Basic Soil and Plant Nutrition

UC Master Gardeners of Monterey and Santa Cruz
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University of California
Agriculture and Natural Resources

UCCE Master Gardener Program
Monterey and Santa Cruz Counties

Objectives

- Knowledge of soil composition
- Knowledge of soil texture/pH
- Knowledge of the 16 essential and 3 beneficial nutrients used by plants
- Know the difference between mobile and immobile nutrients
- Be able to use “Key to Nutrient Disorders” handout

Root Requirements from Soil

- Soil must be sufficiently moist to allow roots to take up and transport nutrients
- The pH of the soil must be within a certain range for nutrients to be release-able from the soil particles
  - Vegetables, grasses, most ornamentals 5.8 – 6.5
  - Tomatoes 6.2 – 6.8
  - Cucumber 6.0 – 7.0
  - Lettuce 6.0 – 6.5

Root Requirements from Soil

- The temperature of the soil must fall within a certain range for nutrient uptake to occur
  - Germination Temperature Requirements
  - Although some plant species' seeds require a temperature as low as 50 degrees Fahrenheit to germinate, a wide variety of commonly grown perennial plants and vegetable crops have optimal seed germination temperatures between **65 and 80 degrees Fahrenheit.**

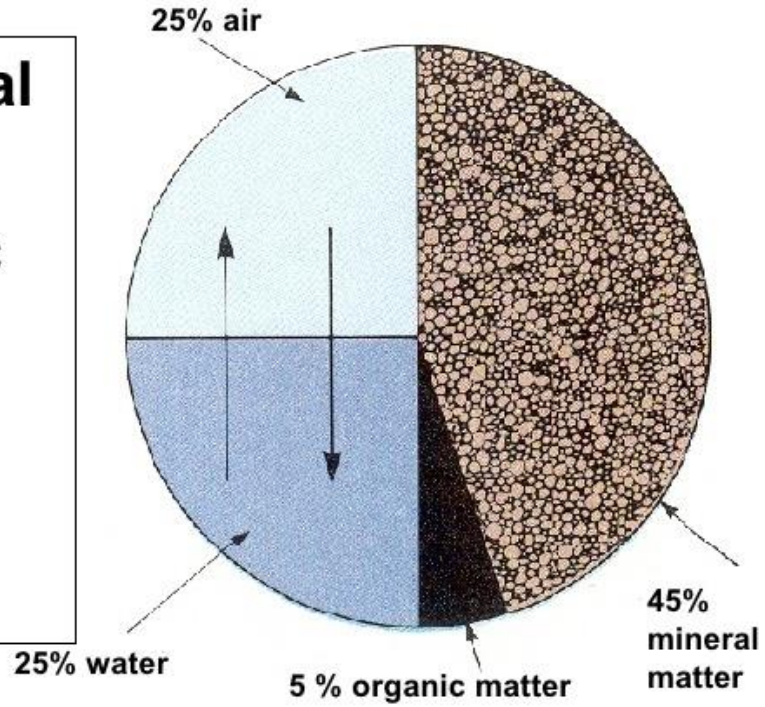
Temperature

- Absorption of nutrients is affected by change in temperature. In general, an increase in temperature results in an increase in the absorption of nutrients up to a certain optimum level.
- At very high temperature the absorption is considerably inhibited.

Soil Composition

Composition of a Good Planting Soil:

- 45% mineral matter,
- 5% organic matter,
- 25% air &
- 25% water.



