Ministry of Higher Education
Tishk International University
Faculty Of Education
Biology Education Department

Mineral Nutrition

Fourth Grade

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Lecture 5

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OUTLINE

- **Introduction**
- **Criteria for essentiality of nutrients**
- **Types of nutrient**
- **Role of micro and macronutrients**

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MINERAL NUTRITION

https://www.youtube.com/watch?v=6aC-WTAWgOg

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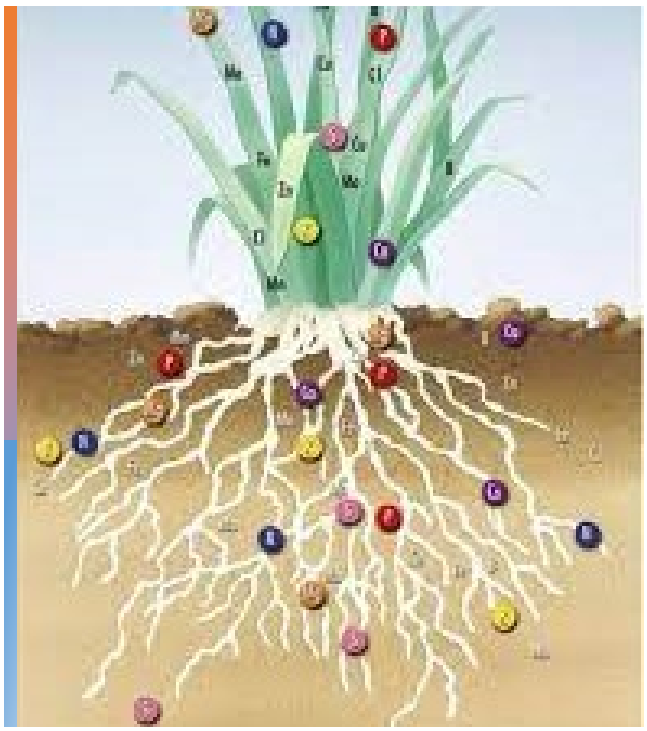

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Introduction

- A mineral is a chemical element which naturally occurs as **inorganic** nutrients in the food and soil, and are essential for the proper functioning of the plant and animal body.
- Other than carbon, hydrogen, oxygen & sulphur- organic molecules

Criteria for essentiality of nutrients

- In the absence of element plant will not complete its life cycle or set the seeds.
- The requirement of the element must be specific and cannot be replaced by another element.
- There is correlation between mineral and plant metabolism

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The element must be absolutely necessary for supporting normal growth and reproduction.

In the absence of the element the plants do not complete their life cycle or set the seeds.

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Types of nutrient

Based on the quantitative requirements nutrients are of two types:

- **Macronutrient:** Generally present in plant tissues in large amount, means they are required by the plants in large amount. E.g C (Carbon), H (Hydrogen), O (Oxygen), N (Nitrogen), P (Phosphorus), S (Sulfur), K(Potassium) , Ca (Calcium), Mg (Magnesium).

- C, H and O are mainly obtained from carbon dioxide and water, while the others are absorbed from the soil as mineral nutrition.

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- **Micronutrient:** Also called trace elements. They are needed in very small amount. E.g Fe (Iron), Mn (Manganese), Cu (Copper), Mo (Molybdenum), Zn (Zink), B (Boron), Cl (Chlorine), Ni (Nickel)

- In addition to above 9 macronutrient and 8 micronutrient there are some other elements which are essential for the growth and development of higher plants. They are: Na (Sodium), Si (Silicon), Co (Cobalt) and Se (Selenium).

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Based on functions of essential elements they are classified under four categories

- Essential elements as components of Biomolecules.

Eg Carbon, hydrogen, oxygen and nitrogen.

- Essential elements that are components of energy related chemical compounds in plants. Provide energy to plants.

E.g. Magnesium in chlorophyll and phosphorus in ATP.

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- Essential elements that activate or inhibit enzyme during metabolism. E.g **Mg** - activator of ribulose bisphosphate carboxylase oxygenase & phosphoenol pyruvate carboxylase-photosynthetic carbon fixation; **Zn-** an activator of alcohol dehydrogenase & **Mo** of nitrogenase-nitrogen metabolism.

