MINERAL NUTRITION

① Hydroponics
- → Defination
- → Discovery - Julius Von Sachs
- → Need
- → Crops - Tomato, Lettuce, Seedless Cucumber

② Essential Minerals
17 minerals
- → Critria for essentiality
- → Macro/Micro Nutrients
- → Function (Broad classification)
- → Detailed function
  - → Deficiency
  - → Toxicity

③ Nitrogen Metabolism

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① Method to study mineral requirements of plants hydroponics.

→ Hydroponics :— Growing plants in a soilless nutrient solution.

→ In 1860, Julius Von Sachs a German botanist, demonstrated Hydroponics for first time.

→ Hydroponics :— Used for commercial production of Tomato, Lettuce, Seedless Cucumber.

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② Out of 105 elements, 60 are found in plants.

→ But all are not essential

→ At some places, Gold, Selenium, and radioactive strontium is also accumulated

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③ Criteria for Essentiality

→ absolutely essential for supporting normal growth and reproduction. (Plants do not complete their lifecycle in their absence)

→ Not replacable for other elements.

→ Must be directly involved in metabolism of plants.

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④ 17 Essential elements

9 Macronutrients
→ present in plant tissue in excess of 10 m mole/Kg of dry matter.

8 micronutrients
→ trace elements, required less than 10 m moles/Kg of dry matter

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⑤ Macronutrients →

Trick → Kon pisega PCM?

C, H, O, N, P, S, K(potassium), Ca, Mg

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⑥ Micronutrients

Trick → Mohobbat Jaan Mam Kyu NiKal Fe Ka.

Mo, B, Zn, Mn, Cu, Ni, Cl, Fe.

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⑦ Function of Essential elements →

→ Components of biomolecules, hence structural elements of cells (CHON)

→ Components of energy related chemical compounds.

→ mg → chlorophyll

→ P → ATP

→ Activators and Inhibitors of enzyme

→ Mg^{2+} → Activator of RUBISCO and PEPcase.

→ Zn^{2+} → Alcohol dehydrogenase.

→ Mo → MoFe → Nitrogenase

→ Alter the osmotic potential of cell

K^+ → opening and closing of stomata.

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⑧ Role of essential elements. →

① Nitrogen → (absorbed as NO_3^- small amt as NO_2^- / NH_4^+)

→ Required by plants in greatest amount.

→ Component of Chlorophyll, DNA, RNA, Hormones, Vitamins.

→ Mainly required by meristamatic parts of plant.

② Phosphorus (absorbed as phosphate ions, $H_2PO_4^-$ / HPO_4^{2-})

→ Constituents of Cell membrane, nucleic acid, certain protiens.

→ For phosphorylation reaction.

→ ATP, NADPH

(3) Potassium (absorbed as K^+)
→ Required in Meristamatic tissues, buds, leaves and root tips.
→ Ion-Cation Balance.
→ Opening and Closing of stomata.
→ Maintainance in turgidity of cells.
→ Involved in protein synthesis and activation of enzymes.

(4) Calcium (absorbed as Ca^{2+})
→ Synthesis of cell Wall.
→ Synthesis of Ca pectate for middle lamella.
→ Formation of mitotic spindle.
→ Required by meristematic tissue.
→ Accumulates in older leaves.

(5) Magnesium (absorbed as mg^{2+})
→ Activates enzymes of respiration (pyruvate dehydrogenase) and photosynthesis (RUBISCO and PEP(ase)
→ In synthesis of DNA and RNA.
→ Constituent of chlorophyll.
→ Maintains ribosome structure.
→ Mobile elements → K^+, N, Mg^{2+}.
→ Immobile elements → Ca, S, Fe.

(6) Sulphur (SO_4^{2-} sulphate ion)
→ present in amino acids cysteine and methionine
→ Constituent of several co-enzymes, Vitamins (thiamine (B_1), Biotin (B_7), Coenzyme A. and ferridoxin (FeS)

(7) Iron (absorbed as Fe^{3+}) (higher oxidation state).
→ Required in larger amount as compared to other micronutrients.
→ Components of Ferridoxin and cytochrome
→ Involved in Z scheme.
→ Activates catalase enzyme.
→ Essential in formation of chlorophyll.

(8) Manganese (absorbed as Mn^{2+})
→ Photolysis of water to liberate O_2 during photosynthesis.
→ Mn^+, Cl^-.

(9) Zinc (absorbed as Zn^{2+})
→ Activates carboxylases, alcohol dehydrogenase.
→ Needed for auxin synthesis.

(10) Copper (absorbed as Cu^{2+})
→ Involved in redox reaction.
→ e^- transport Chain - Respiration

(11) Boron (absorbed as BO_3^{3-}/$B_4O_7^{2-}$)
→ Required for uptake and utilisation of Ca^{2+}.
→ In membrane functioning.
→ In pollen germination.
→ In carbohydrate translocation.

(12) Molybdenum (absorbed as MoO_2^{2+})
→ Component of nitrogenase and nitrate reductase (MoFe compound)

(13) Chlorine (absorbed as Cl^-)
→ Helps in anion-Cation balance.
→ Photolysis of water reaction.
→ Mn^+Cl^-.

(9) Critical Concentration →
Conc. of mineral ion below which deficiency symptoms will appear.

