15. PLANT NUTRITION

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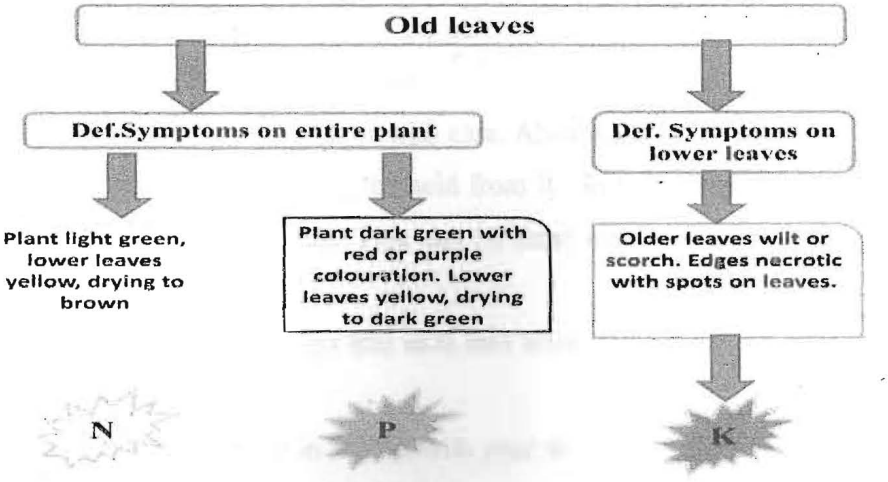
Introduction

There are 20 mineral elements necessary or beneficial for plant growth. Carbon (C), hydrogen (H), and oxygen (O) are supplied by air and water. The six macronutrients, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) are required by plants in large amounts. The rest of the elements are required in trace amounts (micronutrients). Essential trace elements include boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), sodium (Na), zinc (Zn), molybdenum (Mo), and nickel (Ni). Beneficial mineral elements include silicon (Si) and cobalt (Co).

The beneficial elements have not been deemed essential for all plants but may be essential for some. The distinction between beneficial and essential is often difficult in the case of some trace elements. Cobalt for instance is essential for nitrogen fixation in legumes. Silicon, acting as a beneficial element, can help compensate for toxic levels of manganese, iron, phosphorus and aluminum as well as zinc deficiency. With developments in analytical chemistry and the ability to eliminate contaminants in nutrient cultures, the list of essential elements may well increase in the future.



Nutrient	Main function	Mobility in plant	Main uptake mechanism & (uptake form)	Uptake interference or problems	Deficiency symptoms
Nitrogen - N	Protein synthesis = main building block (major effect on growth & quality)	High – transferred to younger plant parts when required = deficiency symptoms on older leaves	Mass flow (NO_3 and NH_4)	Losses may occur due to NO_3 leaching, denitrification, N immobilisation or fixation of NH4 in clay minerals	Low vigour, yellowing of older leaves
Phosphorus -P	Energy transfer (early root growth, fruit and seed set)	High – transferred to younger plant parts when required= deficiency symptoms on older leaves	Diffusion (slow) Root interception (HPO_4, H_2PO_4)	Poor root system reduces uptake potential. High Ca, Fe or Al concentration in soil (high or low pH resp.)	Poor seedling establishment, root development and fruit & seed set, stunted growth, purple discolouration of older leaves
Potassium - K	Carbohydrate (starch & sugars) and protein synthesis, water balance control (root intake, loss through stomata), electrical balance	Mobile= deficiency symptoms on older leaves	Diffusion, some mass flow (K)	Competing with other cations (Mg, Ca or NH_4), fixation of K in clay minerals	Yellowing of margins and tips of older leaves, progressing to white-brownish spots and then 'scorching' (necrosis) of leaf margins
Calcium (Ca)	Component of structural organs, protein synthesis, ion uptake	No relocation within the plant, moves only with transpiration = symptoms on growing tips	Root interception, some mass flow (Ca)	Other cations (K, Mg), Ca leaching in acid soils, inhibition of transpiration (high humidity, dry soil, heat)	Pre-mature dropping of buds and blossoms, bending of tips, brown spotting (apples, celery), blossom end rot in tomatoes
Magnesium (Mg)	Involved in photosynthesis, protein synthesis, energy transfer	Relatively mobile = symptoms on older leaves	Mainly mass flow, also root interception (Mg)	Other cations (K, Ca)	Interveinal chlorosis/yellowing, mottling, green veins, orange, red or purple discolouration possible, leaves may curl at margins
Sulphur (S)	Chlorophyll production,	Relatively low mobility	Mass flow (SO4)		Similar to N deficiency but

	constituent of some proteins				first in young tissue: light green to yellowish leaves with lighter coloured veins
Boron -B	Carbohydrate, starch and sugar metabolism, needed for flowering and pollination, critical component within young growing points (meristematic tissue)	Immobile, moves only with transpiration = symptoms on younger plant parts	Mass flow (BO_4)	High pH inhibition of transpiration (high humidity, dry soil, heat)	Black/brown heart in leafy plants, cracking and deformation of roots or stalks (corky tissue), hollow stems, die back of twigs, dead buds, poor flowering, fruit set
Copper -Cu	Constituent of proteins, energy transfer, N fixation in legumes	Relatively low = symptoms most obvious in younger leaves	Mass flow (Cu)	High pH	Plants look bleached and stunted, tip burn in cereals, dieback of leaves in vegetables, die back of twigs in citrus, mottled leaves
Iron (Fe)	Required for photosynthesis, respiration and chlorophyll production	Immobile = symptoms on younger leaves first	Mass flow, diffusion, some root interception (Fe)	High pH (>7), high Ca level, high Cu concentration	Interveinal chlorosis, leaves become whitish, veins remain green, could be confused with Mg deficiency
Manganese (Mn)	Regulation of carbohydrate metabolism and energy transfer	Medium mobility = symptoms appear over entire plant	Mass flow, some root interception (MnO)	High pH	Chlorosis, may display lots of small, black/brown spots
Molybdenum (Mo)	Essential for N assimilation, important in legumes for rhizobia function	Low mobility = symptoms appear first on young leaves	Mass flow, some root interception	Low pH	Legumes show N-deficiency symptoms, brassicas produce long, narrow, deformed leaves, also typical – chlorosis and upward curling of leaf margin
Zinc (Zn)	Carbohydrate	Reasonably	Mass flow,	High pH	Interveinal

	metabolism and enzyme activation (similar to Mn)	mobile = symptoms appear particularly in older leaves	diffusion, root interception		chlorosis, stunted, stiff, 'bleached appearance, rosetting in fruit trees (bare twigs with leaf clusters at the end), tip burn in cereals