PLANT NUTRITION AND FERTILIZER MANAGEMENT IN NURSERY OPERATIONS


Organized and Presented by:
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Gerardo Spinelli
Donald Merhaut
Lorence Oki

Overview

I. Essential Nutrients
II. Nutrient Uptake Processes
III. Fertilizer Types
IV. Monitoring Crop Fertility Status

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Overview

I. Essential Plant Nutrients
   A. Essential Nutrients
   B. Nutrient Uptake
   C. Nutrient Allocation in Plants
   D. Plant Nutrient Disorders

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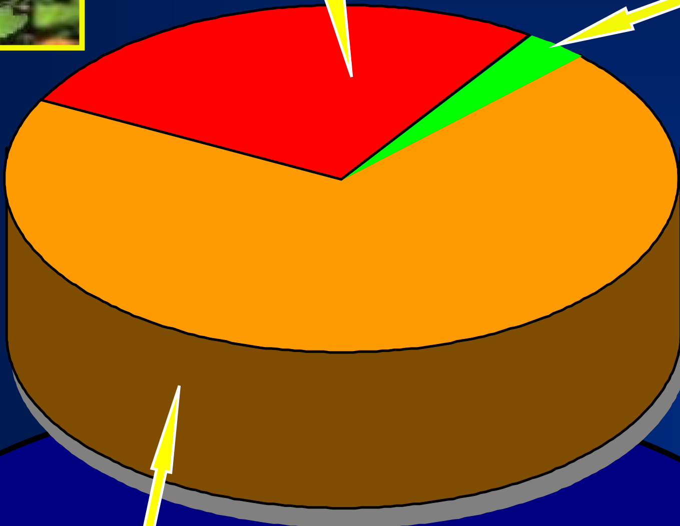
What is in a plant?

Organic matter – 22-27%

(carbon, sugars)

Minerals – 3-15%

from soil by roots



Water – 70-80%

from soil by roots

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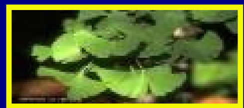

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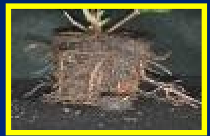

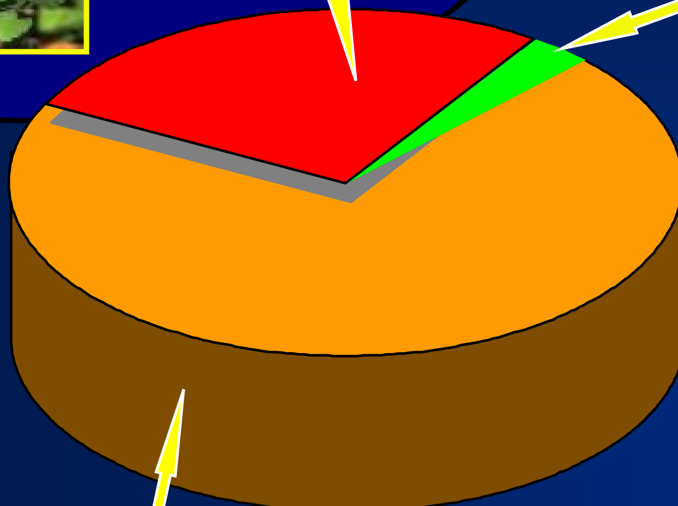

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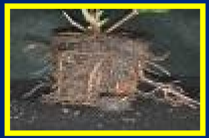

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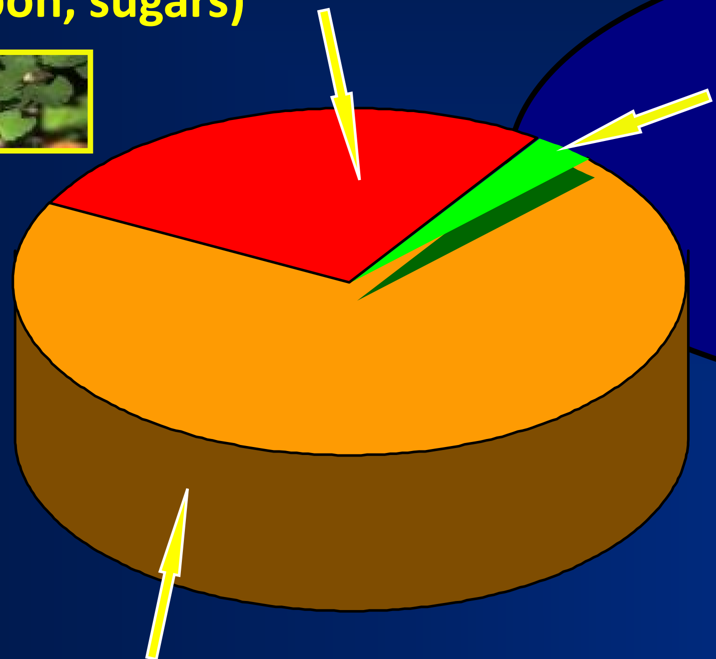

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from soil by roots

Macronutrients

Dry tissue concentration = %

Element	Abbreviation
Nitrogen	N
Phosphorus	P
Potassium	K
Sulfur	S
Calcium	Ca
Magnesium	Mg

Nancy **P**eterson's **K**ite **S**ails **Ca**lmly and **Mg**nificently.

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Macronutrients

tissue concentration = %

Report Number
16-152-0012
Lab No:

Waypoint ANALYTICAL

4741 East Hunter Ave. Suite A
Anaheim, CA 92807
Main 714-282-8777 ° Fax 714-282-8575
www.waypointanalytical.com

PLANT ANALYSIS

Customer Account Number :

Send To :

Grower :

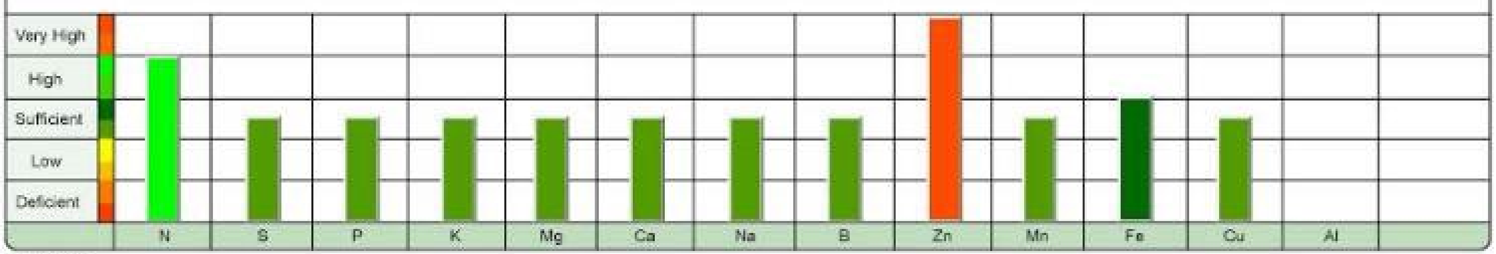
Report Date : 6/2/2016

Field id: **Organic Blackberry - 2014 Victori**
Sample Id :

Crop : **BLACKBERRIES**
Growth Stage :

	Nitrogen %	Sulfur %	Phosphorus %	Potassium %	Magnesium %	Calcium %	Sodium %	Boron ppm	Zinc ppm	Manganese ppm	Iron ppm	Copper ppm	Aluminum ppm	
Analysis	3.26	0.27	0.30	1.51	0.35	0.83	0.06	37	73	96	200	17		
Normal Range	2.00	0.21	0.25	1.50	0.30	0.60	0.00	30	20	50	50	7		
	2.99	0.50	0.39	2.49	0.89	2.49	0.19	50	50	200	200	50		

	N/S	N/K	P/S	P/Zn	K/Mg	K/Mn	Ca/B	Fe/Mn	Ca/K	Ca/Mg
Actual Ratio	12.1	2.2	1.1	41.1	4.3	157.3	224.3	2.1	0.5	2.4
Expected Ratio	7.0	1.3	0.9	91.4	3.4	159.6	386.3	1.0	0.8	2.6



Comments :

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Micronutrients

*dry tissue concentration = ppm
1 ppm = 0.0001 %
Example: Fe 50 ppm = 0.0050 %

Element	Abbreviation
Iron	Fe
Manganese	Mn
Copper	Cu
Boron	B
Zinc	Zn
Molybdenum	Mo
Chlorine	Cl
Nickel	Ni

Fertilizer Management Cuts Back the Zone of Most Clutter of chemicals Nicely

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Micronutrients

tissue concentration = ppm

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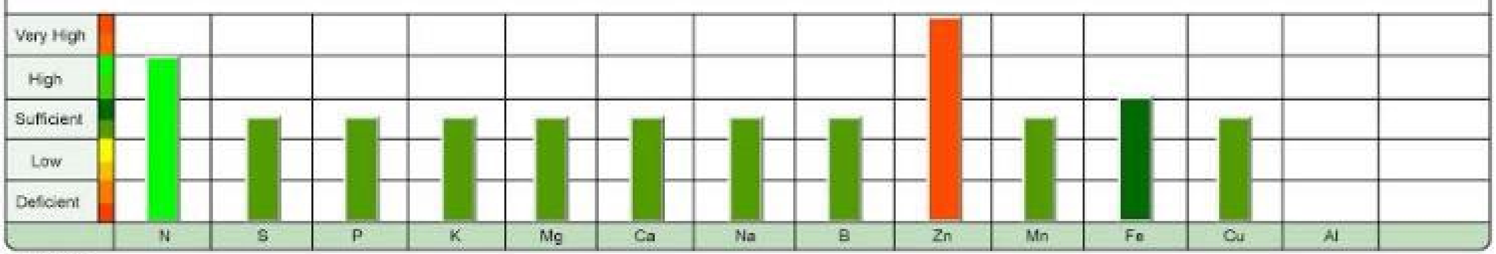

Comments :

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Essential Plant Nutrient Guide

Essential Plant Nutrient Guide

This should serve only as a general guideline since nutrient requirements will vary by differences in climate, cultural conditions and plant species.

