SoilWealth
NURTURING CROPS

Nutrient element functions in vegetable crops

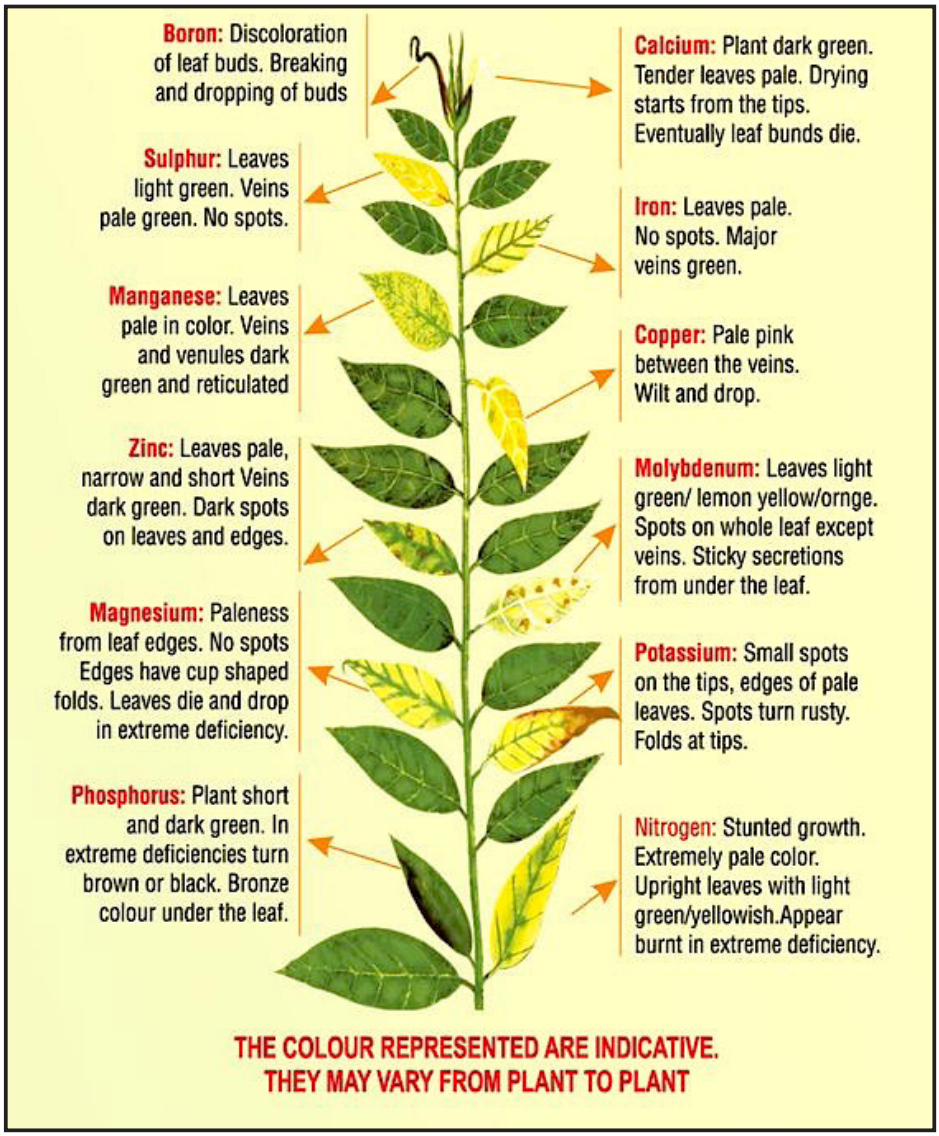
Plant nutrients are commonly split into two categories:

- Major elements (macronutrients) that are required in relatively large quantities by plants, and
- Trace elements (micronutrients) that are essential for plant growth, but are only required in small amounts.

All elements must be available in a form that is useable by the plant, and in balanced concentrations that allow optimum plant growth.

Each of the necessary nutrients in plant growth has a different function in supporting the growth and performance of the plant.

Nutrients also behave differently in plants, they can cause different symptoms when deficient or available in excess. They also enter plants through different mechanisms. The roots of plants do not grow in search of nutrients; rather they rely on "encountering" available nutrients in the soil and absorbing them to develop new root tissue. There are three main mechanisms in which they achieve this.