- Elements altering water potential: Alters osmotic potential of cell. E.g K opening and closing of Stomata; regulates water potential of cells

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Role of micro and macronutrients:

❖Nitrogen:

- It is absorbed as Nitrate NO_3^- ,Nitrogen dioxide NO_2^- , or Ammonium NH_4^+
- Require by plants in greatest amount and for all parts, meristematic & metabolically active cells.
- Important constituent of proteins, nucleic acids, vitamins and hormones.
- https://www.youtube.com/watch?v=BoLpg4GQg04

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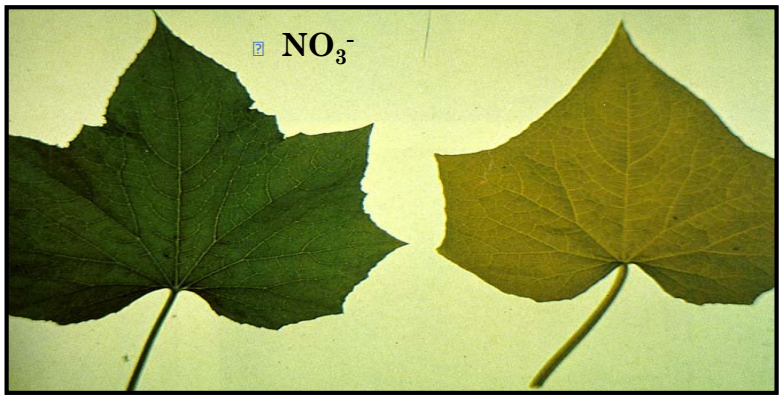

- Deficiency: Poor growth and leaf yellowing
- Nitrogen (nitrate ions: Needed to make proteins and chlorophyll

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Phosphorous

- It is absorbed in the form of phosphate ions in the form di hydrogen phosphate ion $H_2PO_4^-$, or HPO_4^{2-}
- Constituent of certain proteins, cell membrane, all nucleic acid, nucleotides
- Required for all phosphorylation reactions.
- https://www.youtube.com/watch?v=XxqGJVqYIGU

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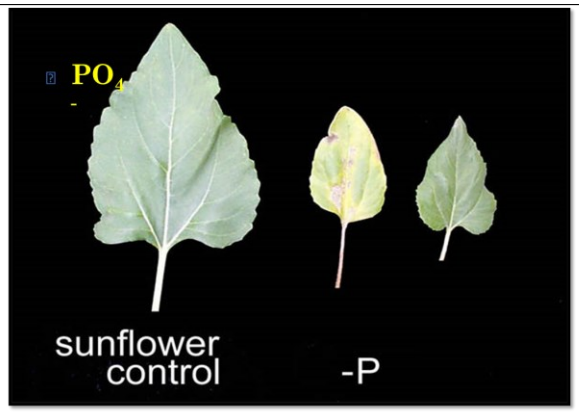

- Phosphorous: Required for photosynthesis and respiration
- Deficiency: Poor root growth and purple younger leaves

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POTASSIUM

It is absorbed as K^+ ions.

Require for meristematic tissues, buds, leaves, and root tips.

Helps in protein synthesis, opening and closing of stomata.

Helps in activation of enzymes.

It maintains the turgidity of cells.

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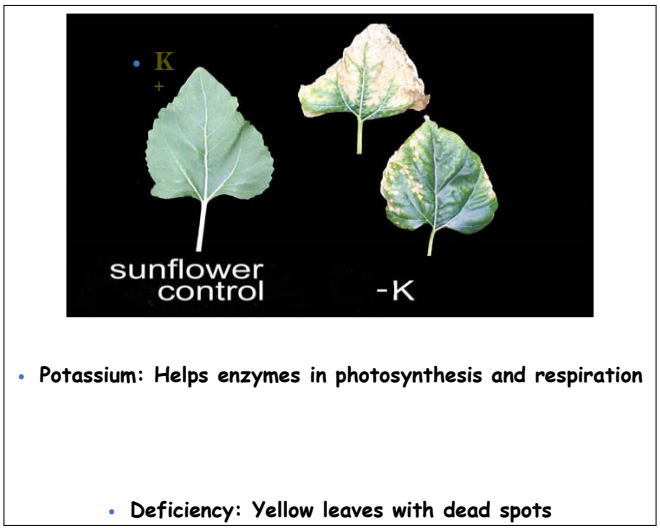

