

Plant Nutrition And Water Quality



Leibig's Law of the Minimum

Low
Fertility

Lack
of
Water

Poor
Stand

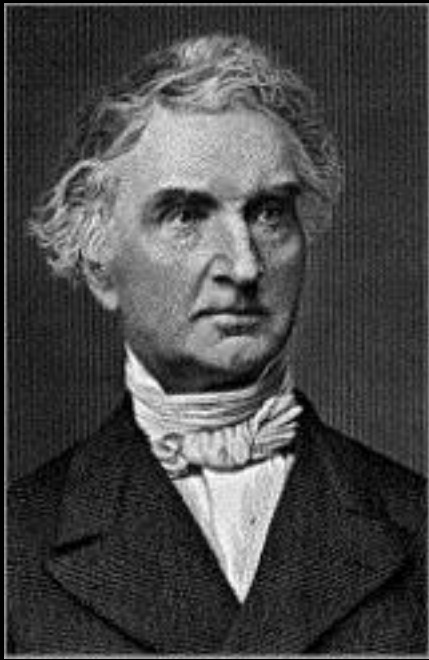
Poor Soil
Structure

Wrong
Variety

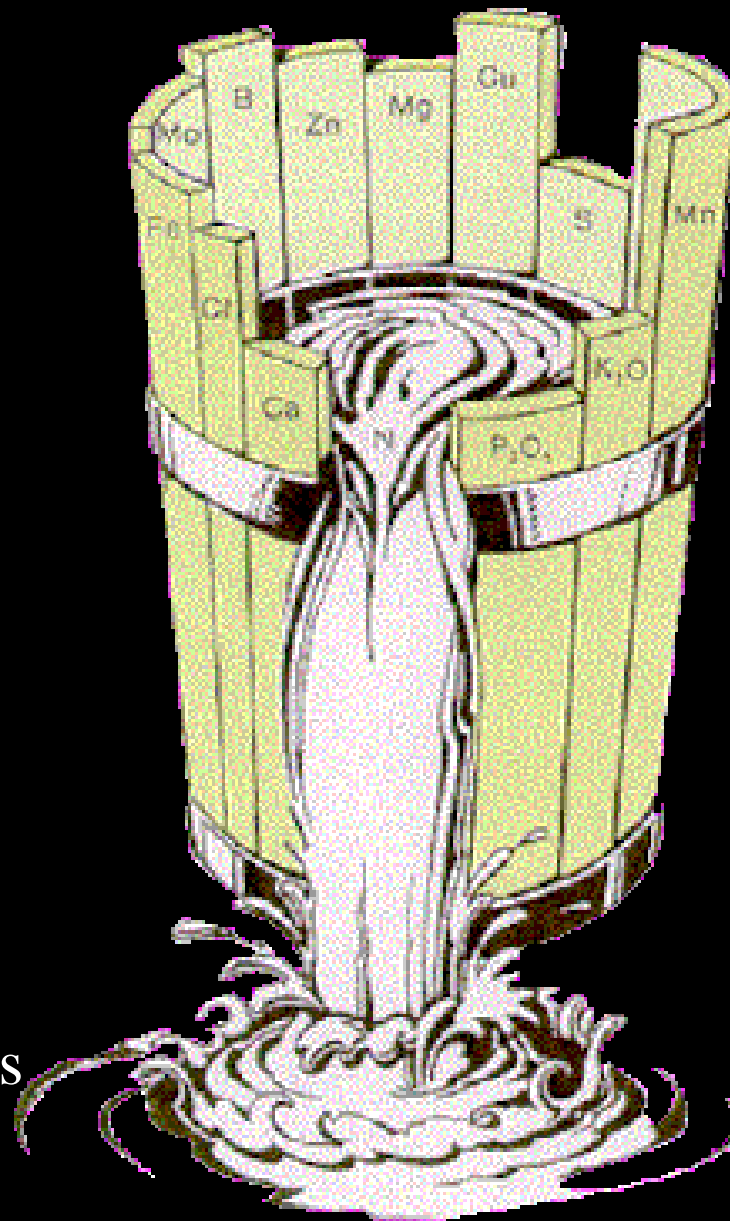
Weeds

Insects
&
Disease





Justus von Liebig
(1803-1873)
German Chemist
Father of Fertilizers



Liebig's Law of the Minimum

$$\frac{dO}{dt} = \min \left(\frac{I}{k_I + I}, \frac{N}{k_N + N}, \frac{P}{k_P + P} \right)$$