The following list gives a general description of characteristics associated with each element.

*Number range (percentage or ppm) gives approximate nutrient concentrations for healthy plants.

*Nutrient Interactions (Toxicity) - describes possible deficiencies of other elements if said element is available in high quantities.

*Nutrient Interactions (Deficiency) – lists other elements, which when in high quantities, may induce deficiencies of said element.

Nitrogen (N) – mobile (1.0-6.0%)

Deficiency Symptoms

Mild. Uniform yellowing and senescence of older leaves.

Severe. Canopy chlorotic, plants stunted.

Soils

*Waterlogged; anaerobic (low oxygen availability); leached sandy soils may be nitrogen deficient.

Nutrient Interactions

Toxicity. NH_4^+ - competes with K, Ca, Mg. Ammonium uptake is optimum at neutral pH and uptake decreases at lower soil pH. Symptoms of ammonium toxicity include leaf necrosis of older leaves, stem lesions and stunted root and shoot growth.

NO_3^- - competes with P and S. Nitrate uptake is optimum between pH 4.5 and 6.0.

Phosphorus (P) – mobile (0.2-0.5%)

Deficiency Symptoms

Mild. older leaves turn dark green to purple. Stems of herbaceous plants become dark red.

Severe. older leaves dark purple necrotic spots.

Soils

*pH. Precipitates with Fe (low pH) or Ca (high pH), inducing deficiency of Fe and P or Ca and P, respectively.

*Cold, wet soils induce P deficiency

Nutrient Interactions

Toxicity. P competes with Fe, Zn, and Cu.

Deficiency. Fe, Zn, Al, and Ca compete with P.

Caution. Many Australian native plants and acid-requring palnts such as azalea, blueberry, and rhododendrons have lower P requirements.

Potassium (K) – mobile (1.5-4.0%)

Foliar K:N ratio 1:1 considered ideal.

Deficiency symptoms

Mild. chlorosis and necrosis develop initially on leaf margins of 2nd and 3rd oldest leaves. Monocots exhibit orange-tan speckling.

Fruit and flower quality decrease (shorter shelf-life).

*Treatment - fertilizer (soil + foliar) effective only on newer leaves. Older necrotic leaves will not recover.

Soils

*Sandy, acid soil; organic soil; peat-based mix.

Nutrient Interactions

Toxicity. K competes with Ca and Mg.

Deficiency. Ca and Mg compete with K.

Calcium (Ca) – immobile (0.5-1.5%)

Foliar Ca:Mg ratio of 2:1 and K:Ca ratio of 4:1 considered ideal

Deficiency Symptoms

Mild. New leaves chlorotic, deformed, stunted.

Severe. Leaf necrosis, meristem dies.

Problematic Situations

*Dry soils, erratic irrigation.

*High humidity, which reduces transpiration.

Nutrient Interactions

Toxicity. Ca competes with Fe, Mn, Zn, Cu.

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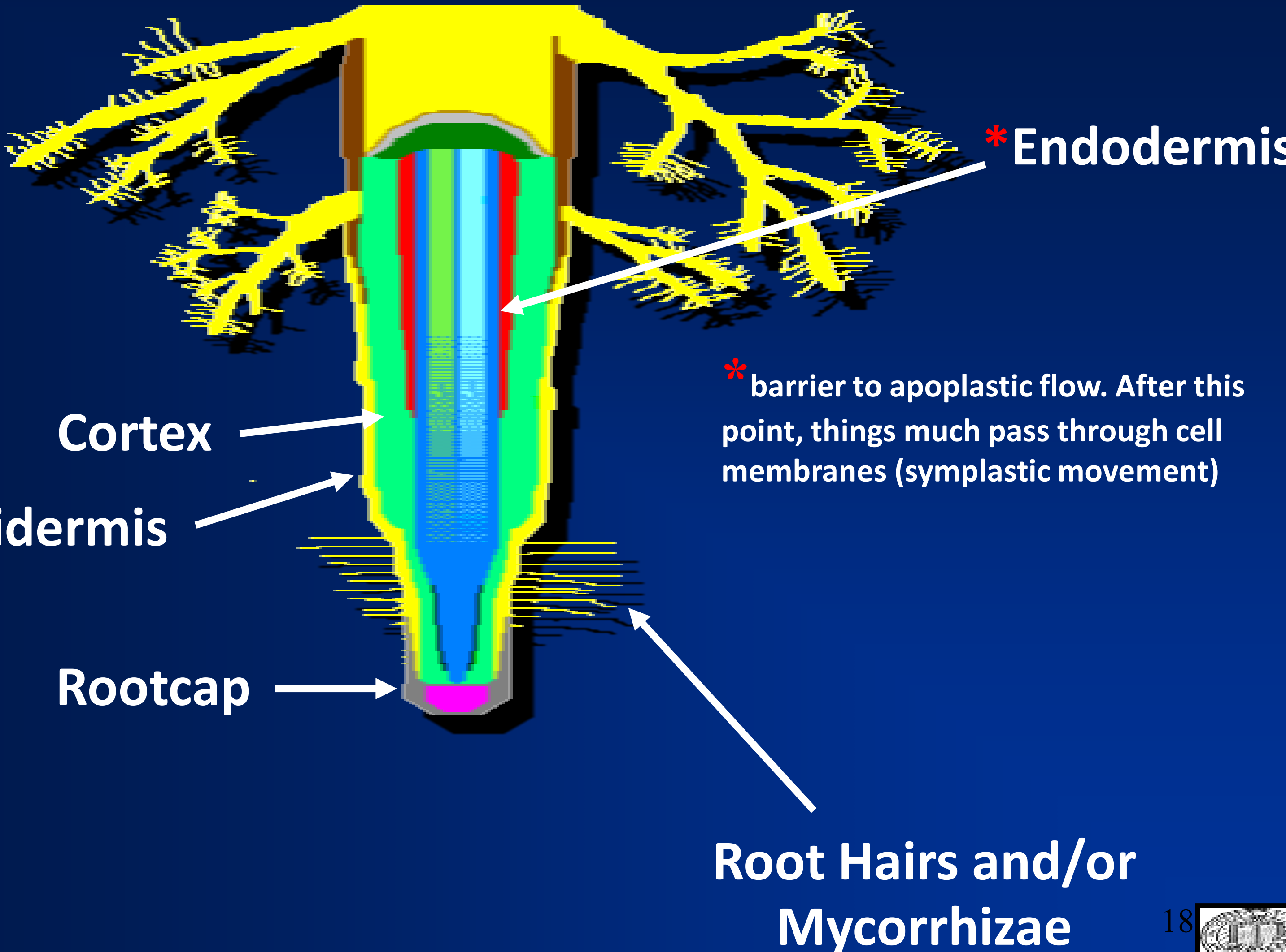
Roots
Water and Nutrient Uptake



*barrier to apoplastic flow. After this point, things much pass through cell membranes (symplastic movement)

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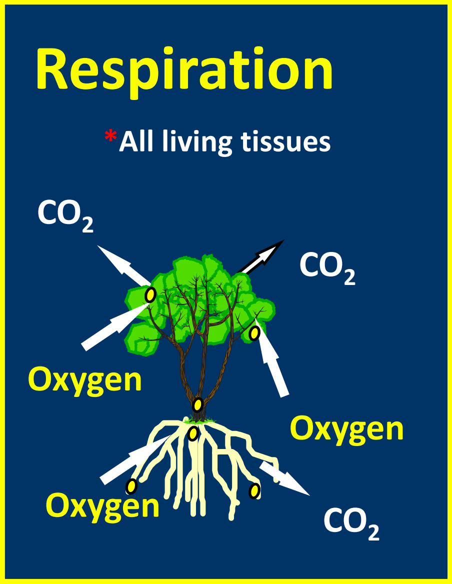
Nutrient Uptake Processes