- Potassium: Helps enzymes in photosynthesis and respiration
- Deficiency: Yellow leaves with dead spots

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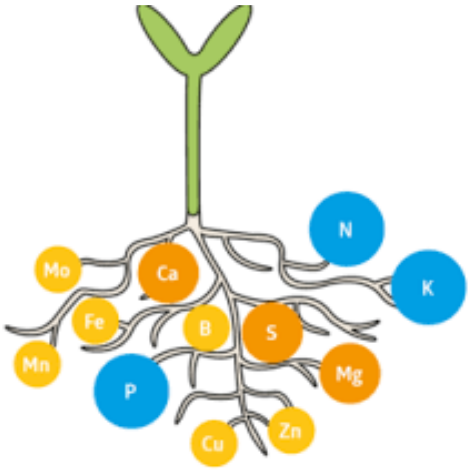

Calcium

- Required by meristematic and differentiating tissues.
- Absorbed in the form of Ca^{2+}.
- During cell division it is used in synthesis of cell wall.
- Required for mitotic spindle formation.
- Activation of enzymes.

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Symptoms of calcium deficiency first appear on younger leaves and tissues, growth is inhibited, and plants have a bushy appearance.

The youngest leaves are usually small and misshapen with brown chlorotic spots developing along the margins, which spread to eventually unite in the center of the leaves.

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Magnesium

- Absorbed in the form of Mg^{2+}.
- Activates enzymes of respiration and photosynthesis.
- Involved in synthesis of DNA and RNA.
- Helps to maintain ribosome structure.

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Deficiency: Symptoms are more severe on the lower leaves because magnesium is moved to the new growth. Deficiency symptoms consist of **interveinal chlorosis (leaf veins stay green while the regions between them turn yellow)**.

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Sulphur

- Absorbed in the form of SO_4^{2-}.
- Present in cysteine and methionine amino acids.
- Present in vitamins (thiamine, biotin, Coenzyme A) and ferredoxin.

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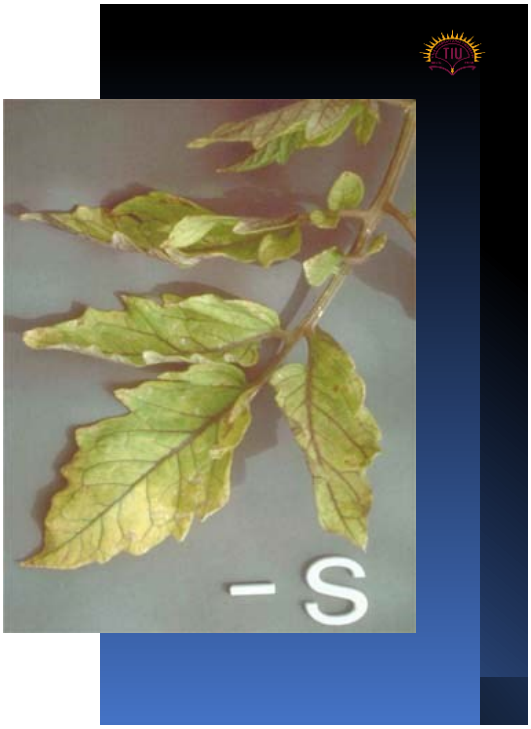
• Plants deficient in Sulphur are small and spindly with short and slender stalks, their growth is retarded, maturity in cereals is delayed



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Iron

- Absorbed in the form of Fe^{3+} (Ferric ion)
- Important constituent of proteins
- Involved in the transfer of electrons like ferredoxin and cytochromes
- Activates catalase enzyme
- Essential for formation of chlorophyll.

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- The symptoms of iron deficiency appear on the youngest, newest leaves. **The area between the leaf veins becomes pale yellow or white** (this is called interveinal chlorosis). Usually, no noticeable physical deformity occurs, but in severe cases the youngest leaves may be entirely white and stunted.

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Manganese

- Absorbed in the form of manganous ion (Mn^{2+}).
- Helps in activation of enzyme during photosynthesis, respiration and nitrogen metabolism.
- Helps in splitting of water to liberate oxygen during photosynthesis.

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- Mn

The most common symptom is for **leaves to turn pale green between the veins, with normal coloured areas next to the veins**. As the deficiency progresses, the area between the veins becomes paler, enlarges and may brown and die.