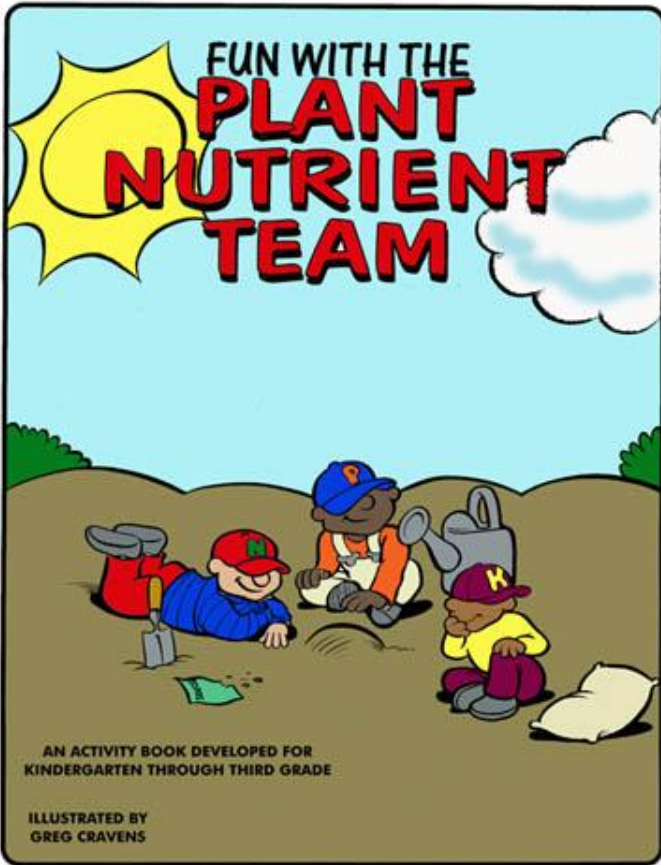


Elements in Plant Nutrition

Essential Elements

- Fresh plant material is 80 to 95% water
- 16-17 essential elements
- Plants cannot complete life cycle without them
- Action must be specific - no other element can take its place
- Element must be directly involved (structure, constituent, enzyme activator, etc.)

Nutrient Classification



Macronutrients

- From air and water: C, H and O
- From soil:
 - Primary - N, P and K
 - Secondary – Ca, Mg and S

Micronutrients (soil):

- Fe, B, Mn, Cu, Zn, Mo, Cl, Ni, Co

Chemistry Fuels Growing Plants

- <http://www.webelements.org/>
- <http://antoine.frostburg.edu/chem/senese/101/index.shtml>
- http://www.americanchemistry.com/s_acc/sec_article.asp?CID=100&DID=1706
- <http://www.ipni.net/>
- <http://www.agr.state.nc.us/cyber/kidswrld/plant/index.htm>
- <http://extension.oregonstate.edu/mg/botany/nutrition.html>

Periodic Table of the Elements

The image shows a periodic table of elements. Elements are color-coded by groups: Alkali metals (orange), Alkaline earth metals (yellow), Transition metals (pink), Lanthanide series (light blue), Actinide series (purple), Poor metals (cyan), Nonmetals (green), Noble gases (light blue), Solid (black), Liquid (green), Gas (red), and Synthetic (black). Elements are also labeled with their atomic number, symbol, name, and atomic mass. A large green box with the text "Plant Nutrients" is overlaid on the bottom right of the table.

1	2											13	14	15	16	17	18
IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1 H Hydrogen 1.00794	2 He Helium 4.002602											13 B Boron 10.811	14 C Carbon 12.0107	15 N Nitrogen 14.00644	16 O Oxygen 15.9994	17 F Fluorine 18.9984032	18 Ne Neon 20.1797
3 Li Lithium 6.941	4 Be Beryllium 9.012182											13 Al Aluminum 26.981538	14 Si Silicon 28.0855	15 P Phosphorus 30.973761	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
11 Na Sodium 22.989770	12 Mg Magnesium 24.3050	3 Sc Scandium 44.955910	4 Ti Titanium 47.867	5 V Vanadium 50.9415	6 Cr Chromium 51.9961	7 Mn Manganese 54.938049	8 Fe Iron 55.8457	9 Co Cobalt 58.933200	10 Ni Nickel 58.6934	11 Cu Copper 63.546	12 Zn Zinc 65.409	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Y Yttrium 88.90585	22 Zr Zirconium 91.224	23 Nb Niobium 92.90638	24 Mo Molybdenum 95.94	25 Tc Technetium (98)	26 Ru Ruthenium 101.07	27 Rh Rhodium 102.90550	28 Pd Palladium 106.42	29 Ag Silver 107.8682	30 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 to 71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.96655	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 to 103	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106	107	108	109	110	111	112	113	114	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Uus Ununseptium	118 Uuo Ununoctium

Atomic mass

Plant Nutrients

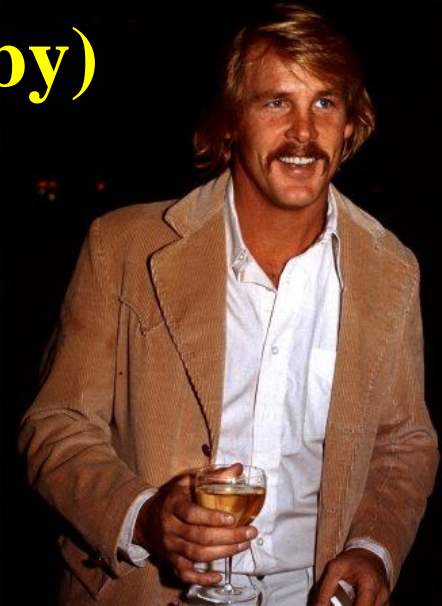
Note: The subgroup numbers 1-8 were adopted in 1984 by the International Union of Pure and Applied Chemistry. The names of elements 112-118 are the Latin equivalents of those numbers.

