



ESSENTIAL PLANT NUTRIENTS IN NEVADA HORTICULTURE

Jay Paxson, Extension Educator, Elko County

When it comes to determining which nutrients are *essential* to plant growth versus which nutrients are merely *beneficial*, the discussion continues unabated. Today, the number ranges between 16 to 20. With the exception of a few minor crops or specific plant species, it's agreed by most growers, gardeners, and plant scientists that the appropriate number remains at 16. Each of these 16 nutrients is equally essential for proper plant growth and development, yet they are required in very different quantities. These differences led to a natural grouping of the elements into three categories: primary plant nutrients (macronutrients), secondary plant nutrients, and micronutrients or "trace elements." To better understand the relative amounts plants require, concentrations (in parts-per-million or ppm) of a "representative" plant are provided in parentheses to the right of the nutrient's ionic form(s) utilized by plants.

To help gardeners and students remember the 16 essential elements, a fun mnemonic was developed: "C-Hopkins Café. Mighty Good. Mob comes in." For those more phonetically inclined another version is: "CHOPKIN'S CaFé Mg MoB CuMnZn." Some sources consider four additional elements to be essential as well; however, most authors feel that these belong in the realm of beneficial rather than essential. These four are: sodium (Na), cobalt (Co), nickel (N), and silicon (Si).^{1,2,3,4,5,6,7,8}

PRIMARY NON-MINERAL PLANT NUTRIENTS FROM AIR & WATER^{1,2,3,4,5,7}

Carbon, hydrogen, and oxygen are supplied to plants primarily through the air and water, and are universally available

CARBON (C) taken up by plants as: CO_3^{-2} , HCO_3 , CO_2 ; (450,000 ppm)^{4,10}

- Forms the skeleton for all organic molecules; essential building block for all plant life
- Involved in structural components, enzymatic reactions, and genetic material, sugars, proteins, and organic acids

HYDROGEN (H) taken up by plants as: H^+ , OH^- ; (60,000 ppm)^{4,10}

- Hydrogen is a constituent of many compounds necessary for plant growth
- Hydrogen together with oxygen forms water, a very large percentage of a plant's total weight
- Involved in electrochemical reactions and maintenance of electrical charge balances across all cell membranes

**OXYGEN (O) taken up by plants as: OH⁻;
(450,000 ppm)^{4,10}**

- Essential for respiration and all oxygen-requiring reactions in plants, including nutrient uptake by roots
- Combines with hydrogen to form water, a large percentage of a plant's total weight
- Essential component of many organic compounds including simple sugars

**PRIMARY MINERAL PLANT NUTRIENTS
(= MACRONUTRIENTS) FROM SOIL^{1,2,3,4,5,7}**

The primary plant nutrients are available to plants primarily from the soil or media in which they grow. Nutrients not present in the soil or growing media, or not available to plants because of high or low pH conditions, must be supplied to plants as fertilizers or supplements.

**NITROGEN (N) taken up by plants as: NO₃⁻,
NH₄⁺; (15,000 ppm)^{4,10}**

- Essential component of nucleic acids, amino acids, proteins, chlorophyll, enzymes, vitamins, and other vital compounds
- Essential component for the process of photosynthesis
- Needed in greater amounts than P and K and is essential for plant growth
- Important energy source for soil microorganisms
- Highly mobile nutrient in plants; NO₃⁻ mobile in soils, NH₄⁺ relatively immobile in soils

**PHOSPHORUS (P) taken up by plants as:
H₂PO₄⁻, HPO₄⁻², PO₄⁻³; (2,000 ppm)^{4,10}**

- Essential nutrient for normal plant growth; involved with nearly every plant function
- Essential component of nucleic acids, phospholipids, ATP, and several coenzymes
- Enhances seed germination, root formation, early growth, and plant meristems
- Stimulates blooming, enhances bud-set, hastens maturity, and aids in seed formation
- Essential component for synthesis of fatty acids, amino acids, and proteins
- Involved in photosynthesis, carbohydrate breakdown and utilization, energy storage and transfer, and respiration

- Bolsters winter hardiness of late- and early-season crops
- Highly mobile nutrient in plants; relatively immobile in soils