*<u>Active</u> - requires energy, derived from respiration



*<u>Selective</u> - roots distinguish one nutrient from another nutrient

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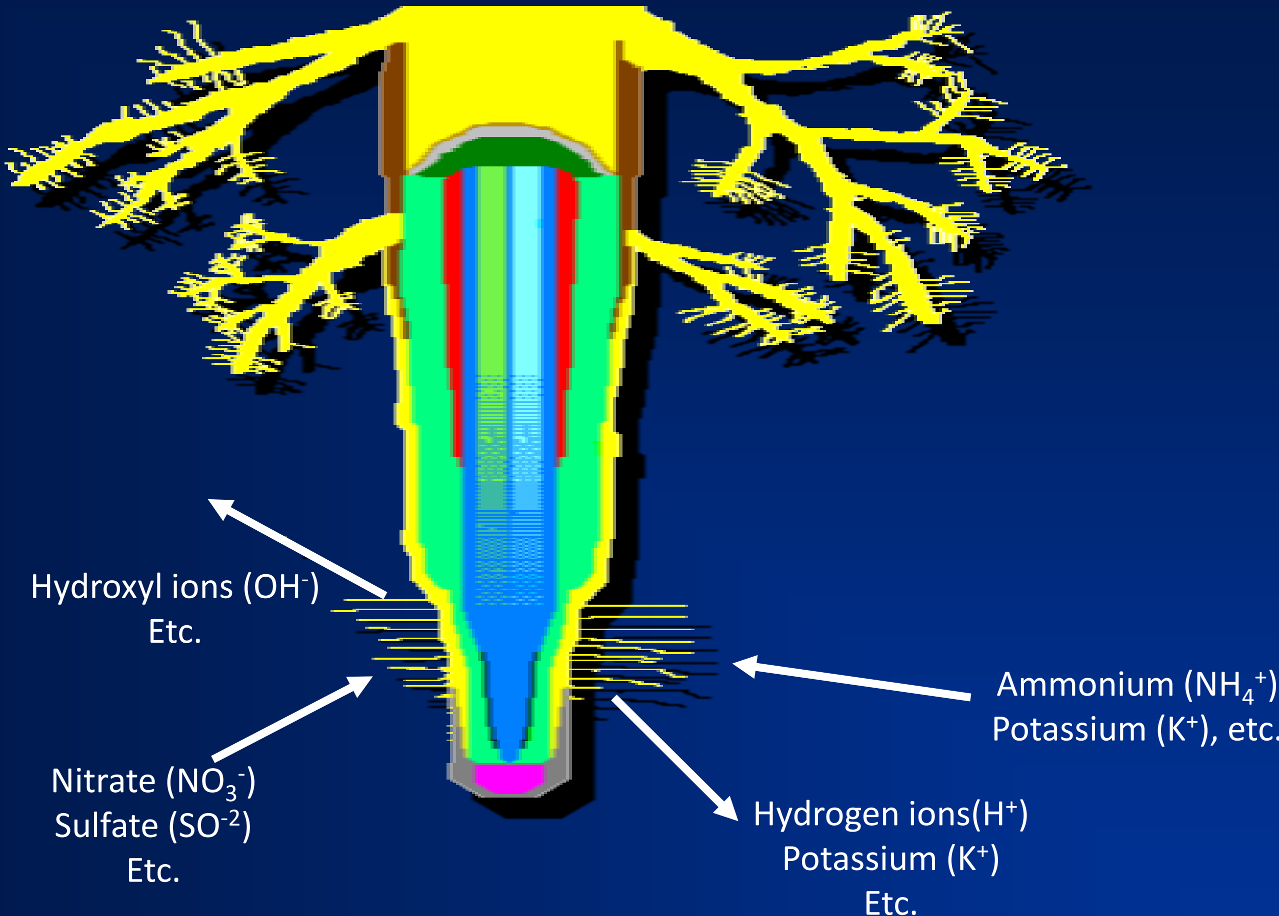
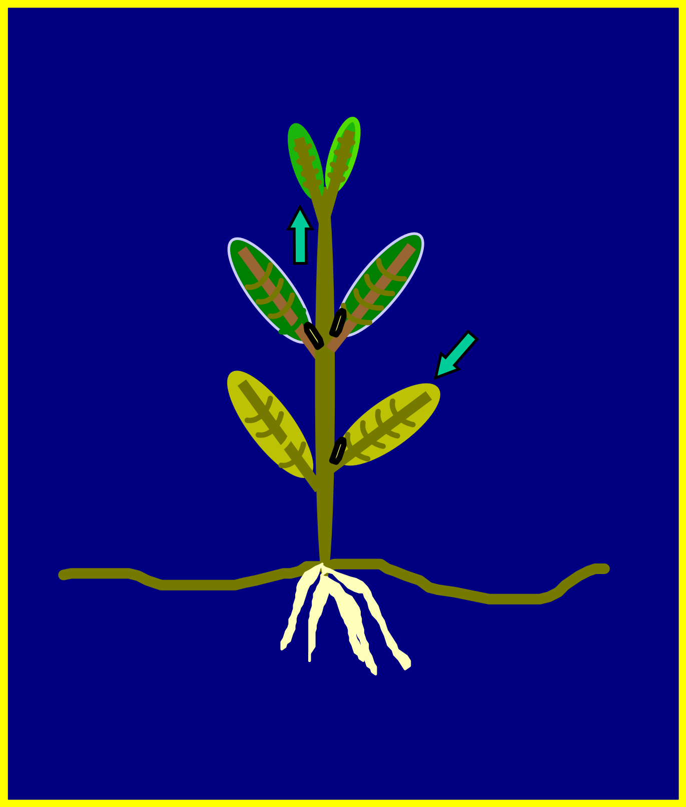
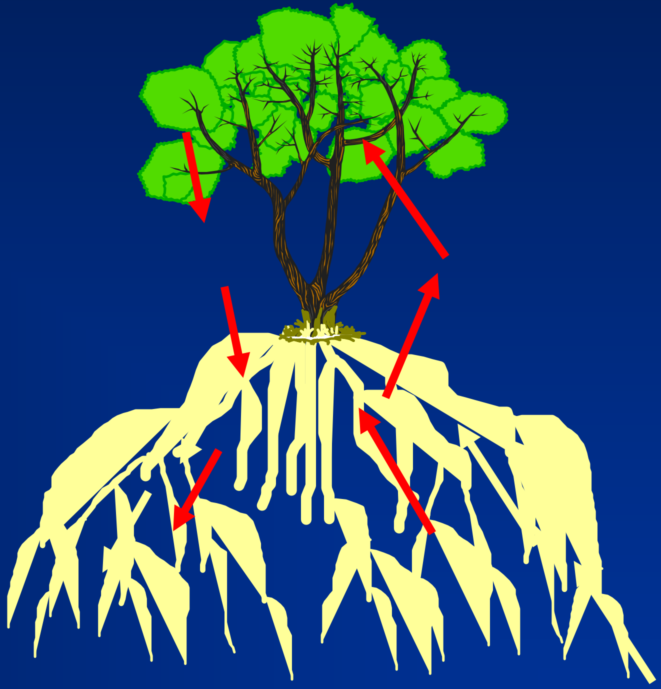
Nutrient Uptake
Influx/Efflux Processes and Selective



Nutrient uptake Signals from Shoots





Signals from shoots to roots

wikipedia

Proteoid Roots

*Cluster root development by select plant species
*Cluster roots originate from plant.
*Signal from shoots for development
*Signal from shoot phosphorus deficiency.
*Shoot Nitrogen and Iron deficiency also.

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Mycorrhizal Roots

Drawing: USDA

*Beneficial fungi colonize outside and/or inside roots
*Symbiotic relationship with root.

*Nursery systems

-Media specific

- Only low fertility/no fungicide program

-Infectivity minimal

-Effectivity minimal

*Exceptions: native nurseries with extremely low fertility programs.

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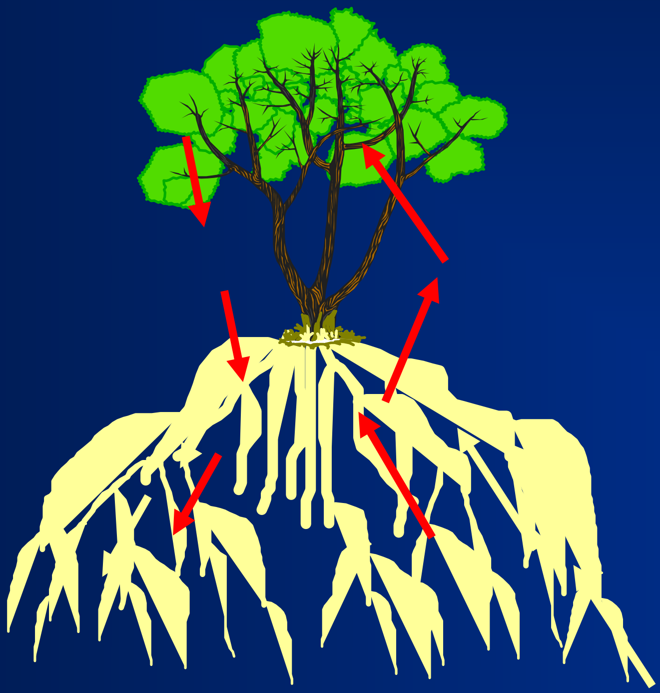
Nutrient Uptake Processes

***Mobile** - move upward in xylem from roots. Also can be remobilized from older tissues and translocated in phloem to younger growth.