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Zinc

- Absorbed as Zn^{2+}.
- Activates carboxylases enzyme.
- Requires for synthesis of Auxins.

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Zinc deficiency causes a type of leaf discoloration called chlorosis, which causes the tissue between the veins to turn yellow while the veins remain green.

Chlorosis in zinc deficiency usually affects the base of the leaf near the stem.

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Copper

- Absorbed as cupric ions (Cu^{2+}).
- Essential for metabolism in plants.
- Activation of enzymes.

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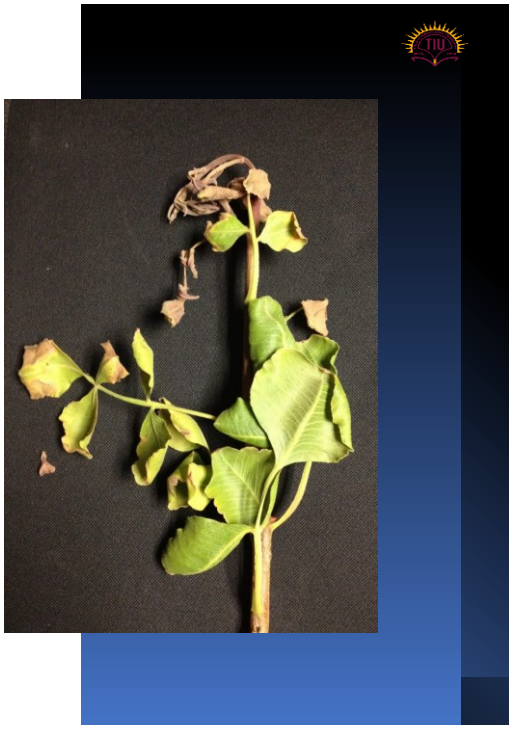
Copper is immobile, meaning its deficiency symptoms occur in the newer leaves. Symptoms vary depending on the crop.

Typically, the symptoms start as cupping and a slight chlorosis of either the whole leaf or between the veins of the new leaves.



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Deficiency happens in newer leaves

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Boron

- Absorbed as BO_3 or B_4O_7.

- Required for uptake and utilisation of Ca^{2+} , membrane functioning, pollen germination, cell elongation, cell differentiation and carbohydrate translocation.

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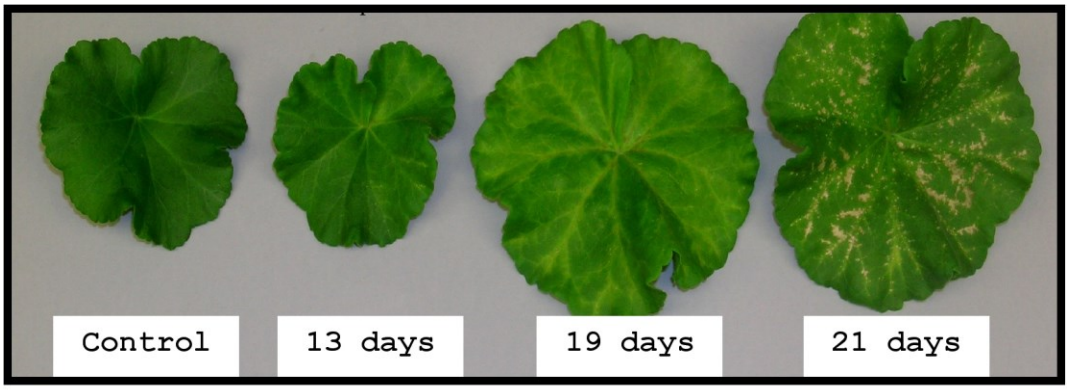

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- **Boron** deficiency affects vegetative and reproductive growth of plants resulting in inhibition of cell expansion, death of meristem and reduced fertility.
- The emerging leaf is red-brown to purple.
- Interveinal necrotic spots and the leaf dies inwards from leaf edges to veins.