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium
138.9055	140.116	140.90765	144.24	145	150.36	151.964	157.25	158.92534	162.500	164.93032	167.259	168.93421	173.04	174.967
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium
(227)	232.0381	231.03588	238.02891	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)

Plant Nutrients



- C. HOPKINS
- Mo (Missouri) CaFe
- Mg (mighty good)
- Cl (clean)
- Mn B (managed by)
- CuZn Ni
(cousin Nick)



Nutrient Status Diagnosis

- Visual symptoms
- Plant tissue analysis
- Soil testing



Deficiency Symptoms

- Vary with plant species
- Color
- Pattern
- Growth response
- Location & History
- New or old plant parts

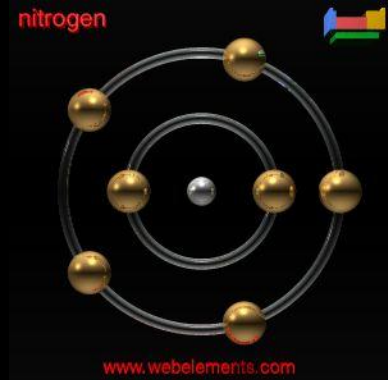




Cholorosis on lower leaves
Light green rest of plant

Nitrogen

- Amino acids, proteins, nucleic acids, nucleotides and enzymes





Phosphorus



- Sugar phosphates - ATP
- Nucleic acids - DNA
- Coenzymes, membranes

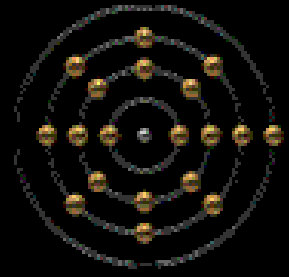
Purpling of lower leaves





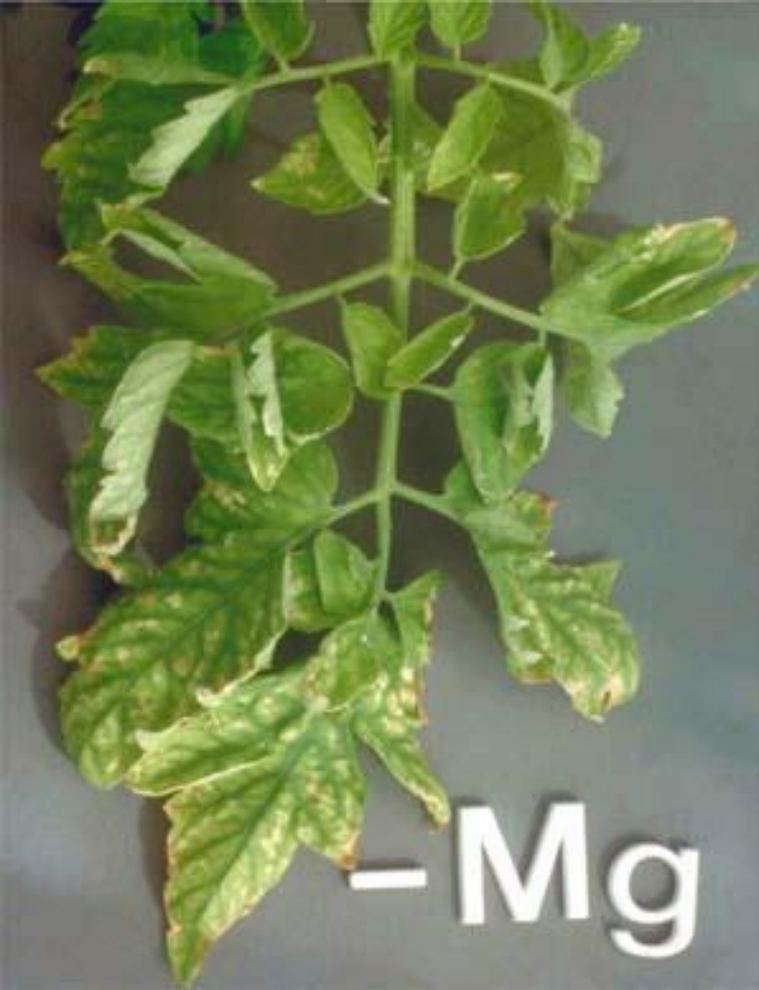