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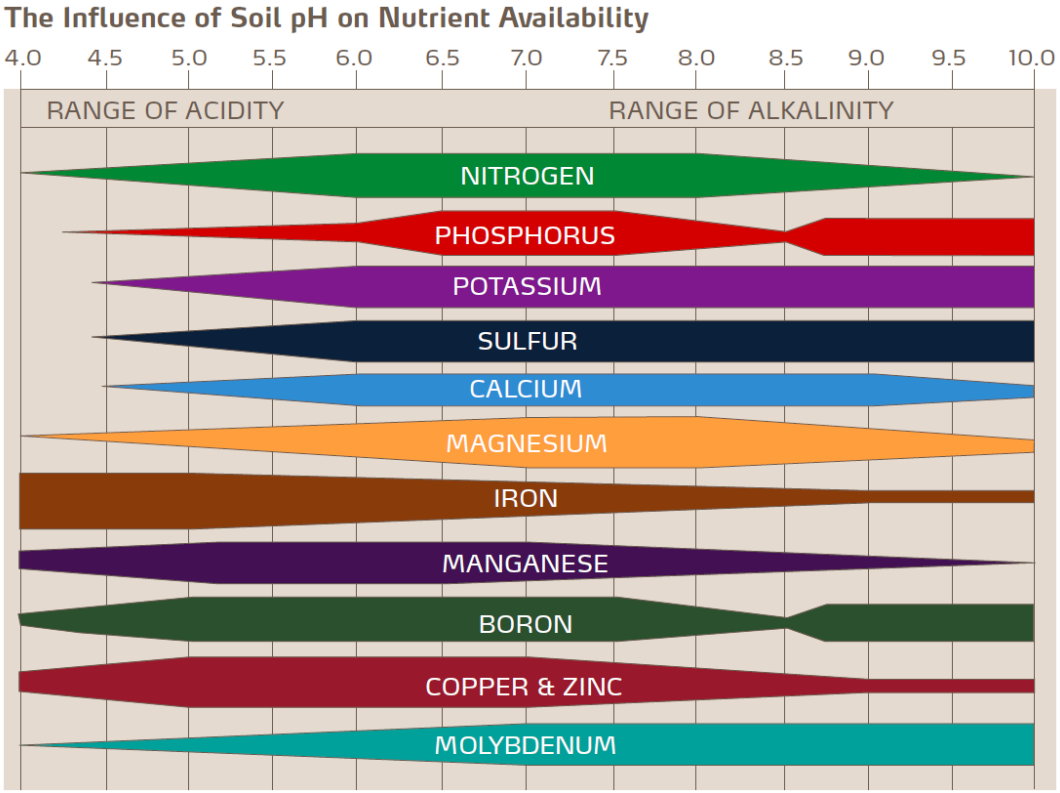
Soil pH

pH - a figure expressing the acidity or alkalinity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid, and higher values more alkaline.