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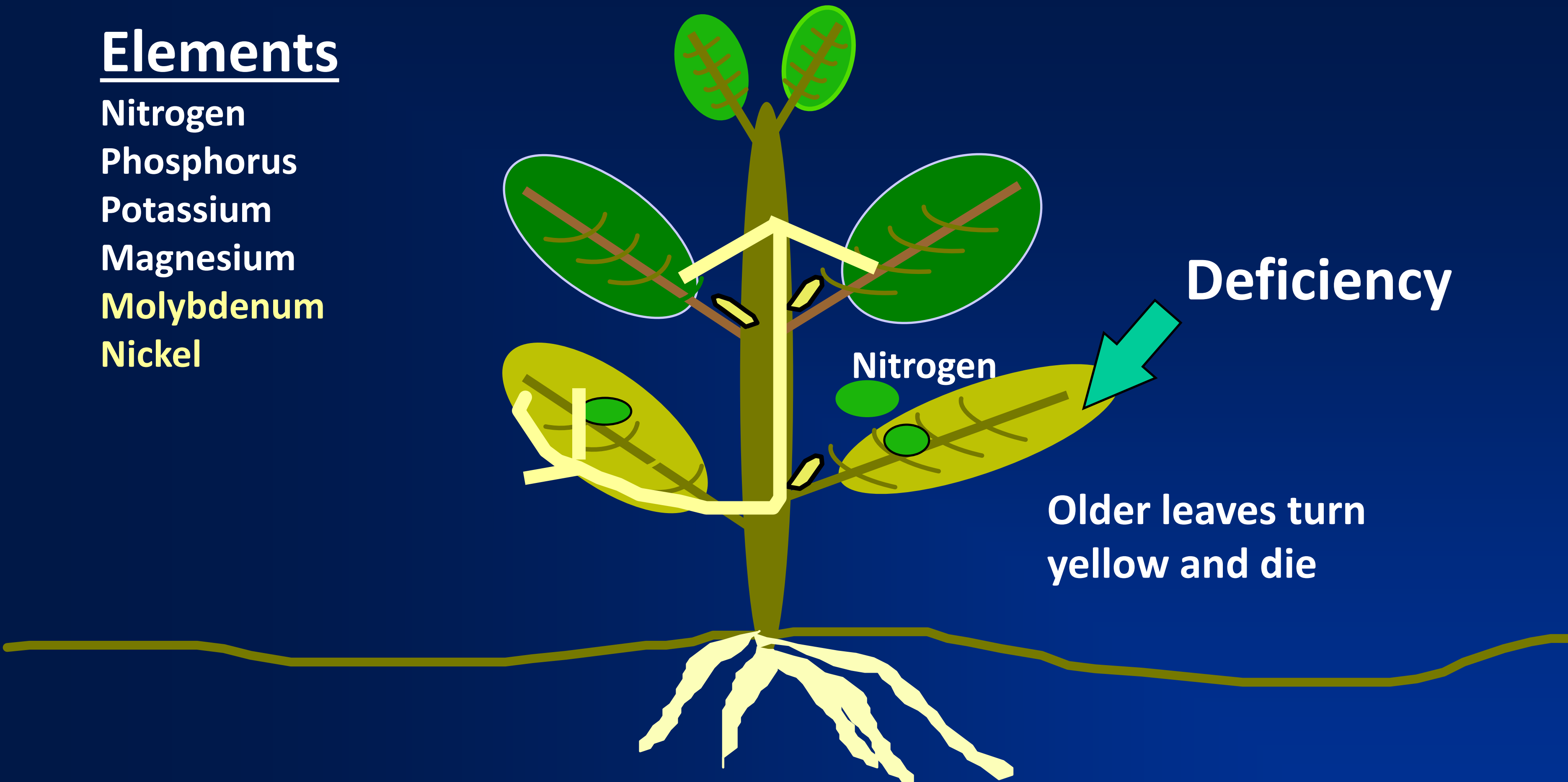
Mobile Nutrients

Elements

Nitrogen
Phosphorus
Potassium
Magnesium
Molybdenum
Nickel



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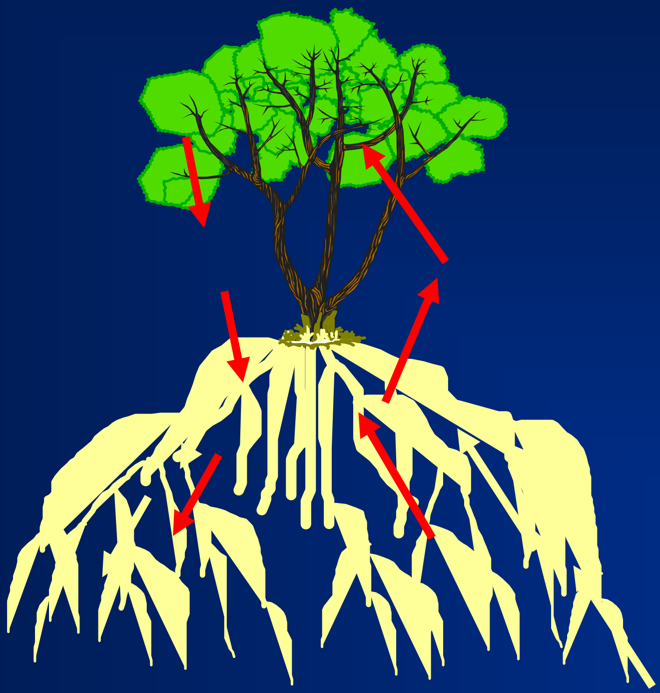
Nutrient Uptake Processes

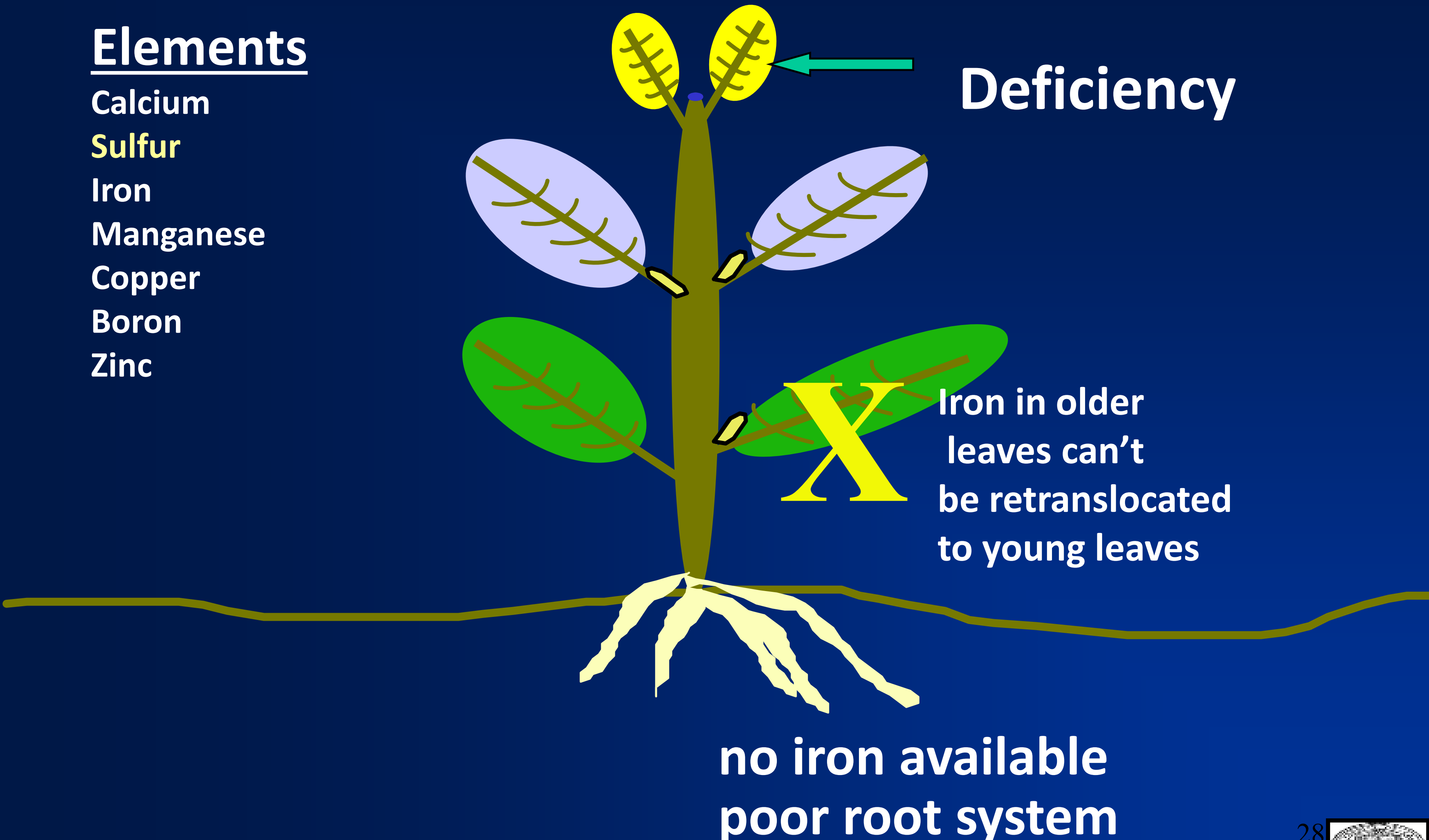
***Immobile** - move only upward in xylem from roots



Immobile Nutrients

Elements

Calcium
Sulfur
Iron
Manganese
Copper
Boron
Zinc



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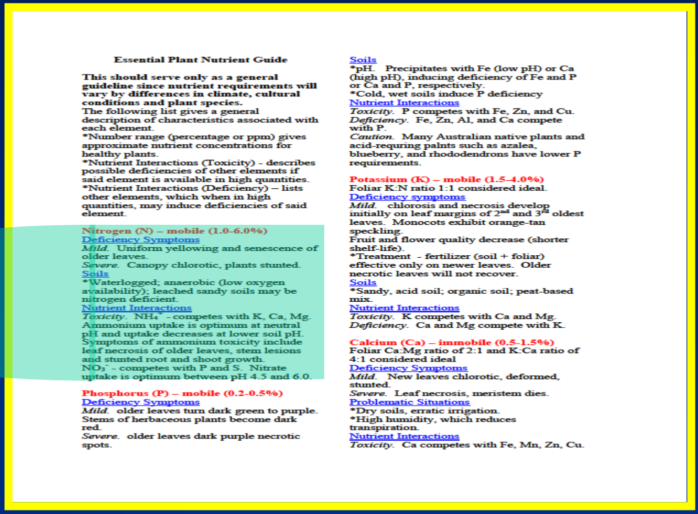

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*High humidity, which reduces transpiration.