Potassium

- Enzyme activator
- Osmotic regulator
- Maintains electrical neutrality

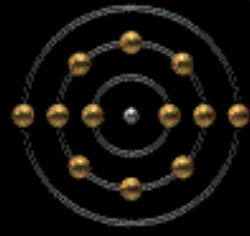


Chlorosis, necrosis on edge of lower leaves





Magnesium



- Part of chlorophyll molecule
- Phosphate transfer

**Intervienal chlorosis
on lower leaves**





Calcium

- Middle lamella of cell walls
- Involved in energy transfer

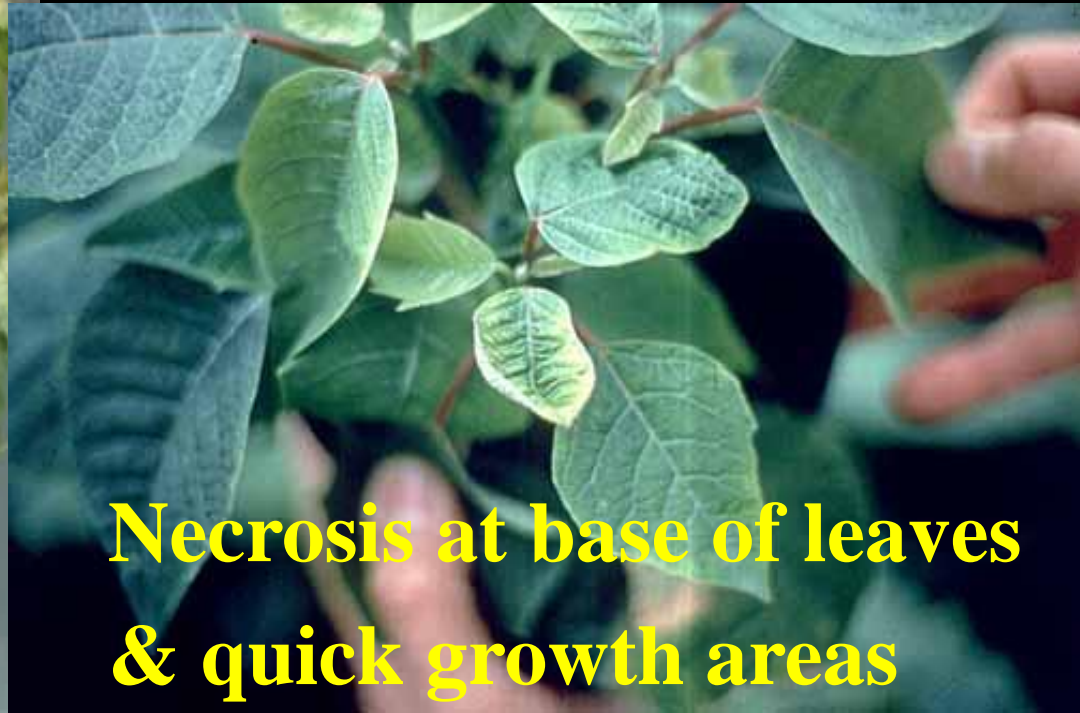


Blossom-end rot



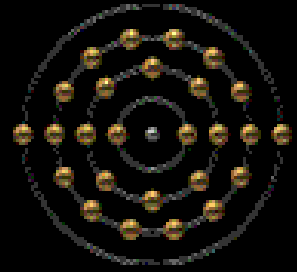
**Leaf
cupping**

-Ca



**Necrosis at base of leaves
& quick growth areas**

Iron



- Cytochromes, photosynthesis, N_2 fixation & respiration



Strong chlorosis
at base of leaves



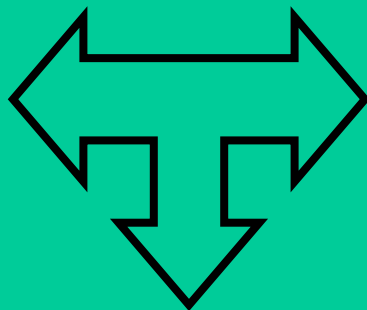
Interveinal chlorosis of the youngest leaves

Plant Nutrient Management

Water



Growing
Medium



Fertilizer

Fertilizer Programs

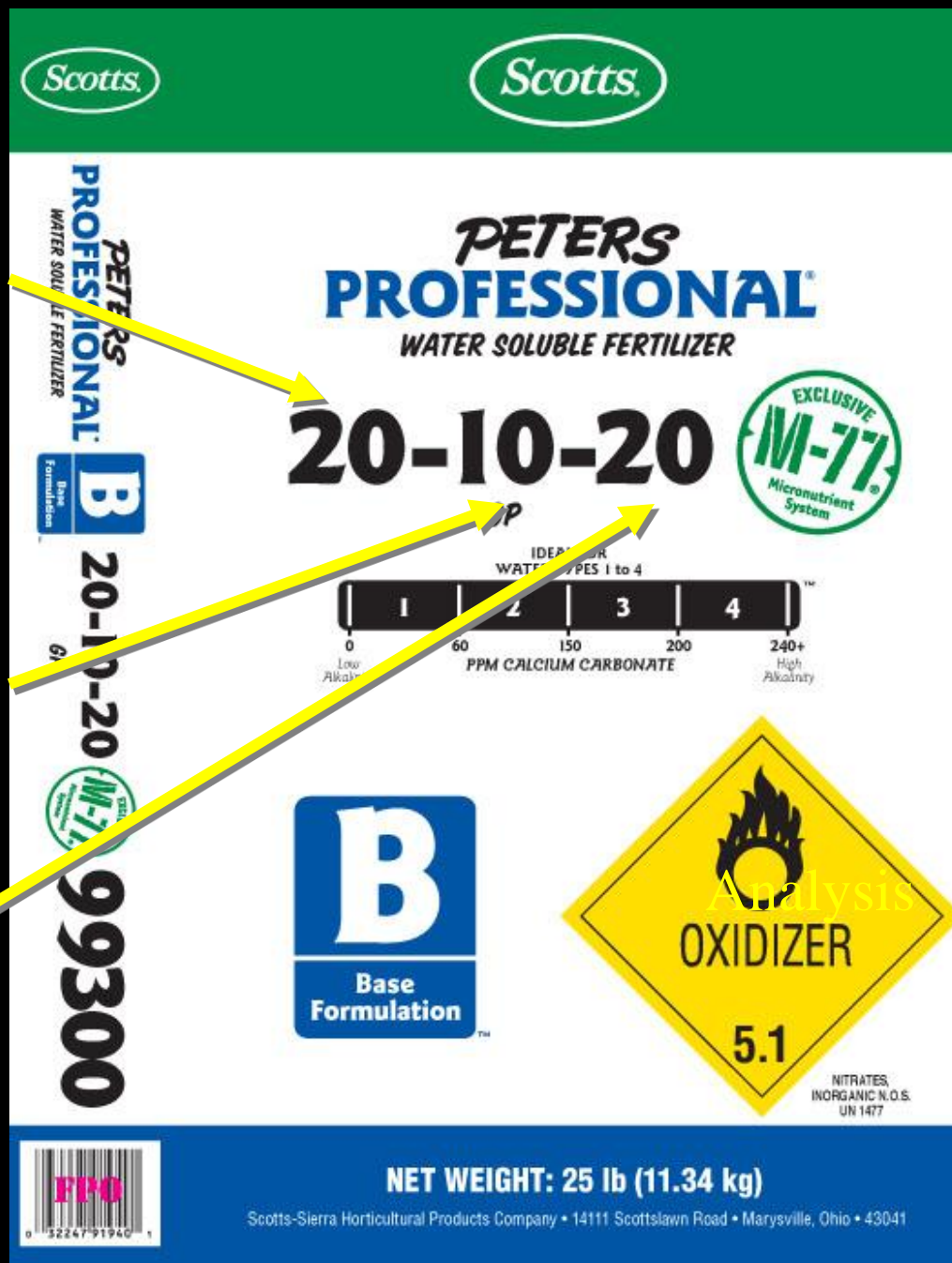
- Preplant fertilization
- Postplant fertilization
- Selecting N form
- Secondary
Macronutrients
- Fertilizing at finish
- Slow-release programs