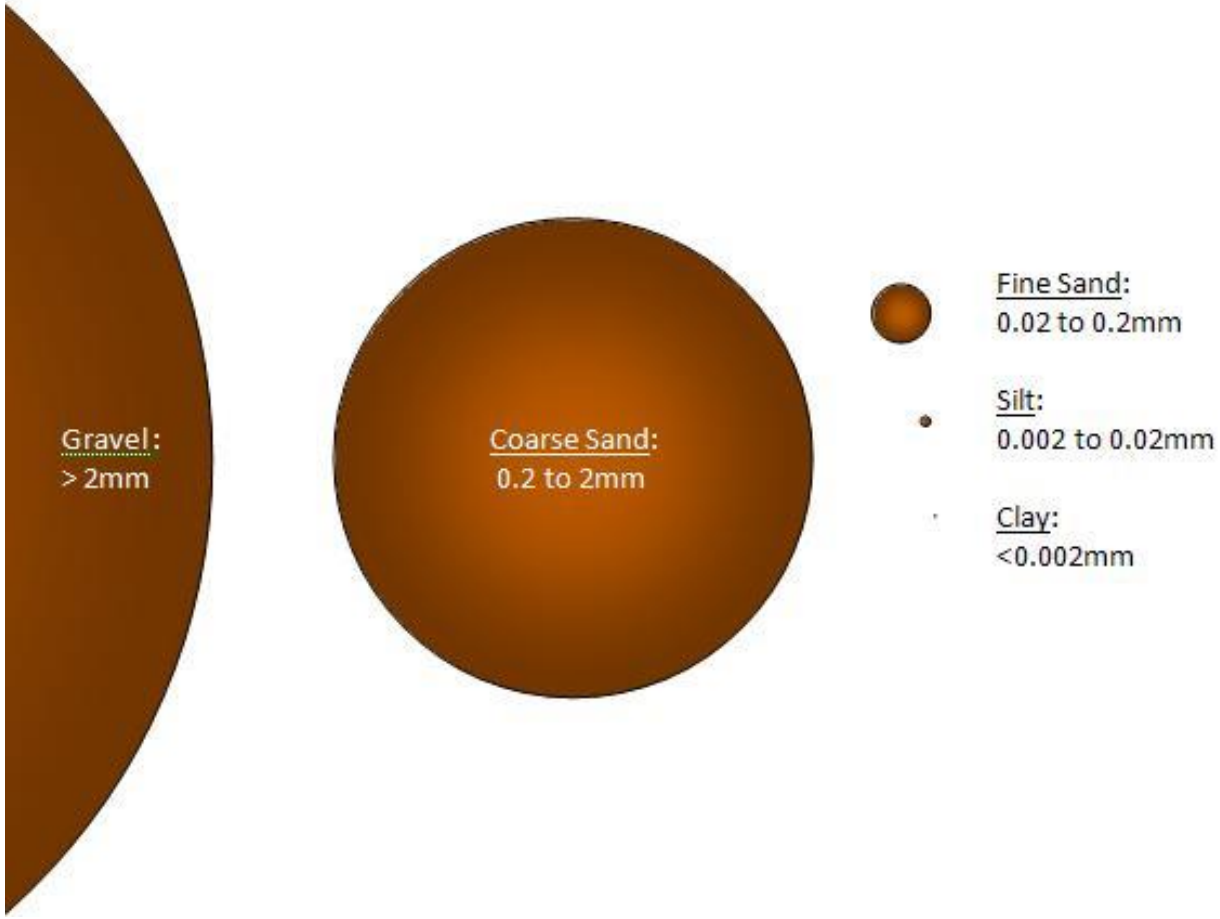
Soil pH and Nutrient Availability

- Extremes in pH impact plant growth rates
  - Highly acid soils
    - Aluminum and Manganese
      - More available/can be toxic
    - Calcium, Phosphorus and Magnesium
      - Less available for plant uptake
  - Alkaline soil
    - Phosphorus and micronutrients
      - Less available

Soil Texture

- The look and feel of a soil is referred to as SOIL TEXTURE and is determined by the size and type of particles that make up the soil (including the organic but mostly referring to the inorganic material).
- The size of the ex-rock pieces (now the inorganic soil particles) varies substantially, from large bits of gravel to much, much smaller clay pieces. How you refer to the soil particles is actually based on their size:
  - Gravel - particles greater than 2 mm in diameter
  - Coarse sand - particles less than 2 mm and greater than 0.2 mm in diameter
  - Fine sand - particles between 0.2 mm and 0.02 mm in diameter
  - Silt - particles between 0.02 mm and 0.002 mm in diameter
  - Clay - particles less than 0.002 mm in diameter