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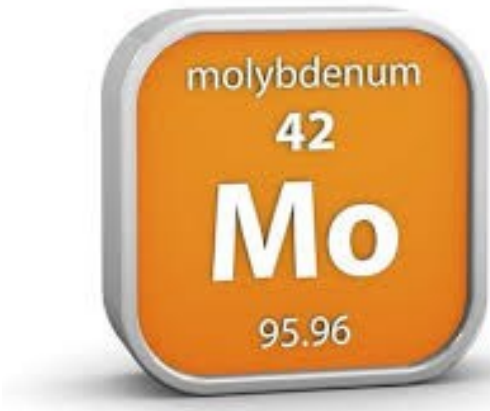
Molybdenum

- Absorbed in the form of Molybdate ions (MoO_2).
- Components of enzymes like nitrogenase and nitrate reductase (Participates in nitrogen metabolism)



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Stunted growth with small leaf size, and possible reddening of veins on the young leaves.

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Chlorine

- Absorbed in the form of Cl.
- Helps in maintaining **anion-cation balance**.
- Essential for water splitting reaction in photosynthesis.

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Wilting of leaves, especially at the margins.

As the deficiency progresses and becomes more severe, the leaves exhibit curling, bronzing, chlorosis, and **necrosis**.

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Deficiency symptoms of essential elements:

- **Chlorosis:**
  - Loss of chlorophyll leading to yellowing of leaf.
  - The deficiency of elements: N, K, Mg, S, Fe, Mn, Zn and Mo.

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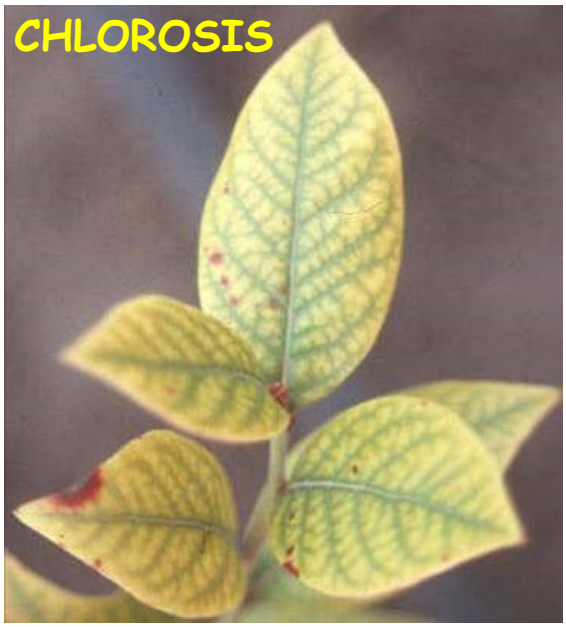

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Necrosis:

Death of leaf tissue.

Caused due to deficiency of Ca, Mg, Cu and K.

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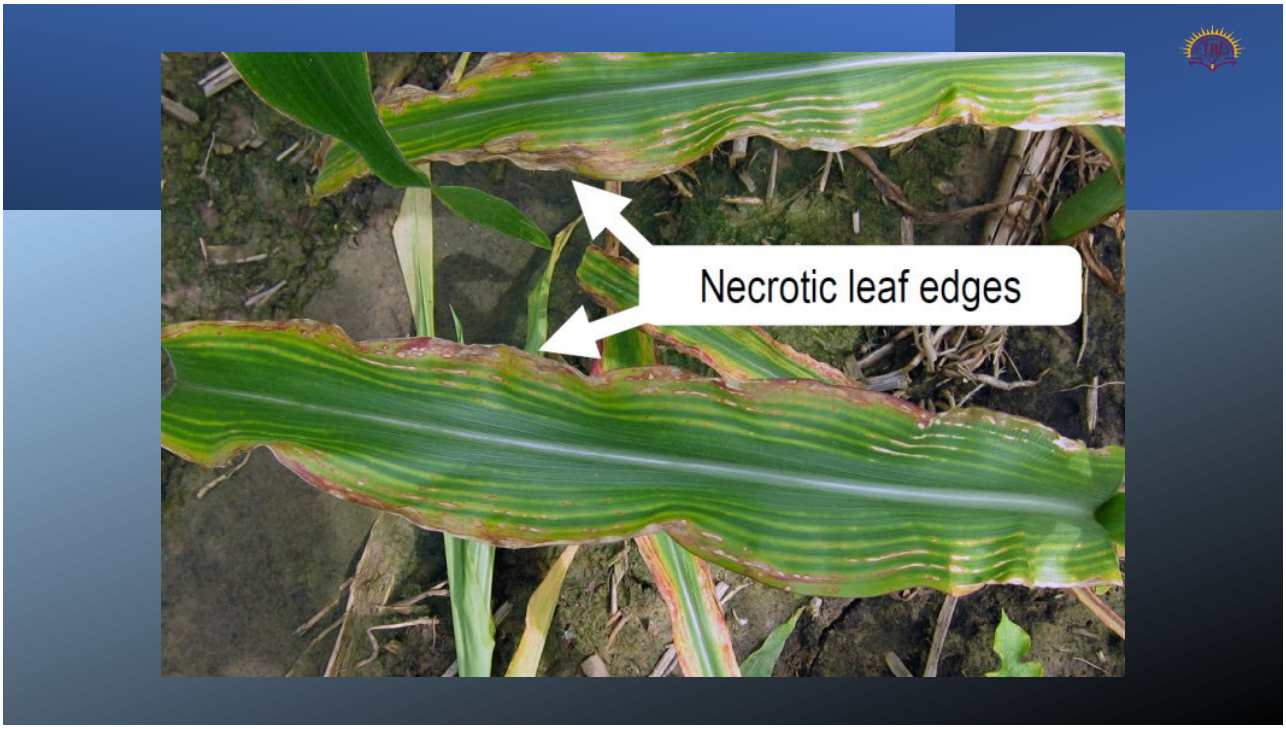

