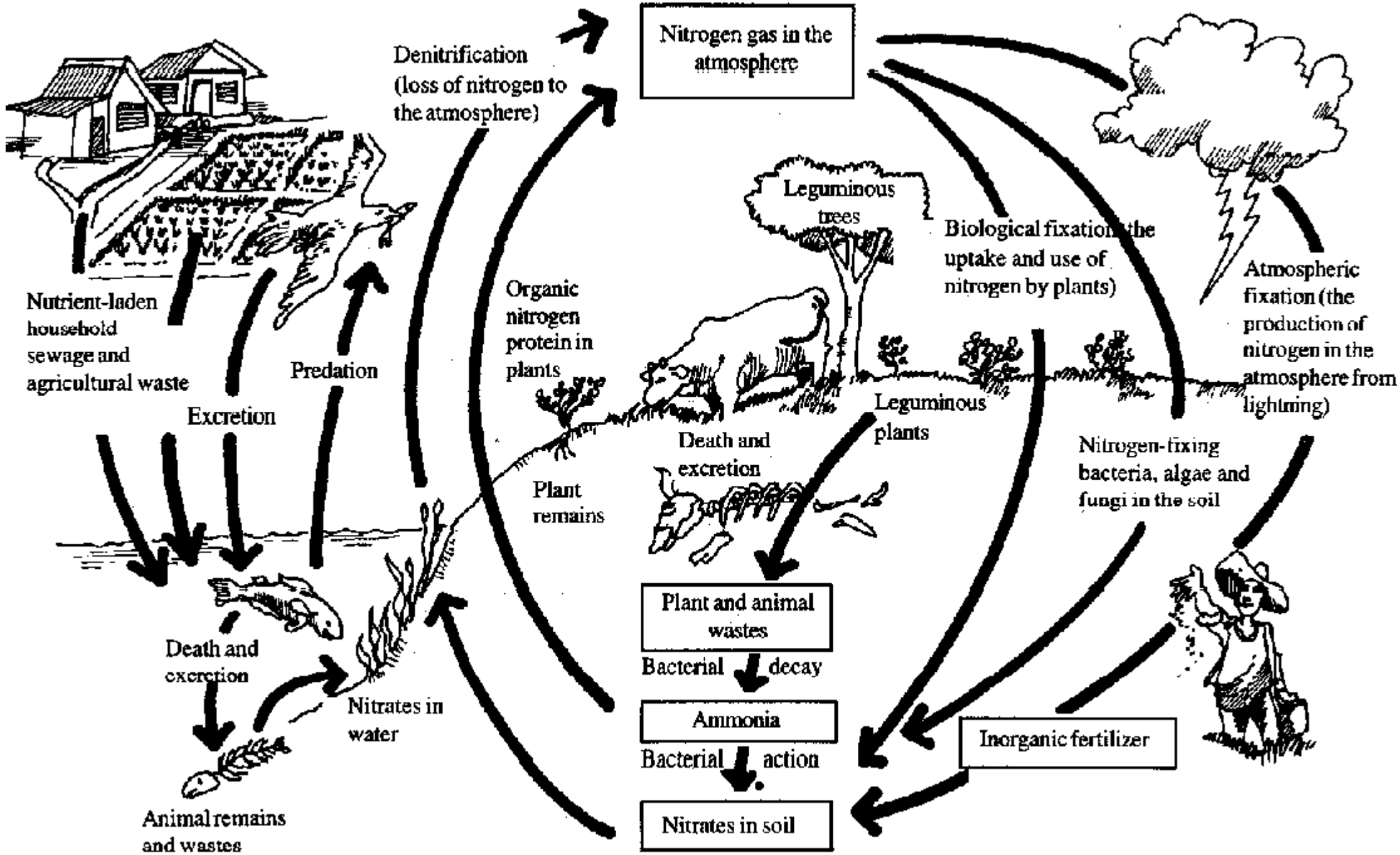
Excess

- Soft overly rapid growth
- Weak stems
- Delayed maturity
- Delayed hardening off
- More prone to disease/insect pressure

Nitrogen: NH_4^+, NO_3^-

Sources

- Ammonium Sulfate – 21% N, 24% S
- Protein Meals – Variable
- Compost and manures – Variable
- Enzymatically digested fish – 2-3% N
- Symbiotic and free living Nitrogen fixers


Nitrogen gas in the atmosphere
Denitrification (loss of nitrogen to the atmosphere)
Leguminous trees
Biological fixation (the uptake and use of nitrogen by plants)
Atmospheric fixation (the production of nitrogen in the atmosphere from lightning)
Nutrient-laden household sewage and agricultural waste
Excretion
Predation
Organic nitrogen protein in plants
Plant remains
Death and excretion
Leguminous plants
Nitrogen-fixing bacteria, algae and fungi in the soil
Death and excretion
Nitrates in water
Plant and animal wastes
Bacterial decay
Ammonia
Bacterial action
Inorganic fertilizer
Animal remains and wastes
Nitrates in soil

Phosphorus: P 3-

Functions

- Reproductive growth
- Part of genetic material
- Energy storage and transfer
- Early root growth
- Aids blooming and fruiting
- Speeds crop maturity
- Somewhat mobile

- Desired value: 220-330 lbs.