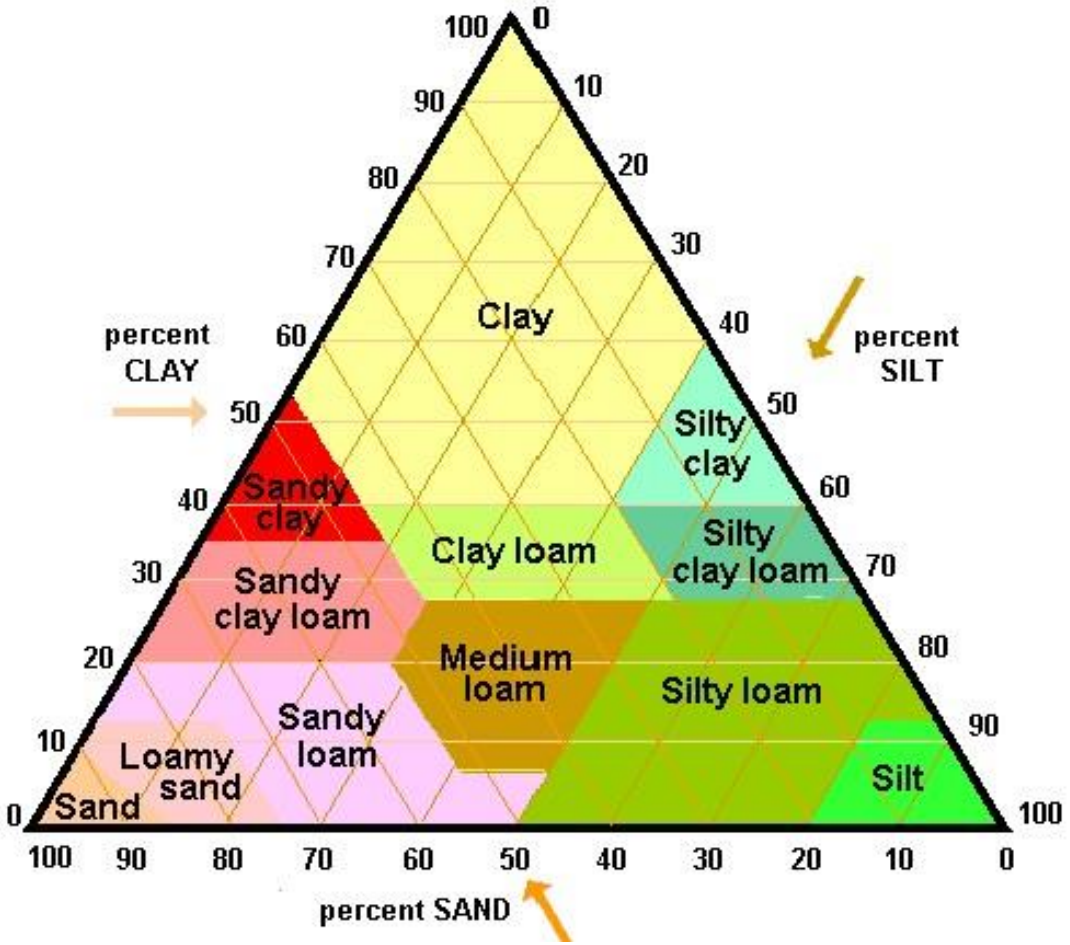
Particle Sizes



Relating Soil Texture to Soil Function

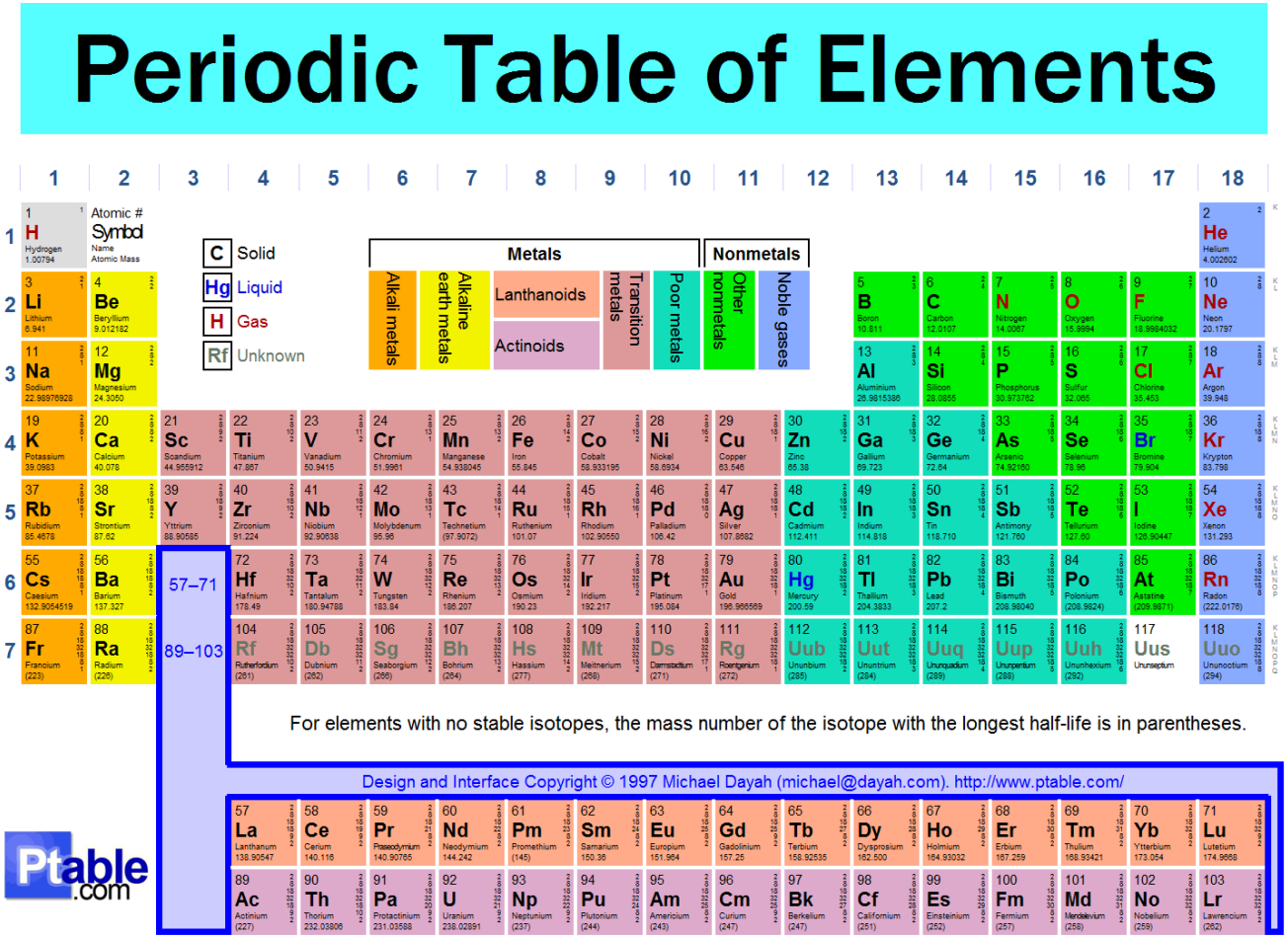
- Texture effects important soil functions:
  - Total amount of pore space
    - Govern processes of water and air movement through soil
  - Ability to retain nutrients (CEC)
  - Accumulate more organic matter