**POTASSIUM (K) taken up by plants as: K⁺;
(10,000 ppm)^{4,10}**

- Essential in photosynthesis and many metabolic processes in plants
- Activates many enzymatic reactions in plants, essential to synthesis of proteins
- Involved in cell division; helps translocation of carbohydrates between plant parts
- Regulates turgor pressure in guard cells, thus the opening and closing of stomates
- Increase stalk and stem stiffness; encourages root growth
- Increases plant's resistance to disease and aids in plant's drought-tolerance
- Increases size and fullness of seed and grain crops; increases oil content of oil crops
- Enhances winter hardiness and hardening off of woody plants
- Highly mobile nutrient in plants; relatively immobile in soils

SECONDARY PLANT NUTRIENTS^{1,2,3,4,5,7}

**CALCIUM (Ca) taken up by plants as: Ca⁺²;
(5,000 ppm)^{4,10}**

- Essential constituent of cell walls, enhances cell wall elasticity, prevents development of brittleness in meristems tissues
- Serves as a base for neutralizing organic acids generated during the growing process
- Aids carbohydrate translocation and nitrogen absorption
- Increases fruit set in some plants
- Low mobility nutrient in plants; relatively immobile in soils

**MAGNESIUM (Mg) taken up by plants as: Mg⁺²;
(2,000 ppm)^{4,10}**

- Essential component of chlorophyll, and essential for photosynthesis
- Regulates the uptake of other essential elements; serves as a carrier of phosphorus compounds, facilitates translocation and metabolism of carbohydrates
- Activator and component of many plant enzymes required in growth process
- Enhances production of oils and fats

- Highly mobile nutrient in plants; relatively immobile in soils

SULPHUR (S) taken up by plants as: SO_4^{-2} ; (1,000 ppm)^{4,10}

- Integral component of amino acids, therefore essential to protein synthesis
- Essential for production of chlorophyll and utilization of phosphorus and other essential nutrients; enhances the efficiency of nitrogen for protein synthesis
- Essential component of oils in aromatic compounds (e.g., garlic and onion)
- Essential for nodule formation on legume roots
- Increases size and weight of grain crops, aids in seed production
- Highly mobile nutrient in plants; mobile in soils

MICRONUTRIENTS (“TRACE ELEMENTS”)
1,2,3,4,5,7

Micronutrients are listed in descending order of need by most plants. Excessively high or low soil pH makes certain elements more or less available to plants, causing toxicity or deficiency problems.

IRON (Fe) taken up by plants as: Fe^{+2} , Fe^{+3} ; (100 ppm)^{4,10}

- Essential as a catalyst for the synthesis of chlorophyll and photosynthesis
- Essential component of many enzyme functions within plant cells
- Involved with sulfur to form compounds that catalyze other reactions within plant cells
- Essential nutrient within young growing parts of plants
- Intermediately mobile nutrient in plants; relatively immobile in soils

CHLORINE (Cl) taken up by plants as: Cl^- ; (100 ppm)^{4,10}

- Involved in electrical charge balance in some plant physiological functions
- Involved with oxygen production in photosynthesis
- As a mobile anion in plants, chloride is involved in opening and closing stomates
- Indirectly affects plant growth by stomatal regulation of water loss
- Enhances maturity of small grains on some soils

- Chloride (Cl^-) highly mobile nutrient in plants; mobile in soils

MANGANESE (Mn) taken up by plants as: Mn^{+2} , MnO_4^- ; (50 ppm)^{4,10}

- Serves in several enzymatic reactions that involve the energy compound ATP, and as an activator of enzymes for nitrogen absorption
- Essential for the synthesis of chlorophyll
- Controls several oxidation/reduction systems
- Intermediately mobile nutrient in plants; relatively immobile in soils

BORON (B) taken up by plants as: BO_3^{-3} , H_3BO_3 , $\text{B}_4\text{O}_7^{-2}$; (20 ppm)^{4,10}

- Serves as an important enzyme activator
- Involved in the production of starch for production of cellulose
- Important involvement in sugar transport to meristems tissues in roots and shoots
- Involved in fertilization and germination of pollen grains, and growth of pollen tubes
- Involved in cell wall formation and development
- Involved in nitrogen, phosphorus, hormone, and fat metabolism
- Low mobility nutrient in plants; mobile in soils

