Early Detection of Nutrient Deficiencies and Toxicities

IPM Scout Training Program

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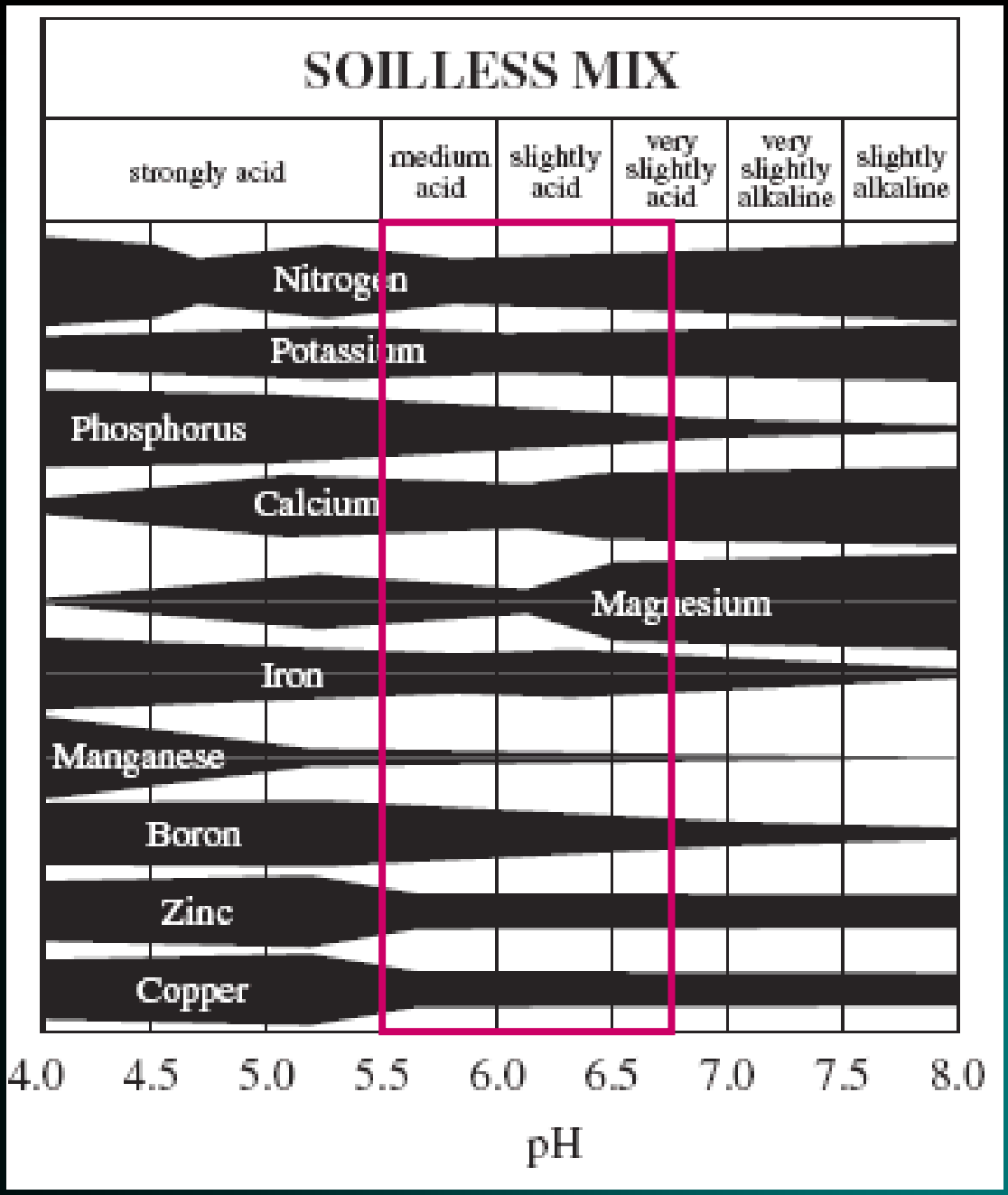
Making the Plant Happy

Objectives for this topic include:

- Identifying nutrient deficiencies in plants


SOILLESS MIX
strongly acid
medium acid
slightly acid
very slightly acid
very slightly alkaline
slightly alkaline
Nitrogen
Potassium
Phosphorus
Calcium
Magnesium
Iron
Manganese
Boron
Zinc
Copper
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
pH

	Nutrient	%	ppm
Macronutrients	Nitrogen	1.5	
	Potassium	1.0	
	Calcium	0.5	
	Magnesium	0.2	
	Phosphorus	0.2	
	Sulfur	0.1	
Micronutrients	Chlorine		100
	Iron		100
	Manganese		50
	Boron		20
	Zinc		20
	Copper		6
	Molybdenum		0.1
	Nickel		0.05?