Soil Texture Pyramid



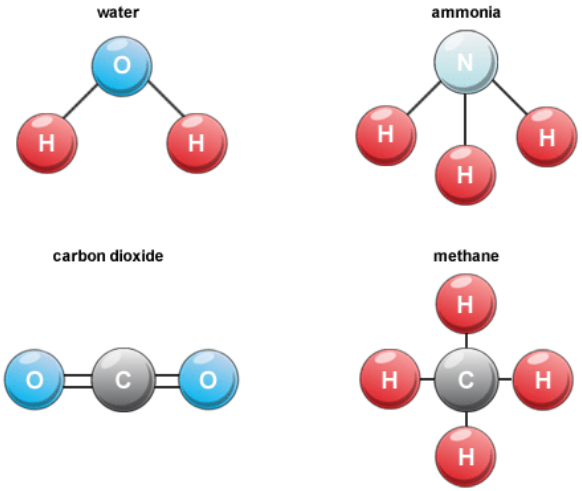
Element Definition

- An element is a substance consisting of atoms which all have the same # of protons, ie the same atomic number



Compound Definition

In chemistry, a compound is a substance that results from a combination of two or more different chemical elements, in such a way that the atoms of the different elements are held together by chemical bonds that are difficult to break.



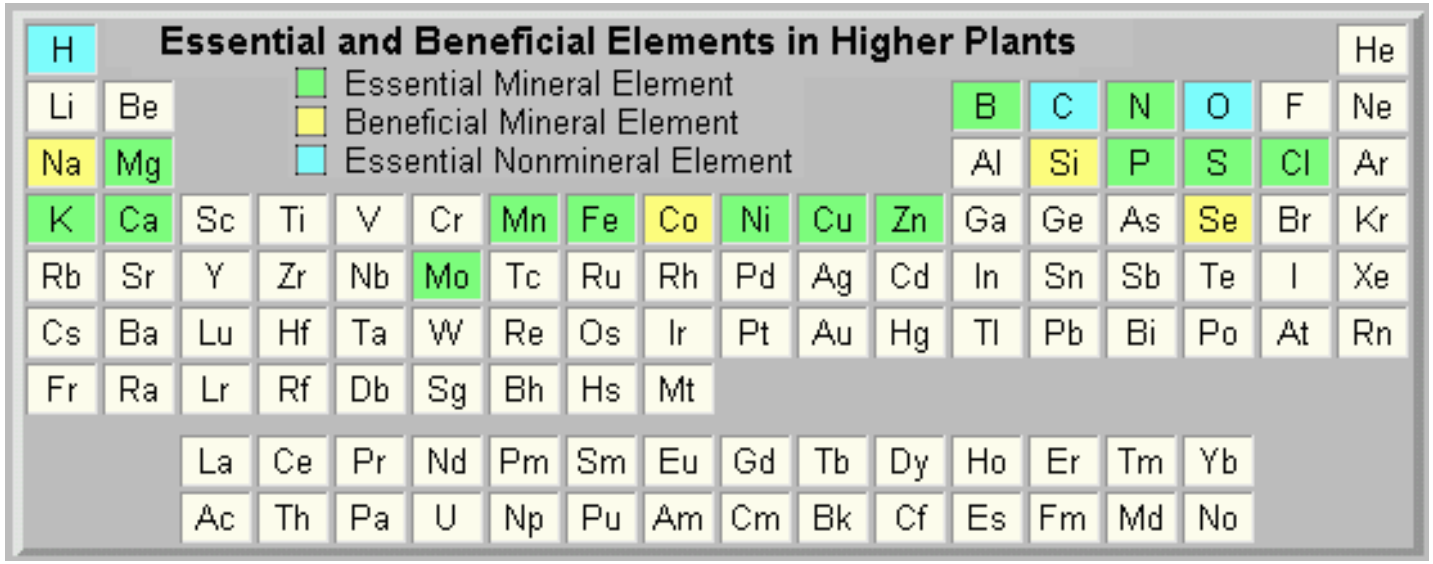
Plant Nutrition Essential Elements

In defining the concept of an **essential element**, a more precise set of criteria were established by Arnon and Stout in 1939, who stated that an essential element:

- Must be required for the completion of the life cycle of the plant
- Must not be replaceable by another element
- Must be directly involved in plant metabolism, that is, it must be required for a specific physiological function

Types of Essential Elements

- Macronutrients are required in large quantities by plants
- Micronutrients are required in trace quantities by plants
- Beneficial elements, elements which promote plant growth in many plant species but are not absolutely necessary for completion of the plant life cycle



Macronutrients

Macronutrients are needed in relatively large amounts by plants.

Element	Symbol	Source	Form Used
Oxygen	O	Air/Water	H_2O
Hydrogen	H	Air/Water	H_2O
Carbon	C	Air/Water	CO_2
Nitrogen	N	Soil	NO_3^-, NH_4^+
Phosphorus	P	Soil	H_2PO_4 & HPO_4^{2-}
Sulfur	S	Soil	SO_4^-
Potassium	K	Soil	K^+
Calcium	Ca	Soil	Ca_2^+
Magnesium	Mg	Soil	Mg^{2+}

Micronutrients

Micronutrients are needed in relatively small amounts by plants

Element	Symbol	Source	Form Used
Iron	Fe	Soil	Fe^{2+}
Manganese	Mn	Soil	Mn^{2+}
Boron	B	Soil	$H_2B0_3^-$
Molybdenum	Mo	Soil	MoO_4^{2-}
Copper	Cu	Soil	Cu^{2+}
Zinc	Zn	Soil	Zn^{2+}
Chlorine	Cl	Soil	Cl^-

Beneficial Nutrients

- Beneficial elements, elements which promote plant growth in many plant species but are not absolutely necessary for completion of the plant life cycle:
  - Sodium (Na) is involved in osmotic (water movement) and ionic balance and is required by some plants.
  - Cobalt (Co) is required for nitrogen fixation in legumes and in root nodules of nonlegumes because it is a component of enzymes essential for nitrogen fixation. Deficient levels could result in nitrogen deficiency symptoms.
  - Silicon (Si) is a component of cell walls and is essential to some types of grass.

Mobility of Nutrients

Mobile	Symbol	Immobile	Symbol
Phosphorus	P	Boron	B
Nitrogen	N	Calcium	Ca
Molybdenum	Mo	Sulfur	S
Magnesium	Mg	Iron	Fe
Potassium	K	Maganese	Mn
Cloride	Cl	Zinc	Zn

Deficiency Symptoms - N

- General chlorosis.
- Chlorosis progresses from light green to yellow.
- Entire plant becomes yellow under prolonged stress.
- Growth is immediately restricted and plants soon become spindly and drop older leaves.

Deficiency Symptoms - P

- Leaves appear dull, dark green, blue green, or red-purple, especially on the underside, and especially at the midrib and vein.
- Petioles may also exhibit purpling. Restriction in growth may be noticed.

Merlot with advanced P deficiency symptoms.

