



**Centurion**  
**UNIVERSITY**

*Shaping Lives...  
Empowering Communities...*

# **ASAC 1101 : FUNDAMENTALS OF SOIL SCIENCE (2+1)**

**Level : B.Sc (Ag), I semester**

**Dr. PEDDA GHOUSE PEERA S.K.**

**SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**

**M.S.SWAMINATHAN SCHOOL OF AGRICULTURE,CUTM,  
PARLAKHEMUNDI**

## **Topic**

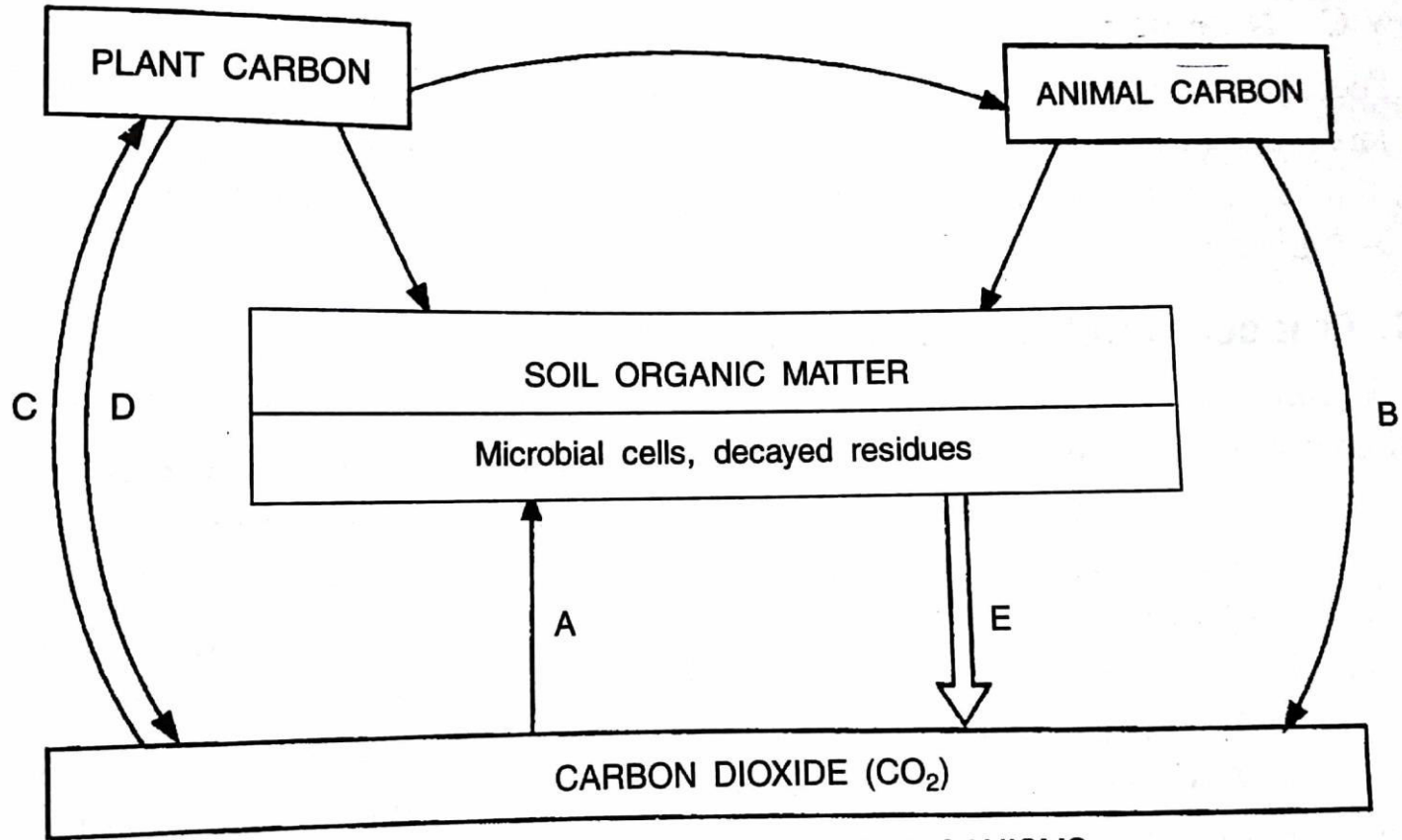
**Carbon cycle- Biological N fixation- C:N  
ratio- PGPR**



# CARBON CYCLE

- The series of processes by which carbon compounds are inter converted in to the environment, involving the incorporation of carbon dioxide into living tissue by photosynthesis and its return to the atmosphere through respiration, the decay of dead organisms, and the burning of fossil fuels.
- **The carbon cycle revolves about CO<sub>2</sub> and its fixation and regeneration.**
- The carbon cycle was discovered by **Joseph Priestley** and **Antoine Lavoisier**, and popularized by **Humphry Davy**.