Nitrogen
(N)

Phosphate
(P_2O_5)

Potash
(K_2O)



Reading
Fertilizer
Bags

N:P:K



Preplant Fertilization

- Starting off right
- Nutrients must be present and in useable forms
- Adjusting pH prior to planting is key
- Most grower mixes contain balanced water-soluble starter charge, wetting agent and dolomitic lime (Ca, Mg)

Nitrogen



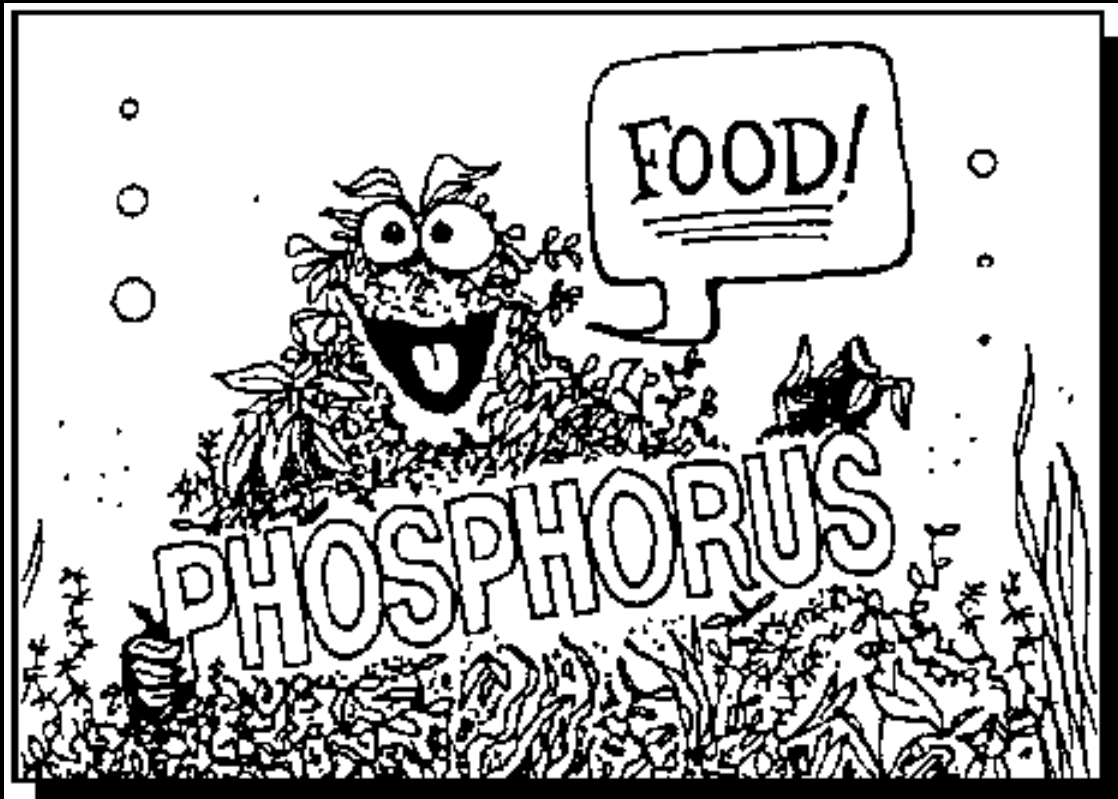
- Incorporate a controlled-release fertilizer at or soon after the time of planting
- Supplement during growing season
 - liquid fertilizer or
 - top-dressing granular or
 - CRN



