



**MSc. Botany SEM IV**

**Nutrient Disorders in Plants**  
**Macronutrients**

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# Essential Nutrients

**An essential element can be recognized by the following criteria of essentiality given by Arnon and Stout (1939):**

- **The plant must be unable to grow normally or complete its life cycle in the absence of the element.**
- **The element is specific or can not be replaced by another element.**
- **The element plays a direct role in metabolism.**

- **Sixteen elements have been found to be essential.**
- **Macronutrients (at least 1 mg/g of dry wt., >1ppm)**  
**-C, H,O, N, P, K, Ca, Mg, S.**
- **Micronutrients (< 0.1 mg /gm dry wt., <1ppm).**  
**-Fe, Mn, Cu, Zn, Mo, B and Cl**
- **Secondary nutrients- Ca, Mg and S.**

# General Functions

- **As constituents of organic structures.**
- **Enzyme action.**
- **Charge carriers.**
- **Osmoregulation.**
- **Secondary metabolism, growth hormones and signalling molecules.**
- **Protective role- oxidative stress.**
- **Regulatory role- genes encoding high affinity transport. Several TF III A-type zinc finger proteins such as SUPERMAN, AtZFP1.**
- **Role in reproduction.**

## Nitrogen: $\text{NO}_3^-$ , $\text{NO}_2^-$ , $\text{NH}_4^+$

- ❖ **Major structural constituent** -amino acids, proteins, nucleotides, nucleic acid, porphyrins and alkaloids.
- ❖ **Osmoprotectant** - glycine–betaine, proline.
- ❖ **Phytosiderophores**- nicotianamine derived from L-methionine functions as the precursor.
- ❖ **Alkaloids** - pharmacological properties.
- ❖ **Nitric oxide** - a signal molecule in response to a wide range of external and internal factors.

## Phosphorus: $\text{PO}_4^-$

- **Structural component of biomembranes-** Phospholipids, Phosphatidyl ethanolamine, Phosphatidyl choline etc.
- **Nucleic acids** -phosphates group joins the 5' carbon of one nucleotide to 3' carbon of the next nucleoside by covalent phosphodiester bonds.
- **Energy conservation and transfer-** pyrophosphate bonds ( $\text{P} \sim \text{P}$ ) (ATP; UDG $\sim$  $\text{P}$ ; GDP $\sim$  $\text{P}$ ).
- **Regulation of enzymes activity-** nitrate reductase, PEP carboxylase PEP kinase, proton pumping phosphorylase ( $\text{H}^+$ -ATPase).

# Potassium

- **Turgor driven extension growth of cells.**
- **Meristematic growth and cambial activity.**
- **Neutralizes the anionic charges (NH<sub>3</sub><sup>-</sup>, Cl<sup>-</sup>, SO<sub>4</sub><sup>-</sup>)**  
- stabilization of cytosolic and chloroplastic pH to a slightly alkaline reaction (pH 7 to 8).
- **Activator of enzyme-** formate-formyl tetrahydrofolate synthetase, succinyl-Co A synthetase. acetic thiokinase, pyruvate kinase and glutathione synthetase.
- **Regulation of stomatal opening.**

# Calcium

- **Structural constituent of cell walls-** bound to RCOO- group of polyglacturonic acids (pectins).
- **Stability to cell membranes** -bridge between PO<sub>4</sub>- and COO- of phospholipids and proteins.
- **Low cytoplasmic concentration prevent-** interactions with nutrient ions (PO<sub>4</sub>-, Mg<sup>2+</sup>) and inactivation of enzymes.
- **High Ca<sup>2+</sup> in vacuoles-** neutralize anions and osmoregulation.
- **Regulatory role-** second messenger.
- **Ca protein Calmodulin** - activates enzymes Ca<sup>2+</sup> - ATPases, protein kinases in cell signalling.
- **Synthesis of actin filaments-** cell division cycle
- **Pollen-stigma interaction-** pollen viability and pollen tube elongation.



## Sulphur: $\text{SO}_4^{2-} \rightarrow \text{S}_2^{2-}$

- **Organic sulphate compounds-** sulpholipids, phytoalexins, polysaccharides,
- Sulfides-amino acids (cysteine and methionine), coenzymes and secondary metabolites
- **LMW peptides-** glutathione (antioxidant) and thioredoxins (enzyme regulation) phytochelatins, metallothioneins (metal detoxification)
- **Inter conversion of (SH→S-S)-** tertiary structure of proteins and regulation of enzyme activities
- **Iron-sulphur clusters (Fe-S)-** ferredoxin
- **Vitamins and coenzymes** –biotin, coenzyme A, thiamine pyrophosphate.
- **Secondary metabolites** – glucosinolates (brassicaceae, allin (*Allium* sp))

# Magnesium

- **Structural component of chlorophyll-** central Mg atom is coordinated to the nitrogen atoms of the four modified pyrrole rings forming a porphyrin like structure
- **Structural integrity of ribosomes** and binding of the ribosomal aggregates to t-RNA
- **Ionic balance and stabilization of pH-** high vacuolar concentration for osmoregulation and turgor driven cell growth
- **Activator of several enzymes** -ATPases, phosphorylases and phosphokinases
- **Phloem loading and unloading of sucrose-** low activity of proton pumping ATPases.