Nutrient Interactions: Relationships of elemental excess in growing media to potential nutrient deficiencies in plant tissue.

Element in excess in media	Element possibly deficient in plant tissue
Nitrogen as ammonium	Potassium, Calcium, Magnesium
Potassium	Nitrogen, Calcium, Magnesium
Phosphorus	Copper, Zinc, Iron
Calcium	Magnesium, Boron
Magnesium	Calcium, Potassium
Sodium	Potassium, Calcium, Magnesium
Manganese	Iron, Molybdenum
Iron	Manganese
Zinc	Manganese, Iron
Copper	Manganese, Iron, Molybdenum
Molybdenum	Copper

Aluminum: this element is not essential and high levels are rare in artificial soils. High Aluminum will precipitate Phosphorus as Aluminum Phosphate and can highly reduce short term Phosphorus availability.

Mobility of Plant Nutrients: Mobility of elements in the plant often defines the location of visual symptoms of nutrient deficiencies or toxicities:

Very mobile – deficiencies show up in oldest leaves

Moderately mobile – depends on plant

Limitedly mobile - deficiencies show up in youngest leaves

Very Mobile	Moderately Mobile	Limited Mobility
Nitrogen	Magnesium	Iron
Phosphorus	Sulfur	Manganese
Potassium	Molybdenum	Copper
Chlorine		Zinc
		Calcium
		Boron

* Most recently matured leaves are the most accurate leaf sample for nutrient analysis.

Suggested Readings

Growing Media for Ornamental Plants and Turf

Handrek, K and N. Black. Uni. of New South Wales Press

ISBN 0-86840 333-4

Plant Analysis Handbook II

Mills and Jones. MicroMacro Publishing, Inc. Athens, GA.

ISBN 1-878148-052

Nutrient Deficiencies in Bedding Plants

Gibson, Ptchay, Williams-Rhodes, Whipker, Nelson and Dole. Independent Publishing Group, Chicago , IL .

ISBN 978-1-883052-61-4

Nitrogen (N)

– NO_3 and NH_4^+

- utilized for a variety of structural and metabolic compounds
- over half of N in plants is found in the leaves of plants
- between 15 and 30% of that leaf nitrogen goes into the production of Ribulose 1-5-biphosphate carboxylase or Rubisco
- Nitrogen is very mobile within the plant

Nitrogen (N)

Symptoms of Deficiency and Toxicity

- Deficiency
  - occurs in oldest leaves first
  - stunted growth yellowing, chlorosis, stunted growth, leaf drop, increased root shoot ratio

- Toxicity
  - occurs with ammonium only
  - yellowing, chlorosis, root dea
  - interactions with K, Ca, Mg

Phosphorus (P)

$H_2PO_4^-$ -P at pH of 5.0 to 6.5

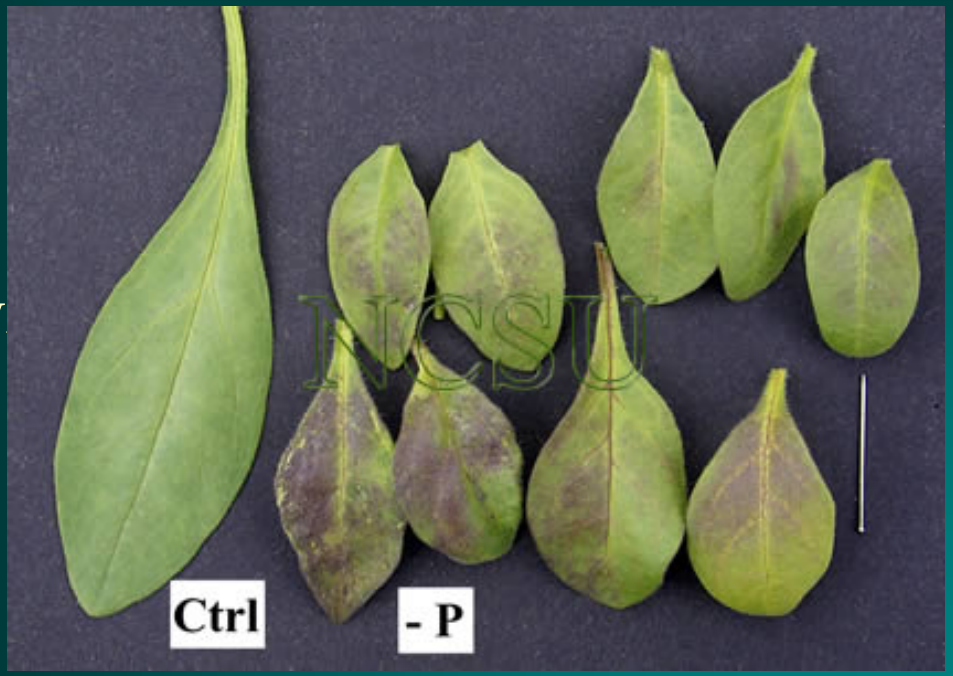
- High pH, P binds with calcium
- Low pH P, binds with iron
- High P fertilizers do not promote root growth
- Utilized for energy transfer, membrane structure, nucleic acids, proteins
- Mobile in plant