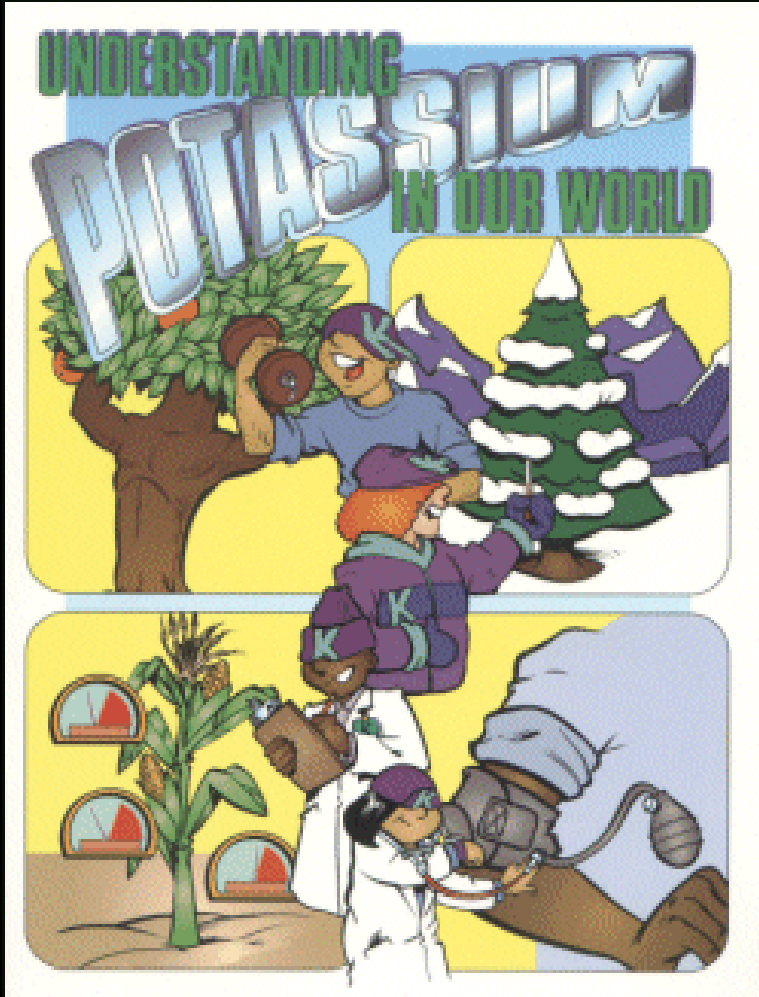
Phosphorus



- Incorporate into media before planting
- Supplement with liquid, CR or granular
- Incorporate with complete fertilizer



Potassium



- Required at higher concentration than P but lower than N
- Supply before planting through CR or complete granular
- Supplement during growing season with CR, complete granular or liquid fertilizer



Preplant Slow-release Fertilizers



- Incorporated in mix or as top dressing
- Adjust pre- and postplant programs



SR or CR



Top dressing

Postplant Fertilization



- Continuous liquid fertilization for N & K
- Soilless media
 - feed P as well
- Categorize plants as very light, light, moderate, heavy or very heavy

Concentration Requirements*

Crop	Conc. Category	Weekly oz/100 gal	Constant oz/100 gal
Bedding Plants	Very light	16	6
Gloxinia	Light	20	10
Geranium	Moderate	32	13.5
Poinsettia	Very Heavy	48	17

*Fertilizer containing 20 percent Nitrogen (20-10-20)

N:P:K

- Best ratio for GENERAL crops is:
 - 2 Nitrogen (N)
 - 1 Phosphorus (P_2O_5)
 - 2 Potassium (K_2O)
 - 20-10-20 industry standard

2:1:2

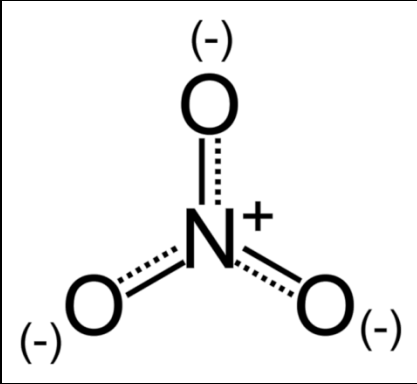
Postplant Fertilization



- **ONCE PER WEEK**
 - **N = 240 to 720 ppm**
- **EVERY WATERING**
 - **N = 90 to 255 ppm**

N Form

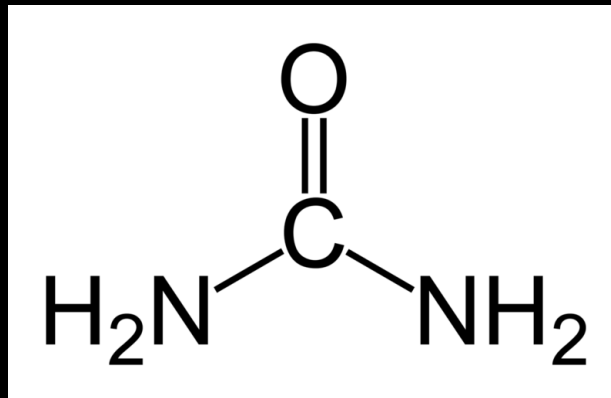
Acid lovers:
azalea, rhodos



Nitrate (NO_3^-)



Ammonium (NH_4^+)



Urea

Response generally identical -
urea must be converted
to ammoniacal N for
assimilation

Ammonium Toxicity

- Some plants are injured when $>50\%$ of total N is ammonium plus urea
- Aim for 40% or less ammonium plus urea
- “All nitrate plants” become “hard” – overall smaller size
- Greater risk in winter due to bacterial slow-down



Nitrogen Form and Plant Growth



- Rosarians use urea and ammonium fertilizers for lush growth
- Nitrate sources for hardening plants