Nutrient Interactions

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Nitrogen

- Plant requirements: 1-6%
- Fertilizer types: NH_4^+ , NO_3^- , urea, manures
- Plant: Mobile
- Cultural: NH_4^+ can reduce K^+, Ca^{++} and Mg^{++} uptake; NO_3^- can reduce PO_4^{-2} and SO_4^{-2} uptake

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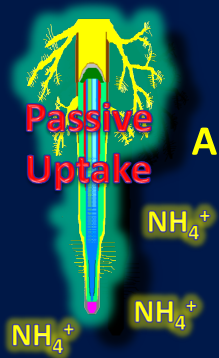
Nitrogen Uptake

-CHO → Storage in vacuoles

Nitrate

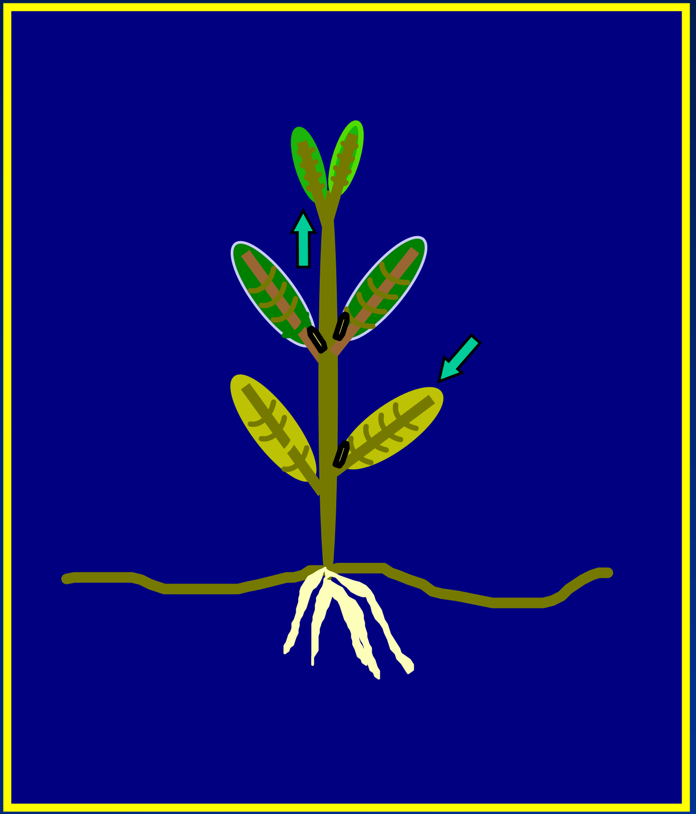
+CHO → Ammonia -> amino acids –> proteins structure



Ammonium → Amino acids –> proteins structure

+CHO -> okay

-CHO -> toxicity



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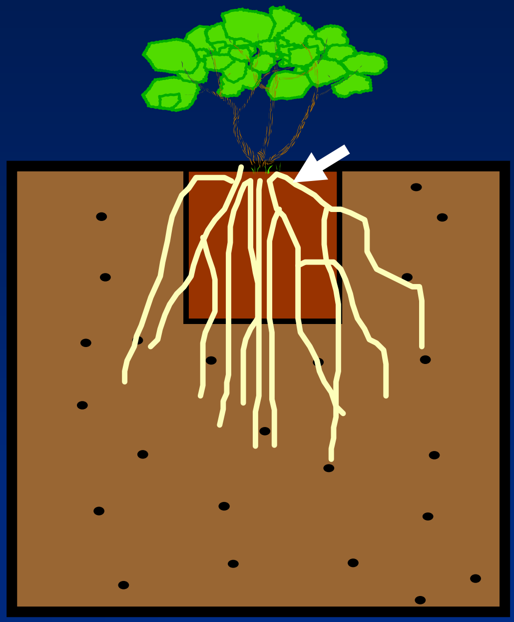
Nitrogen cycling

- <u>Sources</u>
- Fertilizer
- Substrates/Medium -mineralization
- Irrigation Water
- Atmosphere – N fixation, pollution

- <u>Sinks</u>
- Plant - uptake
- Microbes in media - immobilization
- Atmosphere – denitrification (NO_3 -> N_2, N_2O)
- - ammonia volatilization (NH_4 -> NH_3)

- *Runoff of NO_3^-, a negatively charged particle



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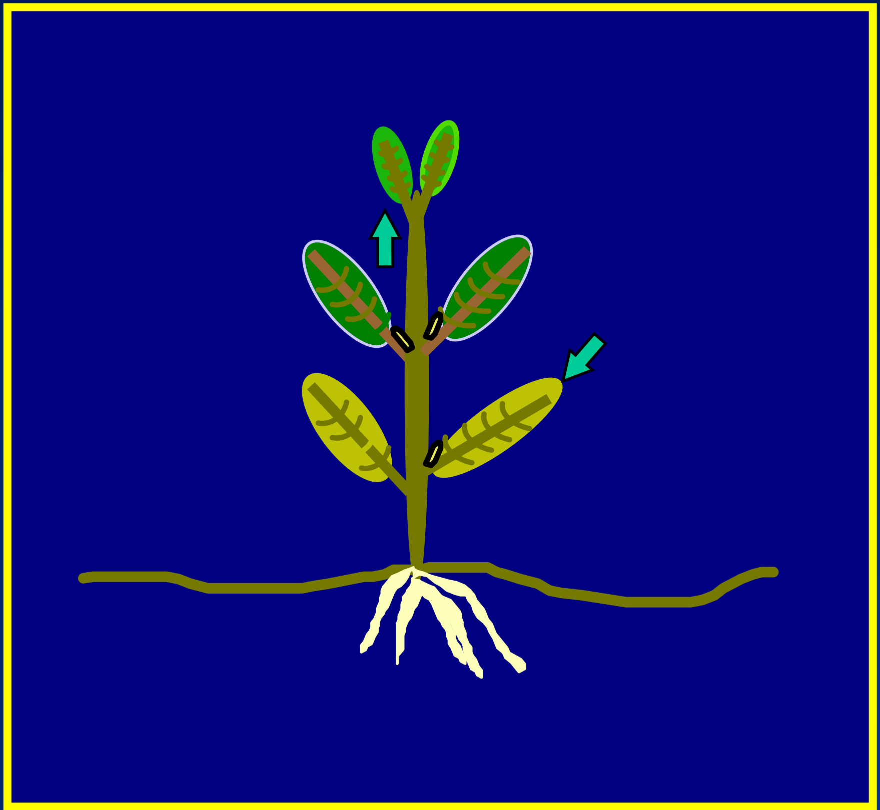
Nitrogen

- Amino acids – protein building blocks
- Chlorophyll – structure
- Enzyme processes
- Turgidity – osmotic potential + stomate control



Nitrogen Deficiencies

Environmental and Cultural conditions

- Cold soils
- Wet soils
- Sandy soils
- High C:N ratio organic substrates
- Leached soils
- flooded, warm soils

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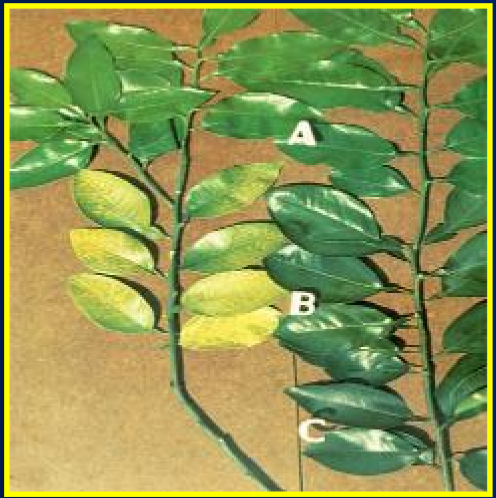
Nitrogen Deficiencies

- Yellowing - oldest leaves
- Stunting - of whole plant
- Toxicity- succulence, necrosis

Maize



Citrus

Mum – yellow, stunted

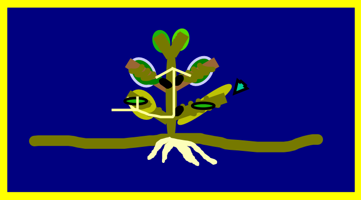
Phosphorus

Plant requirements: 0.20-0.50%

Taken up as: $H_2PO_4^-$ and HPO_4^{-2}

Fertilizer types: Phosphates (PO_4)

Plant: Mobile



Soil: Usually immobile

Cultural:

Cold soils - added

N:P ratio of 10:1

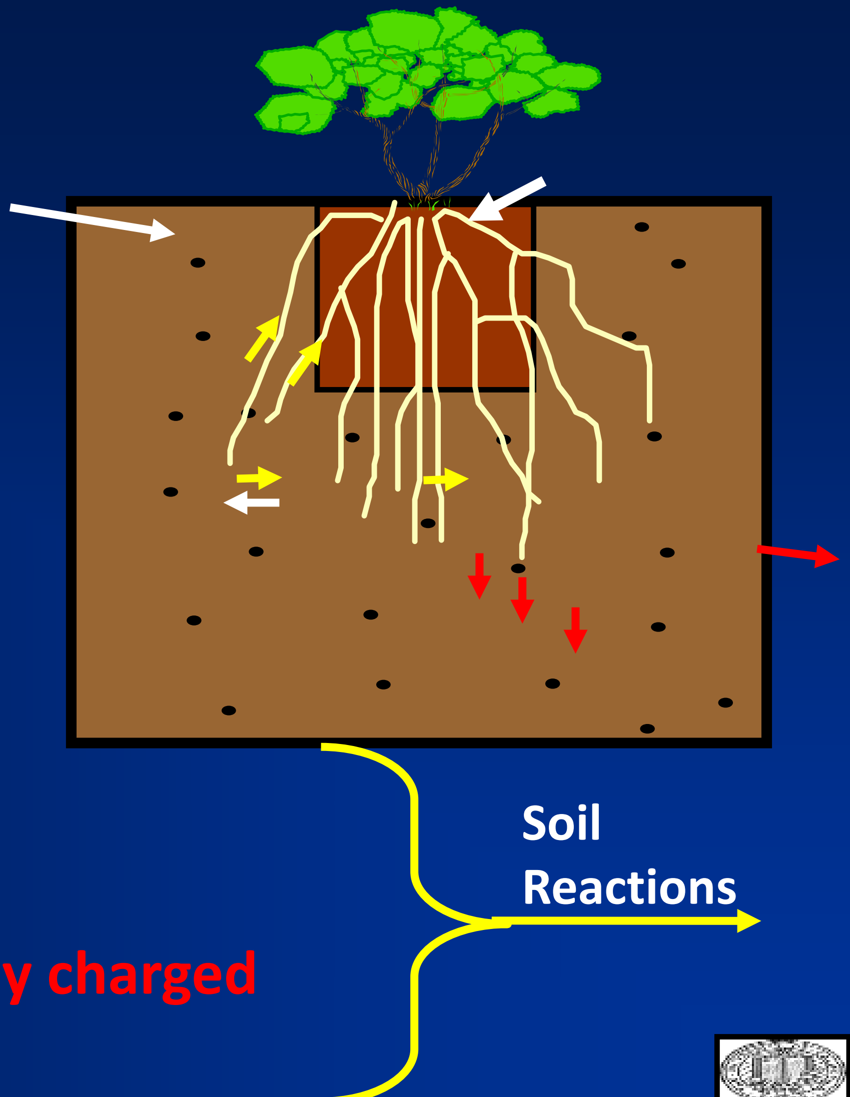
P can reduce Zn

Phosphorus Cycling

Sources
*Fertilizer
*Substrates/Medium
*Irrigation Water

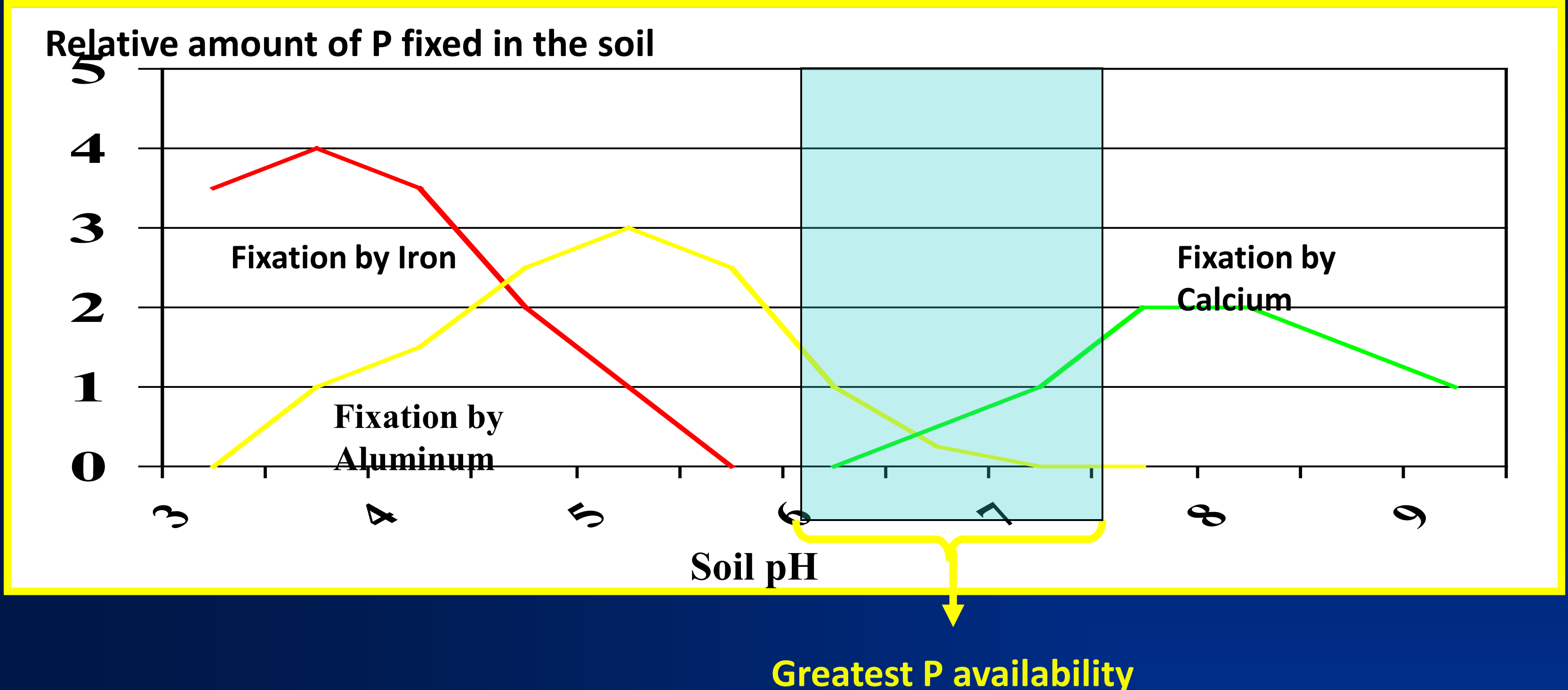
Sinks
*Plant - uptake
*Microbes in media – immobilization
*chemical precipitation

*Leaching
*Runoff



*Runoff of $H_2PO_4^{-2}$, a negatively charged particle

Phosphorus Availability:
as affected by soil pH*

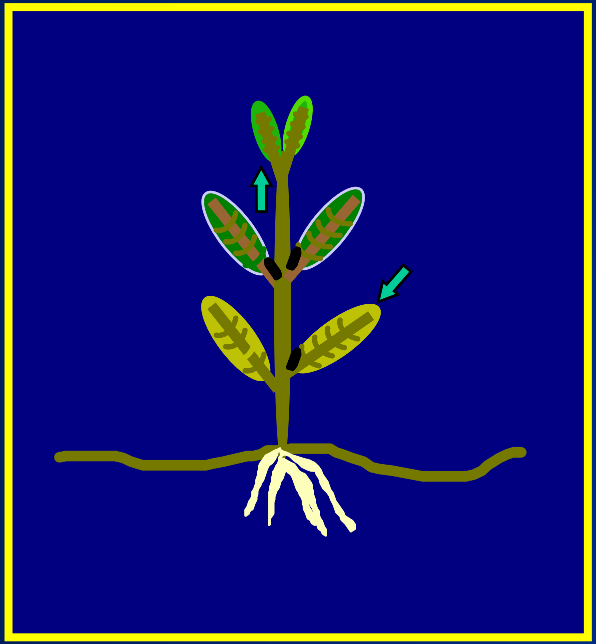


*Adapted from Western Fertilizer Handbook.- Second Horticulture Edition. 1998.
California Fertilizer Association Figure 4.4

Phosphorus

DNA and RNA – in genetic material
ATP – chemical energy transfer and storage

Mobile in plants



Phosphorus Deficiencies

Environmental and Cultural conditions

>Cold Soils
>Limited root growth
>Rapid vegetative growth
>Acid soils
>Calcareous soils

Possible susceptible plants to Toxicity

Plant that have mycorrhizal and rhizobial associations and proteoid roots.
Australian natives – Protea, Boronia, Grevillia
Ericaceous plants – Azalea, blueberry, Rhododendron

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Proteoid Roots

wikipedia

Proteoid Roots from *Leucospermum cordifolium* – formed by plant in response to P, N and Fe deficiency (signal from shoots)

Phosphorus Deficiencies

>Dark green/purple, necrosis - oldest leaves
>Stunting - of roots
>Reduced flowering, seeds, and fruits
>Toxicity causes Fe, Zn, Cu deficiency
>Decreased nutrient uptake


Mum - dark green + stunted


Mum - necrosis


Rice - necrosis


Maize - reddening

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Phosphorus Deficiencies

Fertilization Methods

Onion
P Broadcast

Onion
P banded

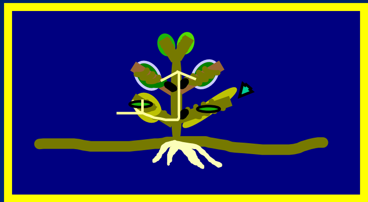
Potassium

Plant requirements: 1.5-4.0%

Taken up as: K^+

Fertilizer types: K salts (KCl, K_2SO_4, etc.)

Plant: Mobile



Soil: Usually immobile

Cultural:

>Sandy, acid soils
>Organic soils
>peat soils

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Potassium Cycling

Sources

*Fertilizer

*Irrigation Water

Sinks

*Plant - uptake

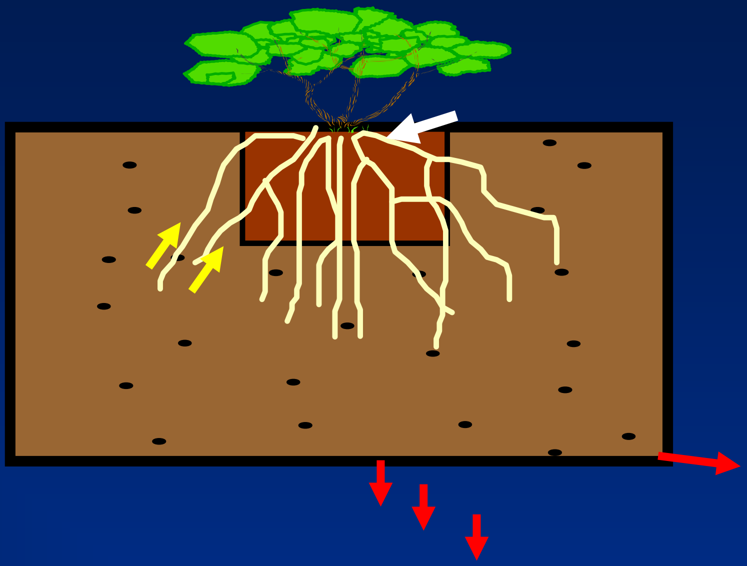
*bound by clay and mineral lattices

*insignificant binding in media

*Leaching – for containers

*Runoff- for containers

*Runoff of K^+ in media, but will be tied up in clay particles.



