THE ABCs, I MEAN NPKs OF TOMATO PRODUCTION

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Tomatoes are a crop that is easy to grow, very responsive to changes in environmental growing conditions, and charact4erized by having a relatively high nutrient/fertilizer requirement. With that said, many experienced growers know that it is not a easy task to maximize the yield potential of a tomato crop, either in field production or greenhouse culture. There are several excellent resources available that can be consulted on other cultural aspects of tomato production, such as proper pruning, disease management, and fruiting maximization.

The functional roles of the essential (C, H, O, N, P, K, Ca, Mg, S, B, Cl, Cu, Fe, Mn, Mo, Ni, Zn) and beneficial (Co, I, Se, Si, Na, etc.) elements are all fairly well know. Several of the essential elements are involved in energy transfer reactions (P, Fe, Mn). Most have functional roles in photosynthesis (N, Mg, P, Fe, S, Cl). Some are constituents of genetic materials and proteins (N, P). Most are also used by plants as enzyme activators (K, Mg, Cu, Mo, Zn) (Jones, 2008). Sufficiency ranges for the essential elements are known for most horticultural crops. When concentrations of elements fall below sufficiency ranges, or are non-existent, deficiency symptoms result. When growing conditions cause too much uptake of essential elements, toxicity symptoms become evident. For the proper diagnosis of deficient and/or toxic conditions, there are many resources that can be consulted that provide descriptions and pictures for each of the elements in suspect. The information that follows in meant as a refresher on nutrient management in tomato production. Listed are the sufficiency ranges for tissue nutrient elements for proper tomato plant growth (which depends highly on stage of plant development):

<u>Essential Macronutrients</u>:

NITROGEN (N) is mobile* in the plant, with a sufficiency range of 4.0 to 6.0 %**.
<u>Essentiality</u>: Constituent of chlorophyll molecule, amino acids, nucleic acids, nucleotides; Involved in the synthesis and translocation of phytohormones like cytokinins (delay maturity). <u>Deficiency</u>: Photosynthesis inhibited, production of CHO's for growth is limited. Uniform yellowing of leaves (older to younger); Slow growing, weak, stunted plants; Reduced cytokinins causes rapid shift towards senescence, early matuation (yield/quality decreased). <u>Toxicity</u>: Chlorophyll production in elevated…dark green leaves; Ammonium N will cause lack of C for growth…stunting, reduced root growth, breakdown of vascular tissues; Leaf burning, shoot elongation.

PHOSPHORUS (P) is mobile in the plant, with a sufficiency range of 0.3 to 0.8 %.
<u>Essentiality</u>: Component of certain enzymes, ATP (energy transfer), RNA and DNA (genetic information). <u>Deficiency</u>: Enhanced anthocyanin production…red/purple coloring; Disruption

of Photosynthesis because of its effect of ATP; Slow growing, stunted plants. Dark green, older leaves. Toxicity: Very high levels can depress uptake of Zn, Fe, and Cu.

POTASSIUM (K) is mobile in the plant, with a sufficiency range of 3.5 to 6.0 %. Essentiality: Maintains cell turgor and water status by controlling the opening and closing of the stomata; Required for accumulation and translocation of CHO's; Involved in cellulose synthesis. Deficiency: Lack of stomatal integrity. Older leaves seem burned at the margins; Reduced lignification of vascular bundles causes stem lodging…plants fall over; Collapse of chloroplast and mitochondria; Droopy, flascid leaves because of reduced ability to conserve water. Toxicity: Competes with Mg and Ca for uptake.

SULFUR (S) is slightly immobile in plant, with a sufficiency range of 0.15 to 0.50 %. Essentiality: Component of amino-acids cysteine and methionine; Involved in protein synthesis; Di-sulfide bonds formed by –SH groups of cysteine and methionine are crucial for tertiary structure of proteins. Deficiency: Growth is significantly impared; Uniform yellowing of younger leaves, stunted plants with woody stems. Toxicity: Plants are relatively insensitive to high sulfate levels.

CALCIUM (Ca) is immobile in the plant, with a sufficiency range of 1.5 to 4.0 %. Essentiality: Maintains cell integrity and permeability. Calcium binds pectins in between cell walls…acts like cement; Removal of Ca from cell walls is part of leaf abscision and fruit ripening…very important in post-harvest quality; Involved in cell elongation and division; May detoxify some heavy metals inside the plant. Deficiency: Growing points of leaves and roots turn brown and die; Reduced growth of meristematic tissues; Leaves curl and become necrotic; Fruit quality reduced…most notably is blossom-end rot in tomato. Toxicity: Competes with K and Mg for uptake sites.