- A - AUTOTROPHIC MICROORGANISMS
- B - RESPIRATION, ANIMAL
- C - PHOTOSYNTHESIS
- D - RESPIRATION, PLANT
- E - RESPIRATION, MICROBIAL

## ○ Steps of the Carbon Cycle:

### 1. **CO<sub>2</sub> used by Plants for Photosynthesis**

### 2. **Consumption by Animals**

- The carbon present in the food made by green plants reaches animals through the food chain. Carnivorous animals receive this carbon when they eat other animals.

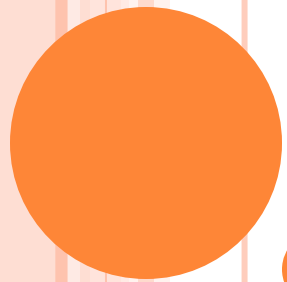
### 3. **Respiration by Plants, Animals and Microbes**

- Carbon dioxide is regularly being returned to the atmosphere by the process of respiration by plants, animals and microbes.

### 4. **Decay and Decomposition**

- When living organisms die, their bodies decay and decompose.





**C: N RATIO**

- The ratio between the nitrogen content in the microbes and in the organic residues and to the carbon content is called as C:N ratio.

## **Importance of C:N ratio**

- C:N ratio mainly controls decomposition rate in soil.
- The wide C:N ratio leads to slow decomposition rate, nutrient **immobilization** may occur, carbon and energy wastage in large quantities.
- In Narrow C:N ratio, Plant residues decompose quickly and release nitrates readily.
- When the residue with high C/N ratio is added to soils, there will be intense competition among the microorganism for available N.
- The C/ N ratio in residues helps determine their rate of decay and the rate at which N is made available to plants.

<b>Indian Soil</b>	<b>12-15:1</b>
<b>Ideal soil</b>	<b>10-12:1</b>
<b>Cultivated soil</b>	<b>8-15:1</b>
<b>Humus</b>	<b>10:1</b>
<b>Micro-organisms</b>	<b>4-9:1</b>
<b>Straw</b>	<b>100:1</b>
<b>FYM</b>	<b>20:1</b>
<b>Legumes</b>	<b>20-30:1</b>
<b>Sawdust</b>	<b>600:1</b>





## Mineralization

The biological conversion of organic forms of C, N, P and S to inorganic or mineral forms is called mineralization.

When the C:N ratio is less than **25:1** causes mineralization by the simultaneous release of inorganic nitrogen. Therefore increases the total mineral nitrogen in the soil.

Mineralization increases the bioavailability of the nutrients

It's the dominant process compared to mineralization

## Immobilization

The conversion of inorganic forms of C, N, P and S by the soil organism into organic forms is called Immobilization.

If the C:N ratio of the decomposing plant material is above about **30:1** the soil microbial population may take nitrogen in mineral form (eg: nitrate). This mineral nitrogen is said to be immobilized.

This may cause nutrient deficiency in plants growing in the soil.