Phosphorus: P 3-

Deficiency

- Stunted growth
- Reddening or purpling of leaves
- Poor or no flowering or fruiting

Excess

- Tie up of other nutrients
- Poor growth

Phosphorus: P 3-

Sources

- Hard Rock Phosphate – 24-30%, up to 30% Ca. Long term source
- Colloidal, Reactive Phosphate - ~20% P_2O_5, ~20% Ca
- MAP Mono-Ammonium Phosphate – 11% N, 52% P_2O_5
- DAP Di-Ammonium Phosphate – 18% N, 46% P_2O_5
- Bone Meal – 21-30% P_2O_5, 1-4% N, 20-30% Ca
- Compost, animal manures – 0.5-3% P_2O_5
- Phosphorus solubilizing microbes

Sulfur: S--

Functions

- Production of S containing proteins
- Chlorophyll production
- Nodulation of legumes
- Seed production
- Mobile

- Desired value: 100-200 lbs.

Sulfur: S--

Deficiency

- Symptoms similar to N deficiency
- Overall pale green color of leaves

Excess

- Symptoms of other anion deficiencies due to suppression

Sulfur: S--

Sources

- Elemental Sulfur – 90-92% S
- Ammonium Sulfate – 21% N, 24% S
- Gypsum – 22-24% Ca, 17-18% S
- Sul-Po-Mag/K-Mag – 22% K2O, 11% Mg, 20-22% S
- Magnesium Sulfate - ~10% Mg, 14% S
- Potassium Sulfate – 50% K2O, 18% S

Boron: B

Functions

- Cell wall integrity
- Keeps Ca mobile
- Flower set
- Translocation of starches and sugars
- Immobile

- Desired value: 1.5–2 ppm

Sources

- Sodium Borate – 10-20% B
- Boric Acid – 17% B

Boron: B

Deficiency

- Growing tip die back
- Internal stem disorders

Excess

- Phytotoxic reaction/death
- To avoid, apply no more than 2 lbs. of actual Boron per acre at one time.

Iron: Fe++

Functions

- Part of many enzymes
- Required for Chlorophyll formation

- Desired value: 200 ppm+

Sources

- Ferrous Sulfate – 21 or 30% Fe

Iron: Fe++

Deficiency

- Interveinal chlorosis on younger leaves

Excess

- No known symptoms

Manganese: Mn++

Functions

- Acts with Fe in chlorophyll formation
- Speeds seed germination and crop maturity
- Helps in uptake of other nutrients
- Stalk strength
- Water hydrolysis
- Potassium Regulation
- Desired value: 150-240 ppm

Sources

- Manganese Sulfate – 32% Mn

Manganese: Mn++

Deficiency

- Interveinal chlorosis with small necrotic spots on young leaves
- Dwarfing

Excess

- Inhibition of Ca and Mg uptake
- Potential oxidation of Fe in the plant (Mn should never be higher than Fe)

Copper: Cu++

Functions

- Part of several enzymes
- Disease resistance
- Moisture control
- Stalk strength

- Desired value: 5-10 ppm

Sources

- Copper Sulfate – 23-25% Cu
- Turkey compost - Variable

Copper: Cu++

Deficiency

- Young leaves wilted
- Weak stem tip
- Disease pressure

Excess

- Root grow inhibition
- Suppression of other nutrients

Zinc: Zn++

Functions

- Part of many enzyme systems
- Water use efficiency
- Essential for non-symbiotic N fixing Azoto-bacters

- Desired value: 6-20 ppm

Sources

- Zinc Sulfate – 36% Zn

Zinc: Zn++

Deficiency

- Necrotic spots in older leaves
- Whitish color in leaves
- Faint yellow mottling along central leaf vein.
- Small leaves

Excess

- Induced deficiencies
- Poor photosynthesis

Molybdenum: Mo

Functions

- Needed by N fixing Bacteria
- Required to make protein

- Desired value: 1-2 ppm

Sources

- Sodium Molybdate – 39% Mo

Molybdenum: Mo

Deficiency

- Whip tail
- Poor Nitrogen metabolism

Excess

- Copper tie up

Other Beneficial Elements

- Cobalt – Essential for N fixation, Cobalamin (B12) formation and Cytokinin formation (Desired value: 1-2 ppm)
- Chlorine (as Chloride) – Required for photosynthesis (Desired value: 25-125 ppm)
- Nickel - Needed by some plants for proper N utilization (Desired value not established)
- Silicon – Builds strong cell walls and disease resistance, especially in high Si accumulating crops like rice and crop families like the cucurbits (Desired value not established)


Questions?