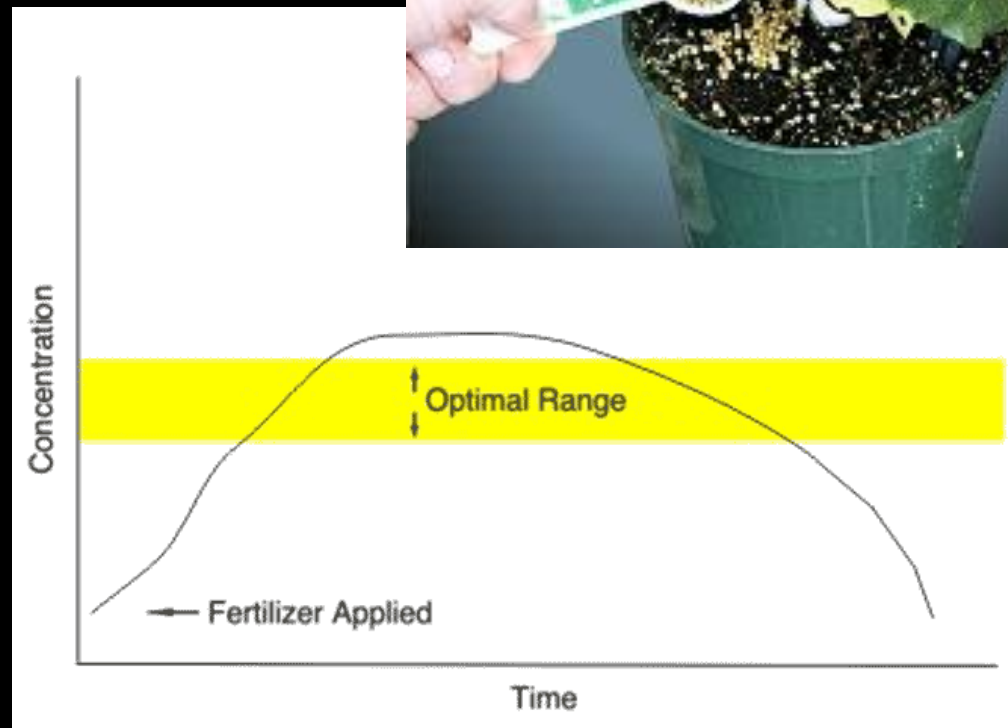


Fertilizing at Finish

- Plants will last longer in retail if nutrients are reduced two weeks before market date
- Check media nutrient levels
- Constant feeding > weekly feeding

Slow Release Fertilization Programs

- Started in 1960s
- Lack of control
- Growth may need to be slowed (cool & cloudy)
- Mixed into media at preplant
- Topdressing
- Reduces labor
- Saves time

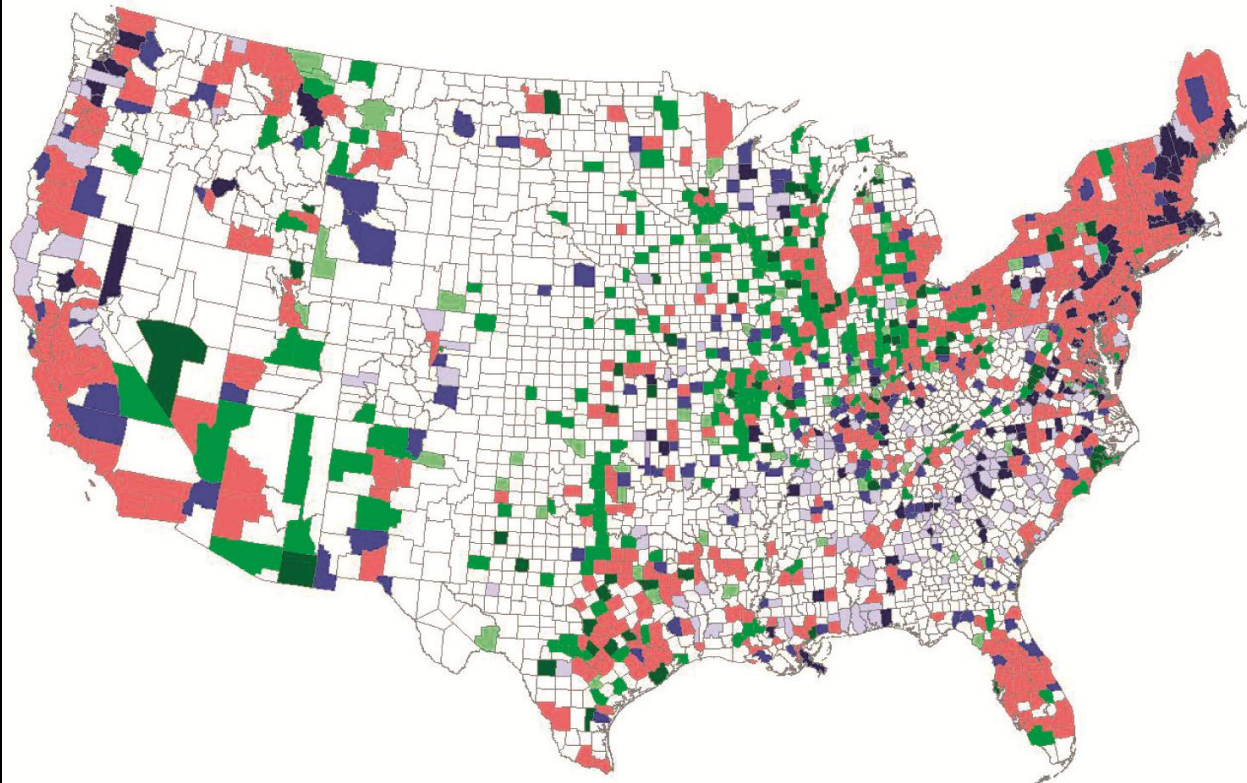









Sources

- <http://www.tfi.org/>
- <http://www.fertilizer.org/ifa/>
- <http://4e.plantphys.net/article.php?ch=5&id=289>
- <http://soil.gsfc.nasa.gov/NutrTeam/pntintro.htm>
- <http://www.ipni.net/>