(10) Deficiency Symptoms. →
(1) Chlorosis → Deficiency of chlorophyll.
Mo, N, K, Mg, Mn, Zn, Fe, S.
Trick → Monk mange manzan Fuse.

(2) Necrosis → Tissue Death
Cu, K, Ca, Mg.
Trick → Cook Ka Magic.

(3) Inhibition of cell division →
N, S, Mo, K.
Trick → No Smoking.

(4) Delay in Flowering →
Mo, S, N. Trick → Slow Motion.

(11) Toxicity of Micronutrients →
→ Any mineral ion concentration in tissues that reduces the dry weight by 10%.

→ Manganese Toxicity

→ appearance of brown spots surrounded by chlorotic veins.

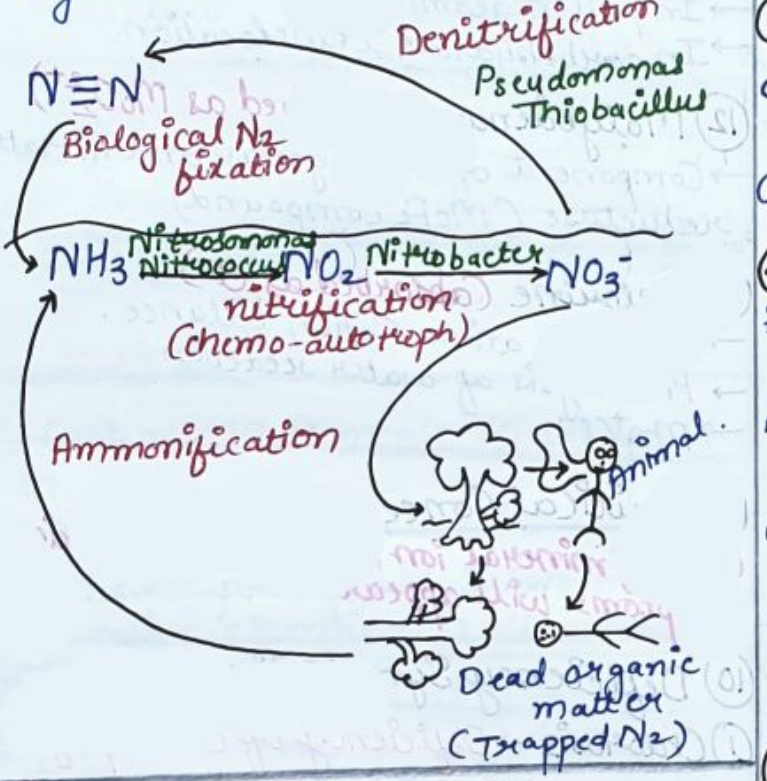
Reality → Mn interferes with absorption of Mg, Fe, Ca.

→ So, these are actually deficiencies of above 3 elements.

(Mn ne Mg Ko Fe Ca Kardiya)

(12) Nitrogen Cycle →

→ Series of events by which, nitrogen circulates between atmosphere and living organisms.



(13) Biological N_2 Fixation

- Free living
  - Aerobic
    - Azotobacter
    - Beijernickia
    - BG-A
    - Nostoc
    - Anabaena
  - Anaerobic
    - Rhodospirillum
- Symbiotic
  - → with leguminous plants: Rhizobium
  - → with non-leguminous plants: Frankia with Alnus

(14) Nodule Formation

Rhizobium attach to root hair cells

↓

Root Hair, Curl

↓

Bacteria invade root via infection thread

↓

Nodule formed

(15) $N_2 \xrightarrow[\text{Nitrogenase (MoFe)}]{16ATP} 2NH_3$

↳ Nitrogenase is sensitive to O_2.

Leghaemoglobin (pink) captures O_2.

→ Nitrogenase works under anaerobic conditions only.

→ So, these microbes live as aerobes under free living conditions (Nitrogenase not functional), but as anaerobic when in symbiotic relations with plants. (Nitrogenase functional).

(16) Fate of Ammonia

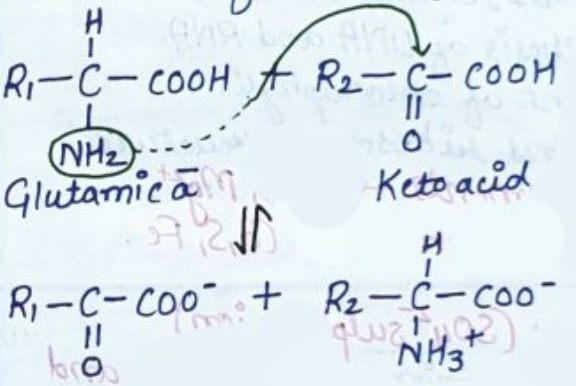
$NH_3 + H^+ \rightarrow NH_4^+$ (ammonium ion)

(1) Reductive Amination

α Ketoglutaric ā + NH_4^+ + NADPH —(Glutamate dehydrogenase)→ Glutamic ā + H_2O + NaDP

(2) Transamination.

Formation of other āa from Glutamic ā.



(3) Amides

$NH_2-C(H)(R_1)-COOH + NH_4^+ \rightarrow NH_2-C(H)(R_1)-CONH_2$

→ Transported to other parts of plants via xylem

Amides: Casparagine, glutamine

(4) Ureides

→ Sometimes, nodules of some plants (Soyabean) export N_2 as Ureids.

→ Have high N/C Ratio.