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- **Stunted growth and premature fall of leaves and buds:**
  - Deficiency of N, K, Mg, S, Fe, Mn, Zn and Mo
- **Inhibition of cell division:**
  - Deficiency of N, K, S, Mo.
- **Delay flowering:**
  - Deficiency of N, S, Mo.

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Toxicity of micronutrient:

- The requirement of micronutrients is always in low amounts while their moderate decrease causes the deficiency symptoms and a moderate increase causes toxicity.
- Any mineral ion concentration in tissues that reduces the dry weight of tissues by about 10 per cent is considered toxic.

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Soil as reservoir of essential elements:

Soil consists of a wide variety of substances.

It not only supplies minerals but also harbours nitrogen fixing bacteria, other microbes, holds water, supplies air to the roots.

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Biological nitrogen fixation:

- Reduction of nitrogen to ammonia by living organisms is called biological nitrogen fixation.
- This is done by enzyme nitrogenase and is present in prokaryotes. Such microbes are called Nitrogen fixers .
- Nitrogen fixing microbes may be free living or symbiotic.

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- Free living : Azotobacter and Bacillus.
- Anaerobic : Rhodospirillum.

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Symbiotic Biological nitrogen fixation:

- Some bacteria like Rhizobium lives in relationship with the roots of several legumes (alfalfa, sweet clover, sweet pea, lentils, garden pea, broad bean, clover beans etc.).
- The most common association on roots is as nodules (out growth on the roots).

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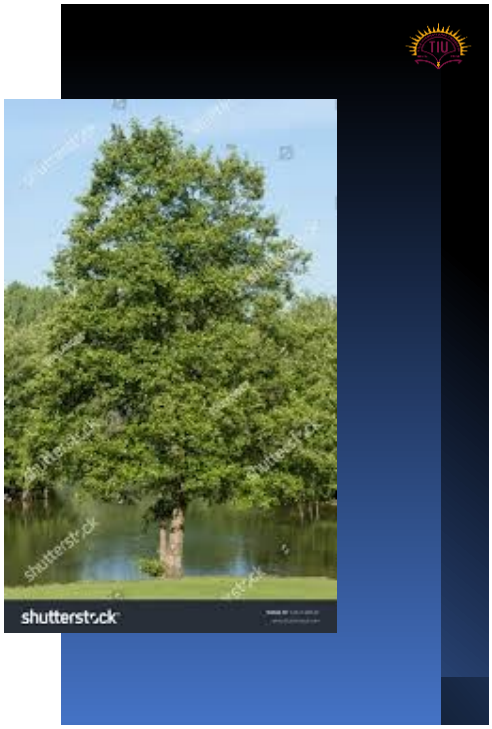
- Such bacteria fixes atmospheric nitrogen into soluble form of nitrogen which are utilized by the plants.
- Frankia, also produces nitrogen fixing nodules on the roots of non-leguminous plants (Alnus) that also fixes atmospheric nitrogen.