Visual symptoms of nutrient disorders
(Source: University of Arizona Cooperative Extension)

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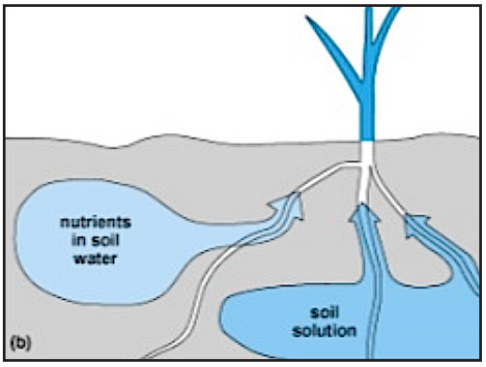
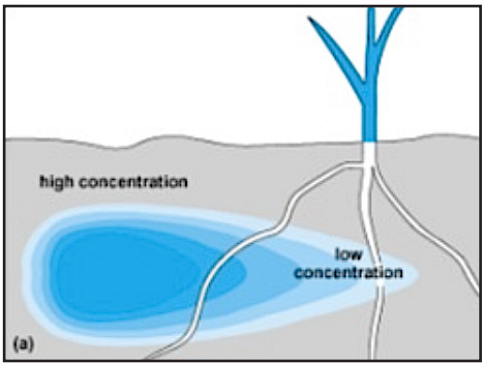
Mass Flow

Mass Flow involves the movement of nutrients dissolved in water into a plant as the plant absorbs it. Some of the water is used by the plant and the rest is leaving plant surfaces via transpiration. Transpiration creates a suction effect, which pulls the water from within the soil pores, carrying nutrients, to come into contact with the plant roots to enable absorption. Calcium (Ca), Boron (B), Magnesium (Mg) and negatively charged molecules like nitrate (NO_3) move via mass flow.



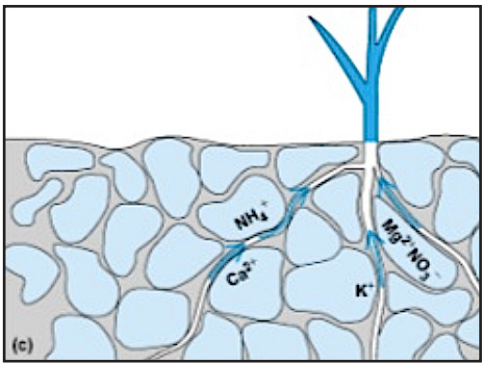
Diffusion

Diffusion is the slow movement of nutrients to the surface of plant roots in response to a gradient in concentration. For instance, nutrient uptake causes a low concentration in the soil that surrounds roots so that nutrients from zones with higher concentration move to the root surface to create an even concentration. However, plant roots will take up the nutrients and maintain a concentration gradient and therefore diffusion keeps going. Potassium (K) mainly moves via diffusion.



Root interception

Root interception occurs when a growing root comes into contact with soil minerals or organic matter, which hold nutrients. The root is then able to absorb the nutrients. Most of the Phosphorus (P) reaches roots via interception.



(Source: Actlabs Agriculture)

Nutrient uptake

Nutrient uptake can happen either passively, with no energy required as a nutrient enters with water, or actively where the nutrient is moved into the root by a “carrier” molecule or ion and uses energy in the process.

Oxygen (O_2) and carbon from carbon dioxide (CO_2), taken up through leaves from the air and or water and hydrogen (H) are the main building blocks of plants, contributing about 48%, 42%, and 6% respectively to the dry matter content of plants. All other nutrients make up the remaining 4% with Nitrogen (N) and Potassium (K) being the greatest contributors with about 1.4 -2% and 1-1.5% respectively. Calcium contributes about 0.5% to the dry matter content; Magnesium (Mg) and Phosphorus (P) provide 0.2% each and Sulphur 1%.

The following table present a summary of the major and trace elements and their relationship to crop performance.