COPPER (Cu) taken up by plants as: Cu^+ , Cu^{+2} ; (6 ppm)^{4,10}

- Serves as an enzyme activator, involved in catalyzing respiration processes
- Serves as a component of chlorophyll formation
- A deficiency of copper interferes with protein synthesis
- Required for lignin synthesis, a necessary component of cell wall strength
- Improves flavor of fruits and vegetables, intensifies color, increases sugar content
- Intermediately mobile nutrient in plants; relatively immobile in soils

ZINC (Zn) taken up by plants as: Zn^{+2} ; (20 ppm)^{4,10}

- Essential as an enzyme activator
- Necessary for chlorophyll production and carbohydrate formation
- Regulates various metabolic activities
- Intermediately mobile nutrient in plants; relatively immobile in soils

MOLYBDENUM (Mo) taken up by plants as: HMoO_4^- , MoO_4^{2-} ; (0.1 ppm)^{4,10}

- Essential for plant growth at very low levels- (0.1 to 2.5 ppm)
- Essential for symbiotic nitrogen fixation in legumes via root nodules
- Essential for reduction of nitrates for synthesis of amino acids and proteins
- Intermediately mobile nutrient in plants; relatively immobile in soils

'BENEFICIAL' NUTRIENTS^{2,4}

SODIUM (Na) taken up by plants as: Na^+ ; (90 ppm) (Required by some C4 metabolic pathway plants)^{4,10}

- Improves nitrogen metabolism in many plants
- Involved in osmotic and ionic balance in plants

COBALT (Co) taken up by plants as: Co^{+2} ; (~0.1 ppm) (Essential in legumes)^{4,10}

- Essential for nitrogen-fixing bacteria in nodules of leguminous plants
- Involved in the formation of vitamin B₁₂ and DNA

NICKEL (Ni) taken up by plants as: Ni^{+2} ; (~0.1 ppm) (Essential nutrient in rice)^{4,10}

- Necessary for the enzyme urease to break down urea into nitrogen available to plant
- Involved in iron uptake, required by seeds to germinate
- Immobile nutrient in plants; relatively immobile in soils

SILICON (Si) taken up by plants as: H_4SiO_4 ; (1,000) ppm^{4,10}

- Component of cell walls
- Enhances resistance to sucking insects and fungi
- Improves heat, drought, and cold tolerance
- Improves photosynthesis
- Extends bloom life

REFERENCES

¹ Morgan, Dorothy. "The Elements of Complete Plant Nutrition.": In: "What is Plant Nutrition?"

<http://retirees.uwaterloo.ca/~jerry/orchids/nutri.html>
5 p.

² "Macronutrients." Oregon Forage Information System, Oregon State University. 2 p.
<http://forages.oregonstate.edu/Oregon/enmain.cfm?PageID=73>

³ Tucker, M. Ray. "Essential Plant Nutrients: Their Presence in North Carolina Soils and Role in Plant Nutrition." North Carolina Department of Agriculture & Consumer Services, Agronomic Division. Miscellaneous Publication October. 1999 9 p.
<http://www.agr.state.nc.us/agronomi/essential.htm>

⁴ Zekri, Mongi and Thomas A. Obreza. "Plant Nutrients for Citrus Trees." University of Florida, IFAS Extension. SL200 5 p.
<http://edis.ifas.ufl.edu/pdf/SS/SS41900.pdf>

⁵ "Fertilizers." 4 p.
<http://www.firststrays.com/fertilizers.htm>

⁶ Brady, Nyle C. "The Nature and Properties of Soil." 8th Edition. 1974. 639 p.

⁷ "Western Fertilizer Handbook." Seventh Edition. Soil Improvement Committee, California Fertilizer Association. Interstate Printers & Publishers, Inc. Danville, IL. 1985. 288 p.

⁸ "Roles of the 16 Essential Nutrients in Crop Development." 4 p.
<http://www.eldoradochemical.com/fertiliz1.htm>

⁹ Hochmuth, G., D. Maynard, C. Vavrina, E. Hanlon, and E. Simonne. "Plant Tissue Analysis and Interpretation for vegetable Crops in Florida." University of Florida, IFAS Extension. HS964. 55 p.

¹⁰ "Plant Nutrition." Dictionary by Labor Law Talk. 2 p.
http://dictionary.laborlawtalk.com/Plant_nutrition

¹¹ "Essential Elements and Ionic Forms." In: "Nutrient Management." University of Florida, IFAS. 4 p.
<http://nutrients.ifas.ufl.edu/nutrient%20pages/BSFpages/EssentialNutrients.htm>