Phosphorus (P)

Symptoms of Deficiency and Toxicity

- Deficiency
  - occurs in oldest leaves first
  - older leaves darken and turn purple, leaf margin necrosis, low production of flowers, fruit and seed

- Toxicity
  - mostly interactions w
    zinc, copper and iron



Potassium (K)

K^+

- Like phosphorus, potassium exists as many forms in soils, and much of it is unavailable to plants,
- Plants take up potassium in large amounts compared to other nutrients. Only the demand for nitrogen is greater. In plant tissue the N:K ratio is close to 1:1.
- Maintains a variety of plant metabolic activity mainly by regulating water status and stomatal control.
- Aides in carbohydrate transport and cellulose production.
- Mobile in plant

Potassium (K)

Symptoms of Deficiency and Toxicity

- Deficiency
  - occurs in oldest leaves first
  - yellowing of margins and tips of leaves
  - edge “scorch”

- Toxicit
  - n
    c

Sulfer (S)

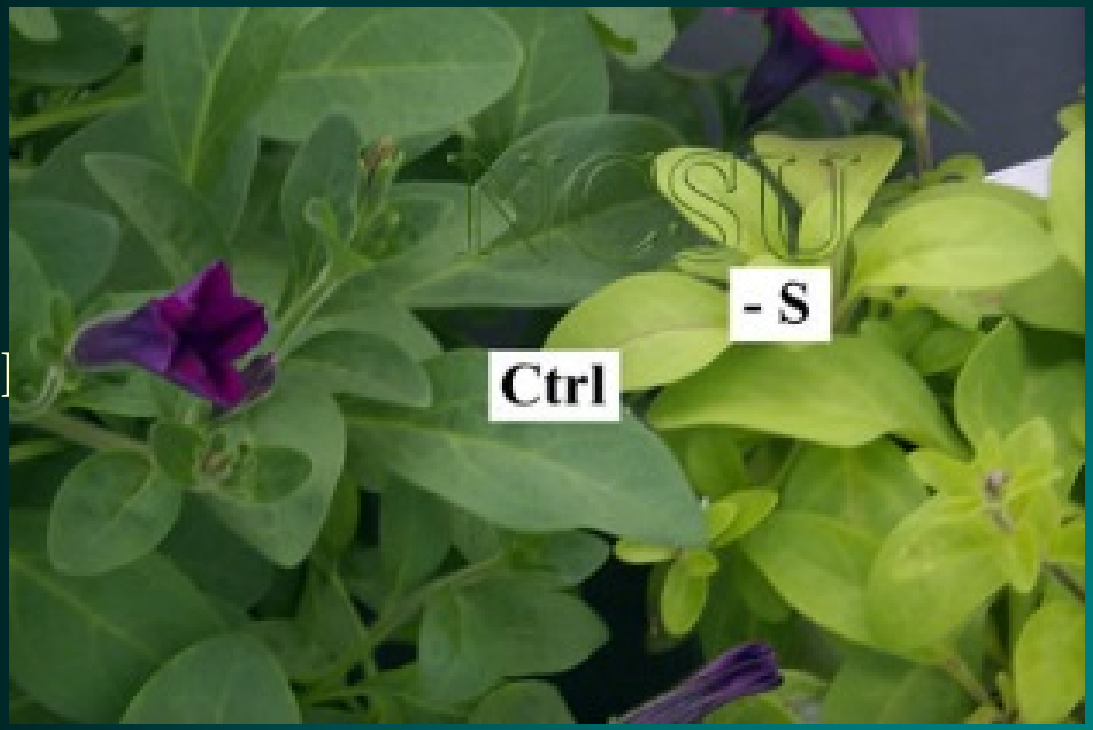
SO_4^{-2}

- In soil, the majority of sulfur is found in organic form and to a lesser extent mineral form as sulfates
- Plant roots actively take up sulfur primarily as sulfates SO_4^{-2},
- Plants utilize sulfur in amino acids, proteins, vitamins and other plant compounds like glycoside oils that give onions and mustards their characteristic flavors..
- Sulfur also activates certain enzyme systems
- Not Mobile in plant