Deficiency Symptoms - K

- Leaf margins tanned, scorched, or have necrotic spots (may be small black spots *which* later coalesce).
- Margins become brown and cup downward.
- Growth is restricted and die back may occur.
- Mild symptoms appear first on recently matured leaves.

Deficiency Symptoms - Ca

- Growing points usually damaged or dead (die back).
- Margins of leaves developing from the growing point are first to turn brown.

Deficiency Symptoms - Mg

- Marginal chlorosis or chlorotic blotches which later merge.
- Leaves show yellow chlorotic interveinal tissue on some species, reddish purple progressing to necrosis on others.
- Younger leaves affected with continued stress.
- Chlorotic areas may become necrotic, brittle, and curl upward.
- Symptoms usually occur late in the growing season.

Deficiency Symptoms - Cu

- Leaves wilt, and curl become chlorotic, then necrotic.
- Wilting and necrosis are not dominant symptoms.

Deficiency Symptoms - Fe

- Distinct yellow or white areas appear between veins, and veins eventually become chlorotic.
- Symptoms are rare on mature leaves.

Deficiency Symptoms - Mn

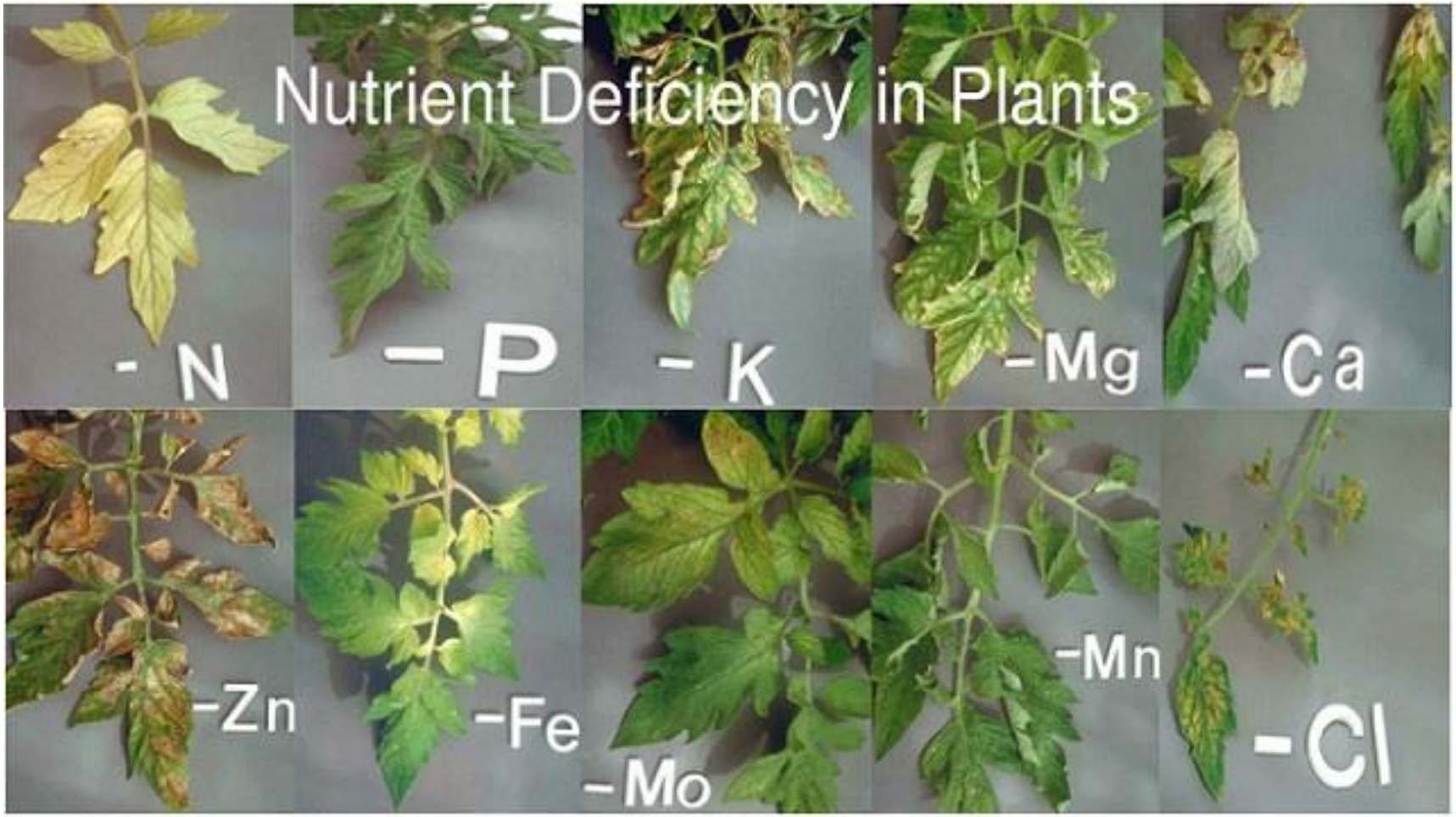
- Chlorosis is less marked near veins.
- Some mottling occurs in interveinal areas.
- Chlorotic areas eventually become brown, transparent, or necrotic.
- Symptoms may appear later on older leaves.