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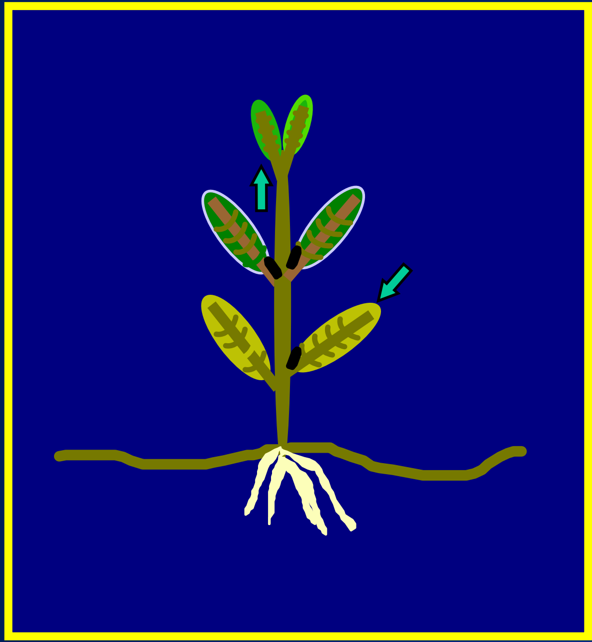
Potassium

Functions in plants

*Sugar translocation
*Starch formation
*Guard cells – stomatal opening/closing
*Cell turgor

Mobile in plants



Potassium Deficiencies

Environmental and Cultural conditions

*wet, compacted soils
*sandy, leached soils
*dry environment
*heavily cropped soils
*Excess applications of nitrogen
*high organic soils

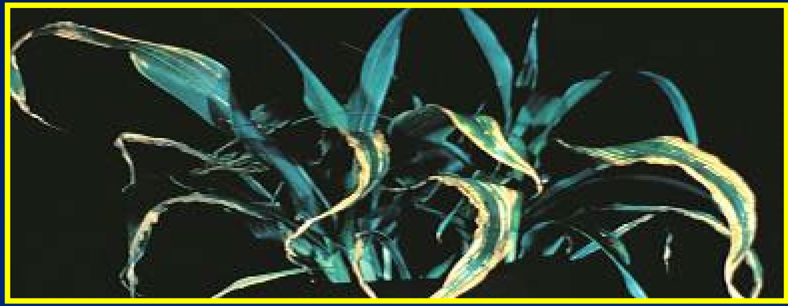
Susceptible plants
*Palms – select species
*Leafy tropicals – select types

UCCE

Potassium Deficiencies

*yellowing - speckling - edges of older leaves
*leaf scorch - edges look burnt
*'lodging' of grasses
*Toxicity = Mg deficiency

Blueberry



Corn

Avocado – similar to the more common chloride tip burn

UCCE

Sulfur

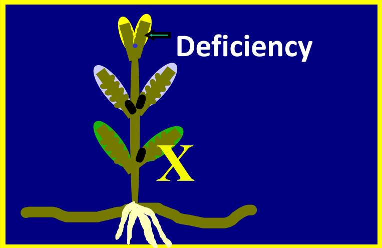
Plant requirements: 0.10-0.50%

Taken up as: Sulfate (SO_4^{-2})
Sulfur dioxide (SO_2)

Fertilizer types: Salts ($MgSO_4$, K_2SO_4, etc.)

Plant: *Not Mobile

Soil: *Mobile



Cultural:

*Sandy, acid soils
*Organic soils
*peat soils
*cold soils

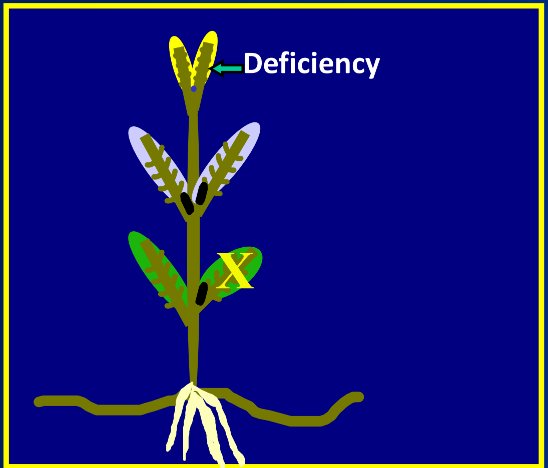
Sulfur

Functions in plants

*Protein synthesis → key proteins of:

*Stress induced proteins
*Pathogen induced proteins
*Nitrogen assimilation

Not Mobile



Sulfur Deficiencies

>yellowing - younger leaves
>red/purple leaves - extreme
>woody stems
>longer roots, unbranched roots
>stunting and delayed maturity
Toxicity = 0.5-0.7 mg/M^3 air. Necrotic spots
>deficiencies less in urban industrial regions

Apple – stunted + yellow

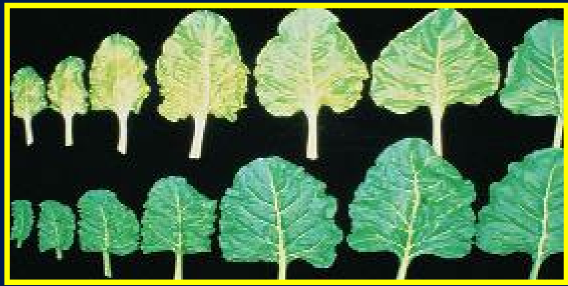
Tomato - yellow

Sulfur Deficiencies

Younger Older

No sulfur

Yes sulfur



Sugar beet – young and old leaves yellow and stunted

No sulfur Yes sulfur

Potato – R to L, def symptoms increase. Same age leaves

Symptomatic of Nitrogen Deficiency

Sorghum – new leaves yellow

Schefflera – yellow leaves

Calcium

Plant requirements: 0.5-1.5%

Fertilizer types: Lime ($CaCO_3$) - Inc. pH, Gypsum ($CaSO_4$)
Calcium chloride ($CaCl_2$)

Plant: Not mobile

Cultural:

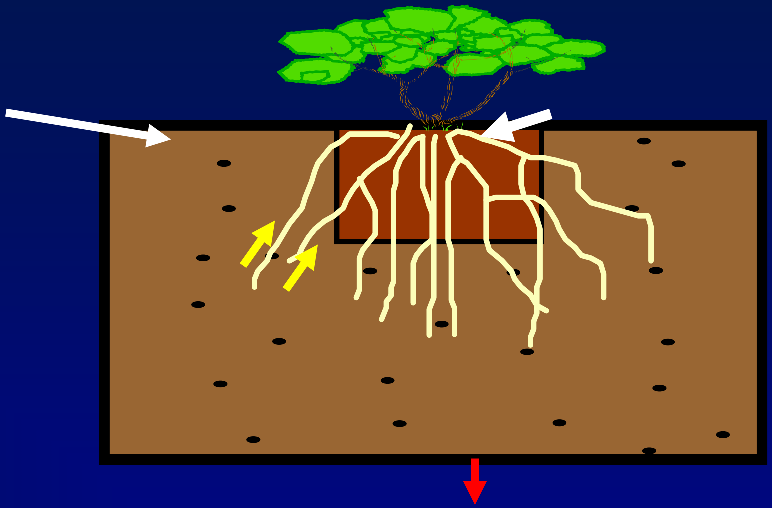
>Uptake reduced: NH_4>Mg>K>Na
>Irregular soil moisture availability
>High humidity
>NO_3 inc. Ca uptake
>Acid soils - leached
>Plant Ca:Mg of 2:1
>Plant K:Ca of 4:1

UCCE

Calcium Cycling

<u>Sources</u>

*Fertilizer
*Irrigation water
*Soil
*Liming



<u>Sinks</u>

*Plant – uptake
*Chemical precipitation in soils
phosphorus at: pH ≥ 6.5

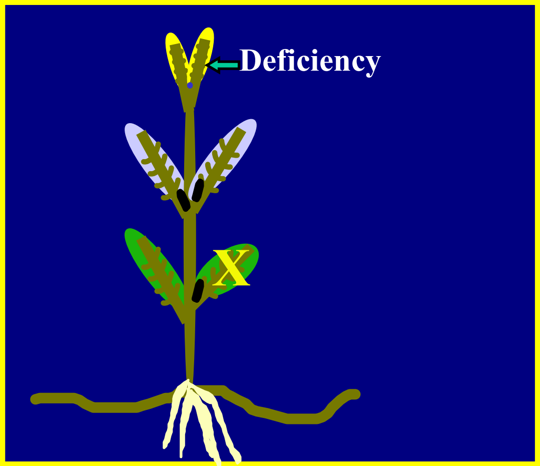
*Containers - leached
*Soils – leached in acid sandy soils

Calcium

Functions in plants

>Cell wall integrity
>Cell membrane integrity
>Cell expansion through osmotic effects in vacuoles

Not Mobile



UCCE

Calcium Deficiencies

>chlorotic, deformed - younger leaves
>necrosis - extreme
>'Blossom-end rot', bitter pit of fruit
>'Brownheart of heading vegetables
>stunted, branched roots
>Toxicity = Mg, K deficiency

Tomato – blossom end rot
Irregular irrigation during fruit set

Mum - deformed

Older younger

Citrus - chlorosis

Calcium Deficiencies

Tomato – tip dieback and subsequent branching of roots

Potato – young growth wilting

Blueberry – chlorosis of new growth

Apple – bitter pit

UCCE

Magnesium

Plant requirements:

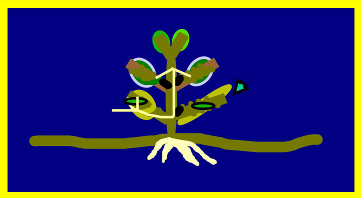
0.15-0.40%
Ca:Mg 2:1
K:Mg 8:1

Fertilizer types:

$MgSO_4$*$7H_2O$
Dolomite $(CaCO_3)(MgCO_3)MgO$

Plant:

Mobile



Cultural:

>Reduced by K, NH_4, Ca, Na
>sandy, leached soils
>Acid soils

Magnesium Cycling

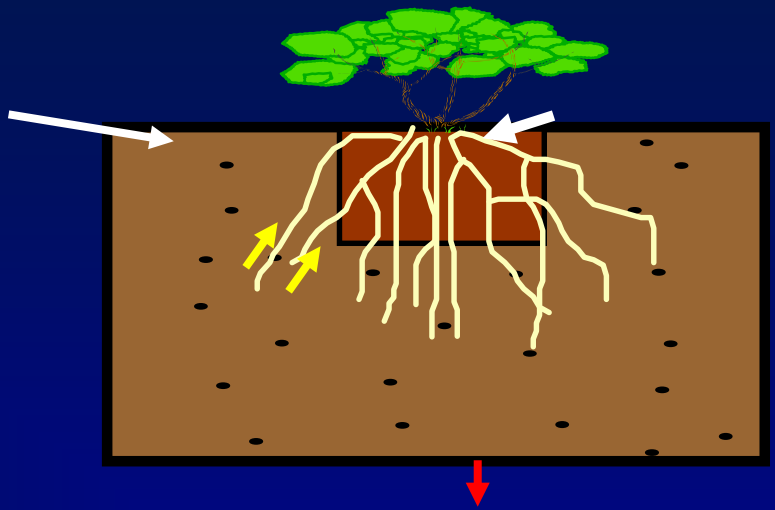
Sources

>Fertilizer

>Irrigation water

>Soil

>Liming - dolomite



Sinks

>Plant – uptake

>Chemical precipitation in soils

>Containers - leached

>Soils – leached in acid sandy soils

Magnesium Deficiencies

>Xmas tree patterned chlorosis
>Interveinal chlorosis – oldest leaves
>Stiff, brittle, veins twisted - extreme

+Mg -Mg

Peach- chlorosis

Mum- lower leaf chlorosis

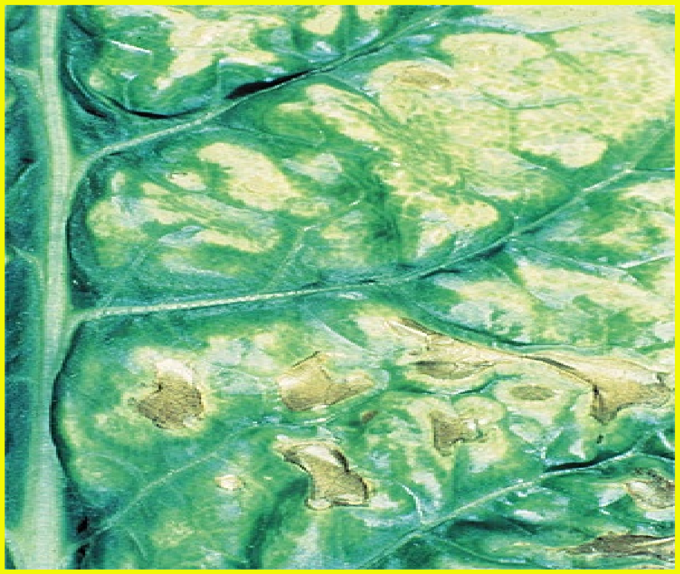
Palm - chlorosis

UCCE

Magnesium Deficiencies

Citrus - chlorosis

Tobacco – Sand drown
(excess irrigation or rain)



Tobacco – interveinal chlorosis

Micronutrients

Element	Abbreviation
Iron	Fe
Manganese	Mn
Copper	Cu
Boron	B
Zinc	Zn
Molybdenum	Mo
Chlorine	Cl
Nickel	Ni

Fertilizer Management Cuts Back the Zone of Most Clutter of chemicals Nicely

Iron

Plant requirements:

50-75 mg/kg (ppm)
P:Fe of 29:1

Fertilizer types:

$FeSO_4$, $FeCl_2$, Fe-chelates

Plant functions:

Enzyme reactions – oxidation/reduction
- *nitrate reduction
- *photosynthesis

Cultural:

>High pH
>Poor drainage
>NO_3/high pH reduced Fe

UCCE

Iron Deficiencies

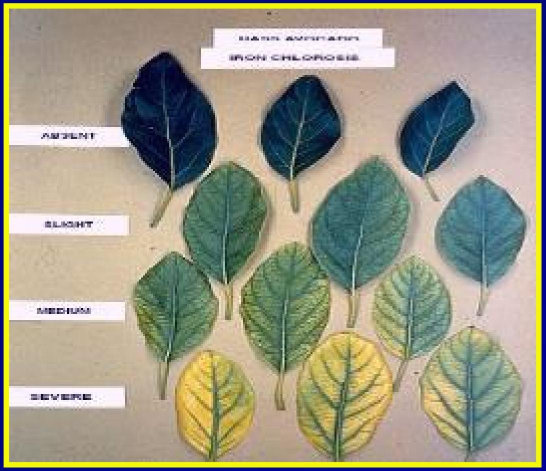
>Interveinal chlorosis - younger leaves
>Toxicity = bronzing, speckling leaves
>root inhibition, roothair promotion (except grasses)

+Fe -Fe

Citrus

Mum

Sorghum



Avocado

Manganese

Plant requirements: 10-40 mg/kg (ppm)

Fertilizer types: $MnSO_4$, $MnCl_2$, Mn-chelates

Plant functions: Enzyme activator

>free radical protection

>energy transfer

Cultural:

>High pH

>Poor drainage

>Acid soils = toxicity

UCCE

Manganese Deficiencies

>Interveinal chlorosis – young leaves
>'Gray Speck'
>Toxicity = marginal yellowing young leaves
>Toxicity = measles on stems, fruit

Citrus

Tomato

Avocado

Palm – cool temperatures

UCCE

Copper

Plant requirements: 3-20 mg/kg (ppm)
200 ppm in fungicides

Fertilizer types: $CuSO_4$, $CuCl_2$, Cu-chelates

Plant functions:
>Lignification of cell walls
>Carbohydrate transport
>Pollen viability

Cultural: Zn, Mo, Al reduce Cu

UCCE

Copper Deficiencies

>Chlorosis, bleached leaves
>Distorted leaves and stems
>Toxicity = Fe deficiency

Citrus – stem dieback

Barley –'pigtailing'

Citrus – gum pockets

Aglaonema – leaf curling

Sugar beet – leaf bleaching

Boron

Plant requirements:	20 mg/kg (ppm)
Fertilizer types:	Borax, Solubor, Boric acid
Plant functions:	>Cell wall synthesis >Plasma membrane integrity >Root elongation >Pollen viability
Cultural:	>B def. reduces P uptake >Ca reduces B toxicity

UCCE

Boron Deficiencies

>Deformed, thick, dark green growing tips
>Roots - slimy, thick, cracked, bumpy, necrotic
>Crown, heart rot
>Toxicity = leaf tip necrosis scorch
5-10 ppm water (sensitive plants)

Apple – stem necrosis

Grape – clubroot, splitting

Grape – fruit set

Strawberry – fruit set

UCCE

Zinc

Plant requirements: 15-50 mg/kg (ppm)

Fertilizer types: $ZnSO_4$, $ZnNO_3$, Zn-chelates

Plant functions:
>Enzyme activity
>Membrane integrity
>Auxin metabolism

Cultural:
>P reduces Zn uptake
>Zn reduces Fe, Mn uptake

Zinc Deficiencies

>Interveinal chlorosis - young leaves
>Banding chlorosis in monocots
>rosetting of shoots – auxin dysfunction
>Toxicity = Fe, Mn, P deficiency

Apple – rosetting

Peach - rosetting

Sugar beet

UCCE

Molybdenum

Plant requirements: 0.15-0.30 mg/kg (ppm)

Fertilizer types: $(NH_4)_2MoO_4$, Na_2MoO_4, molybdic oxides

Plant functions:

>Nitrate reduction

>Nitrogen-fixing enzymes - legumes

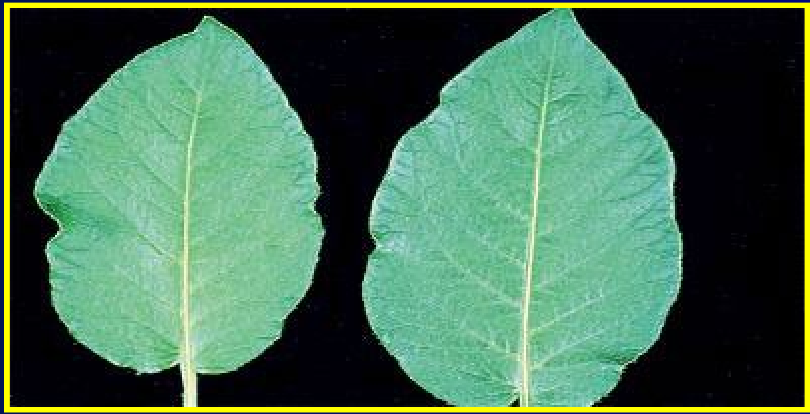
Cultural: >Sandy, leached acid soils

Molybdenum Deficiencies

>Chlorosis, curling - older leaves
>N deficiency – with nitrate-nitrogen fertilizer
>Whiptail brassicas
>Marginal chlorosis of middle-aged leaves (Poinsettia)
>Toxicity = no

Mum

African violet



Potato – left leaf

UCCE

Nickel

Plant requirements: 0.05-5.0 mg/kg (ppm)

Fertilizer types: >usually present as impurities

Plant functions: >assimilation of urea-nitrogen

Cultural: >Sandy, leached acid soils

Deficiency symptoms:
>'mouse-ear' in all leaves
>stunted plants

UCCE