Sulfur (S)

Symptoms of Deficiency and Toxicity

- Deficiency
  - similar to N deficiency
  - occurs in youngest leaves first



- Toxicity
  - There are rarel

Calcium (Ca)

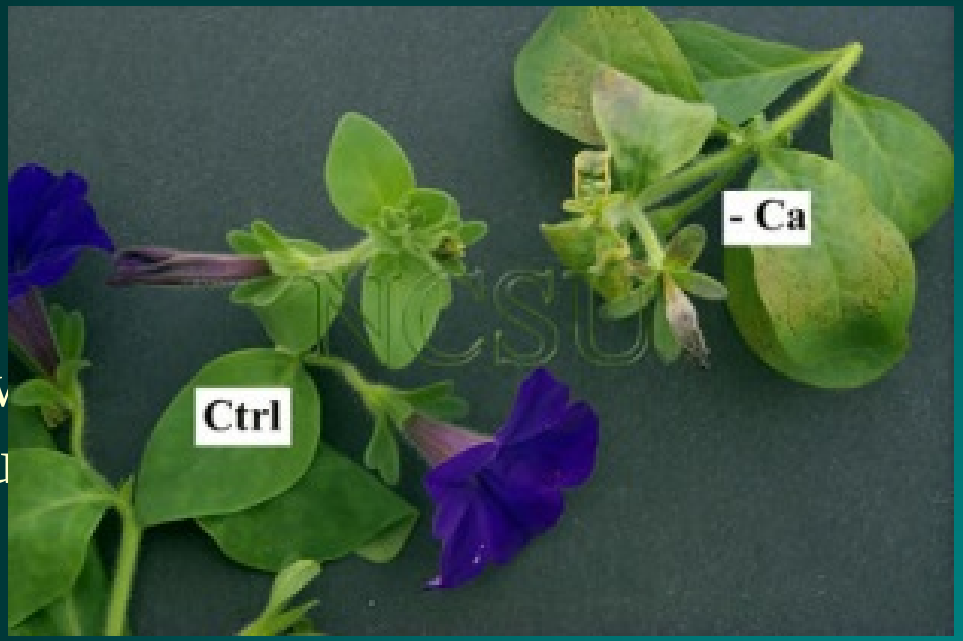
Ca^{2+}

- Free calcium is loosely bound to organic and mineral colloids
- Calcium is taken up passively in roots tips and moves through the plant primarily via the xylem during evapotranspiration
- Mainly found in the cell walls
- Calcium is required for the extension of cell walls during cell growth at shoot and root tips and enhances pollen tube growth.
- Responsible for membrane stability and cell wall integrity
- Not Mobile in plant

Calcium (Ca)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Occurs in youngest leaves first
  - Reduction of growth at meristems
  - Deformed and chlorotic leaves
  - leaf margin necrosis



- Toxicity
  - mostly interactions v
    magnesium, potassiu

Magnesium (Mg)

Mg^{2+}

- Magnesium is made available to the plant through exchange with soil colloid complexes
- Plants take-up magnesium passively, transported mainly through the phloem
- Fifteen to twenty percent of the magnesium in plants is found in the pigment molecule, chlorophyll.
- Cofactor for enzymes that help transfer energy and CO_2 fixation
- Assists in RNA translation for protein synthesis
- Mobile in plant

Magnesium (Mg)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Deficiency symptoms appear in both young and older leaves as interveinal chlorosis.

- Toxicity
  - There is typically no mag

Chlorine (Cl)

Cl^-

- Chlorine naturally occurs in soils as constituents of many soil minerals and is made available through natural weathering.
- Taken actively and passively depending on soil concentrations, active when low and passive when concentrations are high
- Utilized in several processes of photosynthesis.
- Mobile in plant

Chlorine (Cl)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Deficiencies are uncommon

- Toxicity

  Yellowing and burning of leaf tips, with interveinal areas being bleached, scorched and necrotic in severe cases.