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Major Elements

NUTRIENT	MAIN FUNCTION	MOBILITY IN PLANT	MAIN UPTAKE MECHANISM & (UPTAKE FORM)	POTENTIAL UPTAKE INTERFERENCE OR PROBLEMS	DEFICIENCY SYMPTOMS	EXCESS SYMPTOMS
Nitrogen (N)	Protein synthesis N is the main building block of proteins/enzymes and is a key component in chlorophyll (which converts sunlight into energy); it has a major effect on growth & quality	High Transferred to younger plant parts when required resulting in deficiency symptoms on older leaves	Mass flow (NO_3 and NH_4)	Losses may occur due to NO_3 leaching – particularly on light & sandy soils, denitrification, N immobilisation or fixation of NH_4 in clay minerals	Low vigour and yield, delayed maturity and stunted growth. Yellowing of older leaves	Blue green, large, soft foliage, disease susceptibility, lodging, may lead to relative low K, relatively small root system
Phosphorus (P)	Necessary for proper cell division and the formation of new cells. Energy transfer (early root growth, fruit and seed set)	High Transferred to younger plant parts when required resulting in deficiency symptoms on older leaves	Diffusion (very 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 respectively)	Poor seedling establishment, root development and fruit and seed set, stunted growth, purple discolouration of older leaves	Not found to be a problem
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	Competing with other cations (Mg, Na, 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	Ca or Mg deficiency possible, may reduce sugar and starch in root crops
Calcium (Ca)	Component of structural organs, protein synthesis, ion uptake Necessary for proper functioning of growing points, particularly root tips	No relocation within the plant, moves only with transpiration Foliar application may be necessary, if transpiration is inhibited	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, young leaves and growing point affected first	Induced Fe deficiency, also B, Mn, Zn, Competes with Mg and K uptake
Magnesium (Mg)	Involved in photosynthesis, protein synthesis, energy transfer	Relatively mobile Symptoms observed 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	Ca or Mn deficiency possible
Sulphur (S)	Chlorophyll production, constituent of several amino acids which are essential for proteins	Relatively low mobility, symptoms spreading to entire plant	Mass flow (SO_4)	Other anions (nitrate, chloride) may be taken up in preference if available at high levels	Similar to N deficiency but first in young tissue: light green to yellowish leaves with lighter coloured veins	Only in form of SO_2 gas emission near industry

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Trace Elements

NUTRIENT	MAIN FUNCTION	MOBILITY IN PLANT	MAIN UPTAKE MECHANISM & (UPTAKE FORM)	POTENTIAL UPTAKE INTERFERENCE OR PROBLEMS	DEFICIENCY SYMPTOMS	EXCESS SYMPTOMS
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 appear on younger plant parts	Mass flow (as BO_4)	High pH Inhibition of transpiration reduces uptake (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	Narrow margin between sufficiency and toxicity – necrotic spots with yellow margin, may be induced by salinity
Copper (Cu)	Constituent of proteins, energy transfer, helps regulate water movement	Relatively low. Symptoms most obvious in younger leaves	Mass flow (Cu)	High pH, high Mn levels or other trace metals	Plants look bleached and stunted, tip burn in cereals, dieback of leaves in vegetables, die back of twigs in citrus, mottled leaves	Fe deficiency
Iron (Fe)	Required for photosynthesis, respiration and chlorophyll production. Involved in the conversion of nitrate to ammonia	Immobile. Symptoms on younger leaves first	Mass flow, diffusion, some root interception (Fe)	High pH (>7), high Ca level, concentration, high Mn levels or other trace metals, esp. Cu	Interveinal chlorosis, leaves become whitish, veins remain green, could be confused with Mg deficiency	Can look like P deficiency
Manganese (Mn)	Essential for chlorophyll production and photosynthesis. Regulation of carbohydrate metabolism and energy transfer	Medium mobility. Symptoms appear over entire plant	Mass flow, some root interception (MnO)	High pH, cold wet periods	Chlorosis, may display lots of small, black/ brown spots	Bark substrates may contain excess Mn, spotting or necrosis along leaf margins, leaves roll up
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	Chlorotic young leaves, purple in tomatoes, stunted growth, thick leaves, moribund buds
Zinc (Zn)	Carbohydrate metabolism and enzyme activation (similar to Mn)	Reasonably mobile. Symptoms appear particularly in older leaves	Mass flow, diffusion, root interception	High pH, high Mn levels or other trace metals	Interveinal chlorosis, stunted, stiff, 'bleached' appearance, rosetting in fruit trees (bare twigs with leaf clusters at the end), tip burn in cereals	Similar to Fe and Mn deficiency