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Nodule formation:

- Rhizobium multiplies and get attached to epidermal and root hair cell.
- The root hairs curl and the bacteria invade the root hair.
- An infection thread is produced carrying the bacteria into the cortex of the root, where they initiate the nodule formation in the cortex of the root.

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- Then the bacteria are released from the thread into the cells which leads to the differentiation of specialized nitrogen fixing cells.
- The nodule thus formed has a direct vascular connection with the host for exchange of nutrients.

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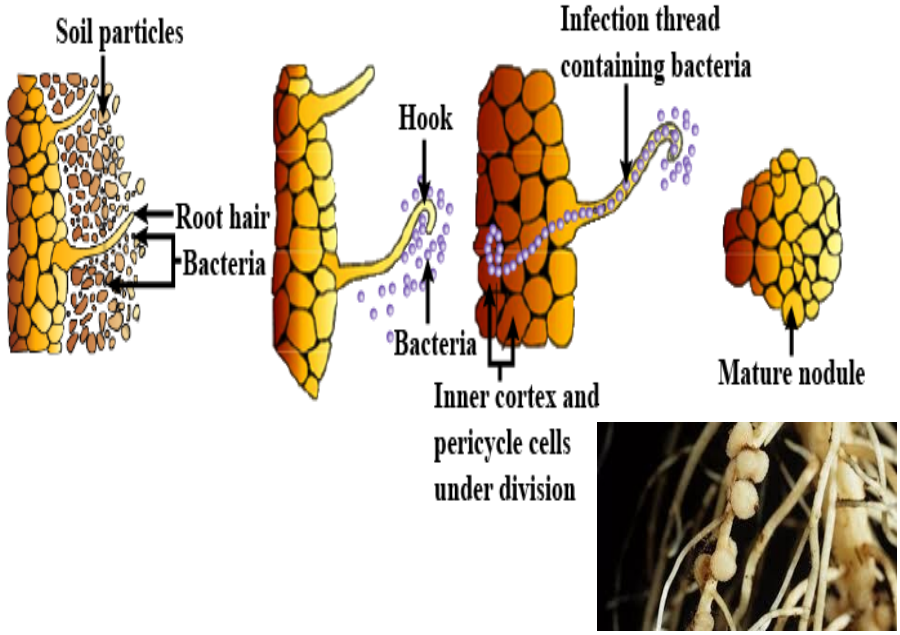
Soil particles
Root hair
Bacteria
Hook
Bacteria
Infection thread
containing bacteria
Inner cortex and
pericycle cells
under division
Mature nodule

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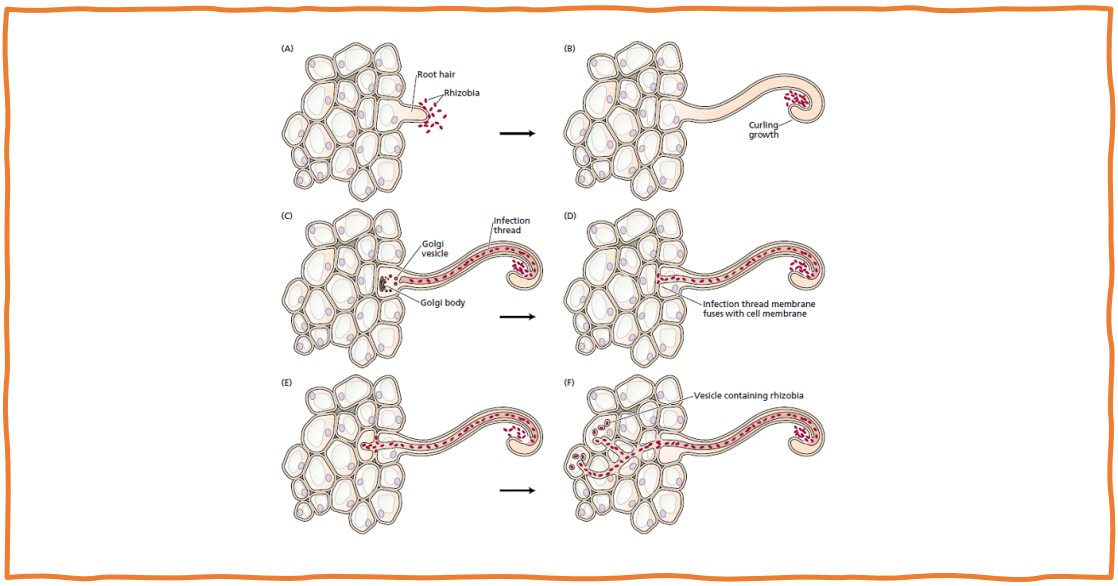
(A)
Root hair
Rhizobia
(B)
Curling
growth
(C)
Infection
thread
Golgi
vesicle
Golgi body
(D)
Infection thread membrane
fuses with cell membrane
(E)
(F)
Vesicle containing rhizobia