Iron (Fe)

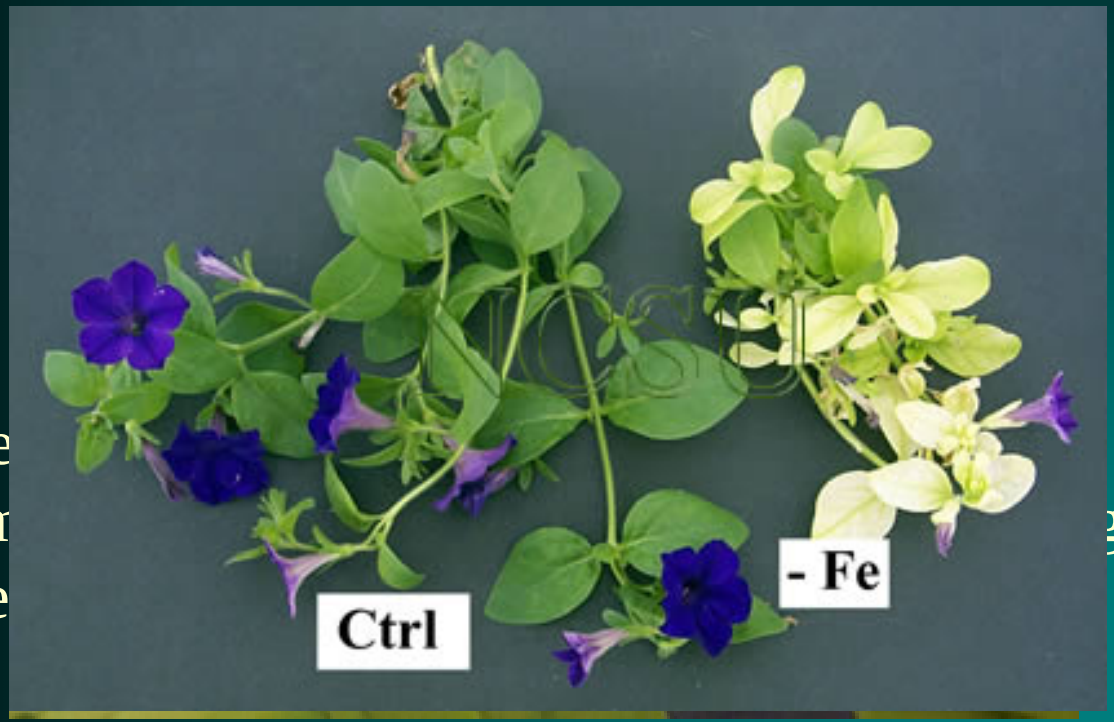
Fe^{2+}

- Iron is ubiquitous in many soils, yet availability depends on soil chemistry.
- Actively taken up by the plant and is transported by xylem to the leaves.
- Utilized in several processes of photosynthesis.
- Not mobile in plant

Iron (Fe)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Iron deficiency is similar to magnesium deficiency symptoms (interveinal chlorosis), but occurs on youngest leaves first



- Toxicity
  - iron interfere
    deficiency (m
    as necrotic le

Manganese (Mn)

Mn^{2+}

- Availability depends on pH and organic colloid content. Increased in low pH
- In the plant manganese is transported in the xylem and delivered to mertistematic tissue where it is largely immobilized.
- Cofactor for many metabolic enzymes and is important factor in photosynthesis. Used to split water.
- Not mobile in plant

Manganese (Mn)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Interveinal chlorosis, similar to iron and zinc.

- Toxicity
  - Toxicity var
  - Occurs in ac
    available
  - Dark purple
    leaf tip necr
  - Toxicity var
    soils are nat
  - Severe toxic

Boron (B)

H_3BO_3

- Availability depends on pH and organic colloid content. Increased in low pH
- Boron moves into the plant, passively taken up in solution by the roots via evapotranspiration, moving through xylem
- Factor in cell growth, including division, differentiation, and elongation
- Cell processes like carbohydrate metabolism and other metabolic pathways
- Concentrated at growth areas including reproductive structures.
- Not mobile in plant

Boron (B)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Stunted new growth as wrinkled and withered leaves, with tip death soon after.
  - Like calcium, deficiencies may be caused by drought or high humidity.