MAGNESIUM (Mg) is mobile in the plant, with a sufficiency range of 0.4 to 1.2 %. Essentiality: Center of chlorophyll molecule; Involved in transfer of phosphoryl groups of ATP/ADP; Cofactor for enzymes affecting phosphorylation; Stabilizes ribosome particles for protein synthesis. Deficiency: Chloroplast structure affected, chlorophyll and grana are reduced; yellowing or interveinal chlorosis of older leaves; margins of younger leaves become necrotic. Toxicity: No symptoms, but imbalances of Mg, Ca and K may reduce growth.

Essential Micronutrients

BORON (B) is immobile in the plant, with a sufficiency range of 30 to 100 ppm. Essentiality: Involved in cell division, cell differentiation, pollen tube development. Deficiency: Abnormal growth of growing points…twisted, stunted. Toxicity: Typical toxicity results in chlorosis of leaf margins or tips followed by necrosis.

CHLOROINE (Cl) is mobile in the plant, with a sufficiency range of 0.5 to 2.5 % ppm. Essentiality: Influences cell osmotic pressure, stomatal regulation. Deficiency: Cell tugor is decreased…wilting and veins pucker; Chlorosis. Toxicity: Reduced or stunted growth in non-tolerant plant species. Salinity is the #1 problem world-wide in growing plants.

COPPER (Cu) is immobile in the plant, with a sufficiency range of 5 to 15 ppm. Essentiality: Component of plastocyanin (chloroplast protein), involved in electron transport in PS I and II. Deficiency: Reduced, stunted growth, apical meristem becomes necrotic. Toxicity: Chlorosis of the leaves. May also induce Fe deficiency. In non-tolerant plants, reduced root growth develops.

IRON (Fe) is immobile in the plant, with a sufficiency range of 60 to 300 ppm. Essentiality: Involved in chlorophyll synthesis, PS I and II, ferredoxin. Deficiency: Formation of chlorophyll hindered, interveinal chlorosis of younger leaves…including bronzing. Toxicity: Results in the "bronzing" of leaf tissue, especially under waterlogged conditions.

MANGANESE (Mn) is immobile in the plant, with a sufficiency range of 50 to 250 ppm. Essentiality: Involved in the Hill Reaction (splitting of water). Deficiency: Interveinal chlorosis of young leaves, with necrotic spots. Toxicity: In most plants Mn toxicity is characterized by brown speckles on mature leaves. It may also appear as interveinal chlorosis and necrosis.

MOLYBDENUM (Mo) is mobile in the plant, with a sufficiency range of 0.6 ppm. Essentiality: Nitrate reductase enzyme…converts nitrate to ammonium in the plant. Deficiency: Limited nitrate reduction causes less N in plant…necrotic leaf margins, chlorosis, curling. Toxicity: Very high levels of Mo will result in malformation of leaf tissues and development of a golden yellow color on the shoots

NICKEL (Ni) is mobile in the plant, with a sufficiency range of 1 to 10 ppm. Essentiality: Urease is the only Ni-containing enzyme identified in higher plants. It is involved in necessary breakdown of urea-N during normal N metabolism. Deficiency: No real deficiency identified in field grown plants. Toxicity: Restricted root growth. Limited dry matter production.

ZINC (Zn) is mobile in the plant, with a sufficiency range of 30to 100 ppm. Essentiality: Needed for some enzymatic reactions (*carbonic anhydrase*). Also is involved in pprotein synthesis. Present in chloroplast. Deficiency: Interveinal chlorosis of older leaves. Stinted growth due to short internodes. Toxicity: In non-tolerant plants toxicity results in inhibition of root elongation. It can also lead to chlorosis in younger leaves by inducing a deficiency of Mg, Fe, or Mn.

*Mobility gives a good indication of the suspected deficient element. Mobile elements will display deficiency symptoms on older leaves, whereas immobile elements will display deficient symptoms on new growth. ** 1% = 10,000 ppm.

The critical macronutrient elements to tomato plant growth are N, Ca, P, K, and Mg. The critical micronutrient elements to tomato plant growth can be narrowed to Fe and Zn (Jones, 2008).

References:

Jones, J.B., Jr. 2008. Tomato plant nutrition, pp. 129-178. In: Tomato plant culture: in the field, greenhouse, and home garden. CRC Press, Taylor & Francis Group, Boca Raton, FL.