Water Quality Varies



- | | |
|---|--|
|  Water Type 1 – Very Low Alkalinity
< 60 ppm (Ca = 0-60 ppm and Mg < 30 ppm) |  Water Types 1 & 2 |
|  Water Type 2 – Moderately Low Alkalinity
60-150 ppm (Ca = 0-60 ppm and Mg < 30 ppm) |  Water Types 3 & 4 |
|  Water Type 3 – Moderately High Alkalinity
150-200 ppm (Ca > 50 ppm and Mg < 30 ppm) |  Varied Water Types |
|  Water Type 4 – Very High Alkalinity
200-240+ ppm (Ca > 50 ppm and Mg < 30 ppm) | |



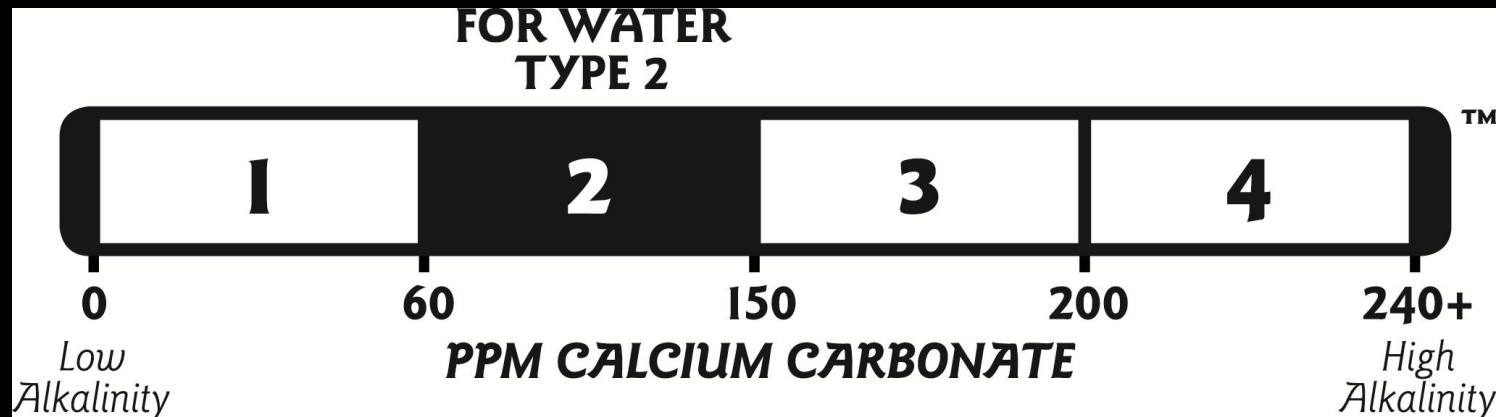
ABC System

- Web-based fertilizer decision system
- Proven N-P-K ratios based on decades of research on water quality & fertilizer performance
- Based on quality of water and crop
- *Scotts Exchange Spring 2008
- petersabc.com



Get your water tested!

- Test kit through Hummert International
- Results – handout
- Recommendations and “petersabc.com”



petersabc.com exercise

Scotts.

Scotts.

PETERS
PROFESSIONAL
WATER SOLUBLE FERTILIZER



20-10-20
GP



99300

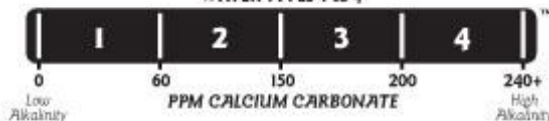
PETERS
PROFESSIONAL
WATER SOLUBLE FERTILIZER

20-10-20

GP




IDEAL FOR
WATER TYPES 1 to 4



NET WEIGHT: 25 lb (11.34 kg)

Scotts-Sierra Horticultural Products Company • 14111 Scottslawn Road • Marysville, Ohio • 43041

Peters Recommended Rates

TABLE 1 Recommended Feeding Rates		
Crop Type	Constant Liquid Feeding ppm N	Periodic Feeding ppm N
Bedding Plants	50 – 150 	150 – 250
Containerized Woody Plants	50 – 100	200 – 350
Flowering Pot Crops	200 – 300	300 – 450
Potted Foliage	150 – 200	250 – 300
Plugs (All Types)	50 – 125	175 – 225
Landscape/Outdoors	200 – 300	400 – 600

Amount of Fertilizer & EC

TABLE 2 Weight (In Ounces) of Product Needed To Mix One Gallon of Concentrate

Target Fertilizer Concentration (ppm N) After Dilution	Injector Ratios			EC mmhos/cm of Target Feed Rate After Dilution
	1:15	1:100	1:200	
50	0.5	3.4	6.8	0.31
100	1.0	6.8	13.5	0.62
200	2.0	13.5	27	1.24
300	3.0	20.3	40.5	1.86

Handouts

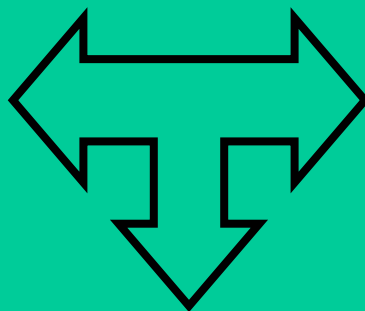
- Jack's chart
- Everiss chart
- Qwaterly
- Fertilizer
- Example water reports

Plant Nutrient Management

Water



Growing
Medium



Fertilizer