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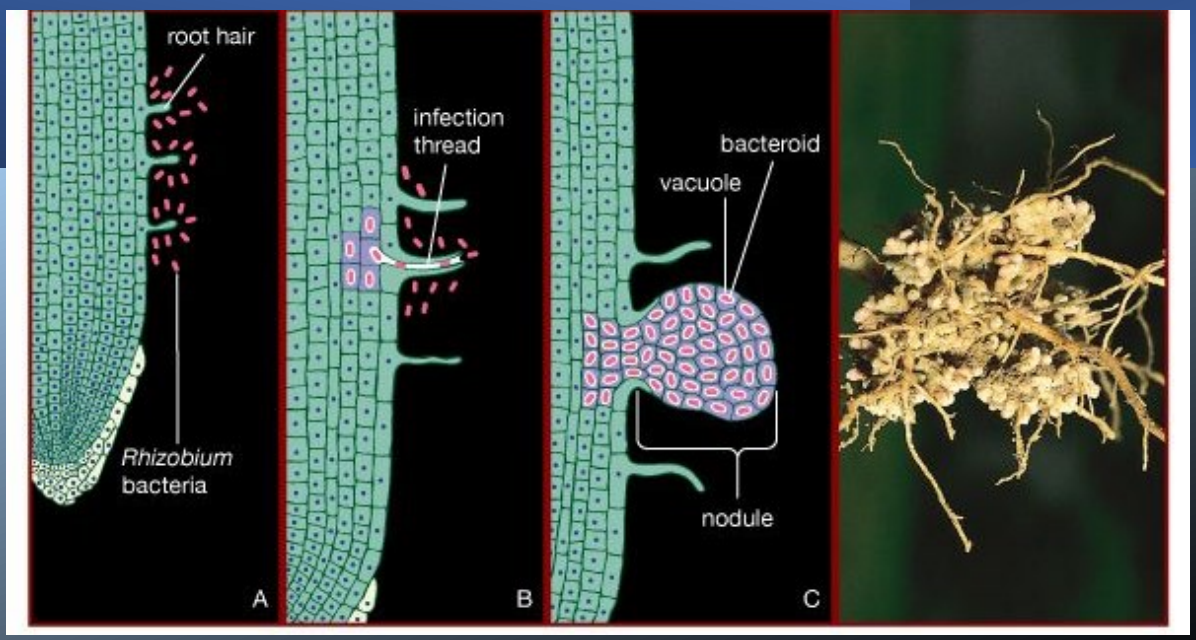

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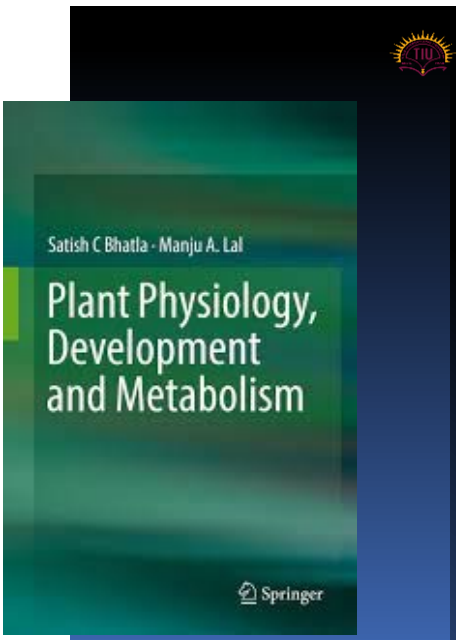
Reference

- Bhatla, S.C., A. Lal, M., Kathpalia, R. and Bhatla, S.C., 2018. Plant mineral nutrition. Plant physiology, development and metabolism, pp.37-81.



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