- Toxicity
  - Toxicit
    and to
  - Differ
  - Yellow
    margi

Copper (Cu)

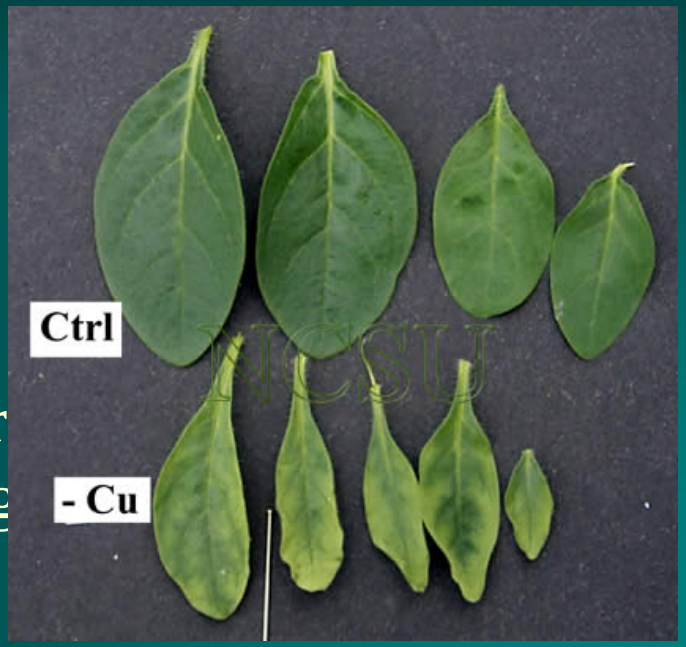
Cu^{2+}

- Optimally available in slightly acid conditions where the copper ion exchanges with other cations on soil colloids
- Root uptake is active and copper moves in the xylem, complexed with amino acids and other nitrogenous compounds.
- Copper is utilized with enzymes for metabolic activities and photosynthesis.
- Not mobile in plant

Copper (Cu)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Show up on the youngest leaves first
  - Depressed and twisted growth
  - New leaves appear pale along the margins but green at the end of the veins.
  - Spotty necrosis occurs in the leaf margins. Stems may become distorted and twisted.



- Toxicity
  - Toxic levels of cooper induce ir
    accompanying symptoms along
    growth.

Molybdenum (Mo)

MoO_4^{-2}

- Molydenum uptake is dependent on solubility of the ion. Unlike many micronutrients, molybdenum becomes more available in higher pH.
- In the leaf, used for an important enzymatic process called nitrate reduction, the first of two important physiological steps that make nitrate usable in the plant
- Relatively mobile in plant

Molybdenum (Mo)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Since molybdenum is essential for nitrate reduction, a deficiency in molybdenum manifests as a nitrogen deficiency
  - leaf chlorosis in older leaves
  - then leaf margin wilting
  - leaf and meristem death
  - most likely show in acid conditions
- Toxicity
  - rare in soils and plants can tolerate relatively high levels of molybdenum

Zinc (Zn)

Zn^{+2}

- present in sulfide and silicate minerals and is also associated with organic colloids
- Zinc is actively taken up by plants and transported through the xylem
- metabolic functions including auxin (growth hormone) production, a cofactor in protein synthesis, enzyme activity and carbohydrate metabolism and regulation.
- chlorophyll production
- may enable plants to tolerate colder temperatures
- Slightly mobile in plant, mainly stored in roots

Zinc (Zn)

Symptoms of Deficiency and Toxicity

- Deficiency
  - Symptoms on older leaves first
  - Include interveinal chlorosis, curled and dwarfed leaves and then leaf scorch and necrosis.
  - excessive phosphorus can interfere with zinc uptake

- Toxicity
  - May occur in low … nicipal sludge has been ac…
  - Toxicity concentra…
  - interfere with iro…

Nickel (Ni)

Ni^{+2}

- Nickel is the newest recognized essential plant nutrient
- requirement was not known because impurities in irrigation water and fertilizers supplied the very low requirements of this nutrient
- required for the enzyme urease to metabolize urea, releasing the ammoniacal nitrogen for plant use
- for iron absorption and seeds production and germination
- evidence to suggest that carbon respiration and nitrogen metabolism are sensitive to Ni nutrition
- Possibly mobile in plants

Nickel (Ni)

Symptoms of Deficiency and Toxicity

- Deficiency
  - rounded, blunt and slightly curled leaves known as "mouse-ear"
  - seen on spring growth and is a result of accumulation of urea to the point of toxicity
- Toxicity
  - At a level of 100 ppm or higher, nickel is considered to be phytotoxic
  - toxicities typically exist in areas where industrial waste has been concentrate
  - In beets severely stunted growth; young leaves at early stage show chlorotic iron deficiency symptoms, followed by severe necrosis, collapse and death