Deficiency Symptoms - Zn

- Leaves may be abnormally small and necrotic.
- Internodes are shortened.

Deficiency Symptoms - B

- Young, expanding leaves may be necrotic or distorted followed by death of growing points.
- Internodes may be short, especially at shoot terminals.
- Stems may be rough, cracked, or split along the vascular bundles.



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Glossary

- Atom - the smallest component of an element having the chemical properties of the element, consisting of a nucleus containing combinations of neutrons and protons and one or more electrons bound to the nucleus by electrical attraction; the number of protons determines the identity of the element.
- Atomic Number – the number of positive charges of protons in the nucleus of an atom of a given element, and therefore also the number of electrons normally surrounding the nucleus
- Cation Exchange Capacity (CEC) - is the total **capacity** of a soil to hold exchangeable **cations**. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients.
- Chlorosis - is a yellowing of leaf tissue due to a lack of chlorophyll. Possible causes of **chlorosis** include poor drainage, damaged roots, compacted roots, high alkalinity, and nutrient deficiencies in the **plant**.
- Coalesce - to come or grow together into a single mass
- Enzyme - a substance produced by a living organism that acts as a catalyst to bring about a specific biochemical reaction.

  - catalyst - soluble protein molecules that can speed up chemical reactions in cells
  - Biochemical - Something that's biochemical relates to chemical processes that occur in living beings, like the chemical reactions in your body
- Humus - the organic component of soil, formed by the decomposition of leaves and other plant material by soil microorganisms
- Ion - an electrically charged atom or group of atoms formed by the loss or gain of one or more electrons, as a cation (positive **ion**) which is created by electron, or as an anion (negative **ion**) which is created by an electron gain
- Internode - a part of a plant stem between two of the nodes from which leaves emerge
- Microbes - Microbes are single-cell organisms so tiny that millions can fit into the eye of a needle
- Metabolism – the sum of the physical and chemical processes in an organism by which its material substance is produced, maintained, and destroyed, and by which energy is made available
- Mottling - an irregular arrangement of spots or patches of color
- Necrotic (necrosis) - the death of cells or tissues from severe injury or disease, especially in a localized area
- Nitrogen Fixation - the chemical processes by which atmospheric nitrogen is assimilated into organic compounds, especially by certain microorganisms as part of the nitrogen cycle
- Osmosis - a process by which molecules of a solvent tend to pass through a semipermeable membrane from a less concentrated solution into a more concentrated one, thus equalizing the concentrations on each side of the membrane

- Physiological -
  the organic processes or functions in an organism or in any of its parts
- Petioles - the stalk that joins a leaf to a stem; leafstalk
- Proton - a stable subatomic particle occurring in all atomic nuclei, with a positive electric charge equal in magnitude to that of an electron, but of opposite sign
- Shoot Terminal - A bud itself is simply described as an undeveloped tip of the embryonic **shoot**, or the portion that grows up and holds the plant together
- Vascular Bundles - a strand of conducting vessels in the stem or leaves of a plant, typically with phloem (moves carbohydrates and other nutrients around plant) on the outside and xylem (conducts water from roots to top of plant) on the inside

IPM Site

- http://www.ipm.ucdavis.edu/index.html
  - Home, garden, turf and landscape pests
  - Vegetables
  - Select a vegetable
    - Under Cultural Tips
      - Fertilizing

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