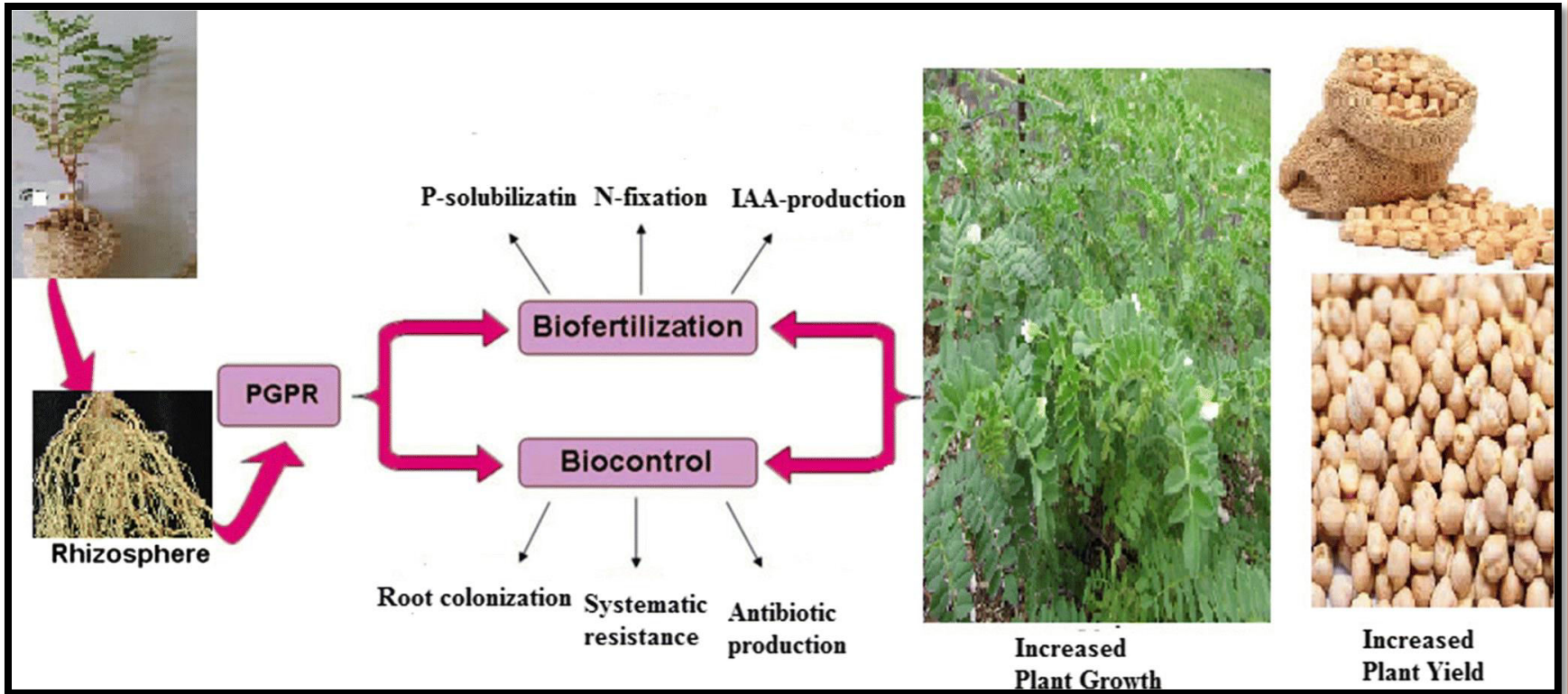
Not a dominant process



**PLANT GROWTH PROMOTING  
RHIZOBACTERIA**

- Plant Growth Promoting Rhizobacteria (PGPR) are a group of bacteria that enhances plant growth and yield *via* various plant growth promoting substances as well as biofertilizers.
- Also known as rhizosphere bacteria that exert beneficial effect on plant growth.
- The primary mechanism of PGPR is to improve the plant growth by colonizing the root system and suppressing the growth of harmful microorganism in rhizosphere.





- Plant growth promoting rhizobacteria can be classified into
  - A. Extracellular PGPR (ePGPR)**
  - B. Intracellular PGPR (iPGPR).**
- The ePGPRs may exist in the rhizosphere, on the rhizoplane or in the spaces between the cells of root cortex
  - Eg: Azotobacter, Azospirillum,
- iPGPRs locates generally inside the specialized nodular structures of root cells.
  - Eg: Rhizobium.





# **BIOLOGICAL NITROGEN FIXATION**

**BNF:** Fixation of elemental nitrogen in the atmosphere by the micro organism through a reductive process into ammonia is called as BNF.

- A variety of prokaryotic organism have the ability to reduce the atmosphere  $N_2$  into ammonia with help of an enzyme called **nitrogenase**.
- Carried out by certain bacteria, actinomycetes, blue green algae, fungi and yeast.
- The most important of these are bacteria, which have ability to fix atmospheric nitrogen by symbiosis or free living.
- Rhizobia are the first group of organism realized for its potential of nitrogen fixation.



<b>Free living</b>	<b>Azotobactor, Derixa, Beijerinckia,</b>
<b>Associative</b>	<b>Azospirillum, Acetobactor</b>
<b>Symbiotic</b>	<b>Rhizobia-Legume, Frankia-Non legume, Anbaena-Azolla</b>





# Cross inoculation groups of rhizobium (CIG)

- Not all rhizobia nodulate all legumes. Rather, particular rhizobia form a symbiosis with particular legumes or groups of legumes.
- The symbiosis between rhizobia and legumes appears to be precisely matched.
- It (CIG) refers the groups of leguminous plants that will develop effective nodules when inoculated with the rhizobia obtained from the nodules from any member of that legume group.



## ○ Rhizobium

<b>Rhizobium Spp.</b>	<b>Cross Inoculation Grouping</b>	<b>Legume Types</b>
R. leguminosarum	Pea group	Pisum, Vicia, Lens
R. phaseoli	Bean group	Phaseolus
R. trifolii	Clover group	Trifolium
R. meliloti	Alfalfa group	Melilotus, Medicago, Trigonella
R. lupini	Lupini group	Lupinus, Orinthopus
R. japonicum	Soybean group	Glycine
Rhizobium sp.	Cowpea group	Vigna, Arachis



## Process of symbiotic N<sub>2</sub> fixation

- Rhizobia have the ability to infect the plant roots and form nodules in them.
- Energy required to break the triple bond between nitrogen atoms in the N<sub>2</sub> molecule is supplied by host plant from photosynthesis.
- The ammonia further converted in to L-ketoglutamic acid and finally in to glutamic acid.



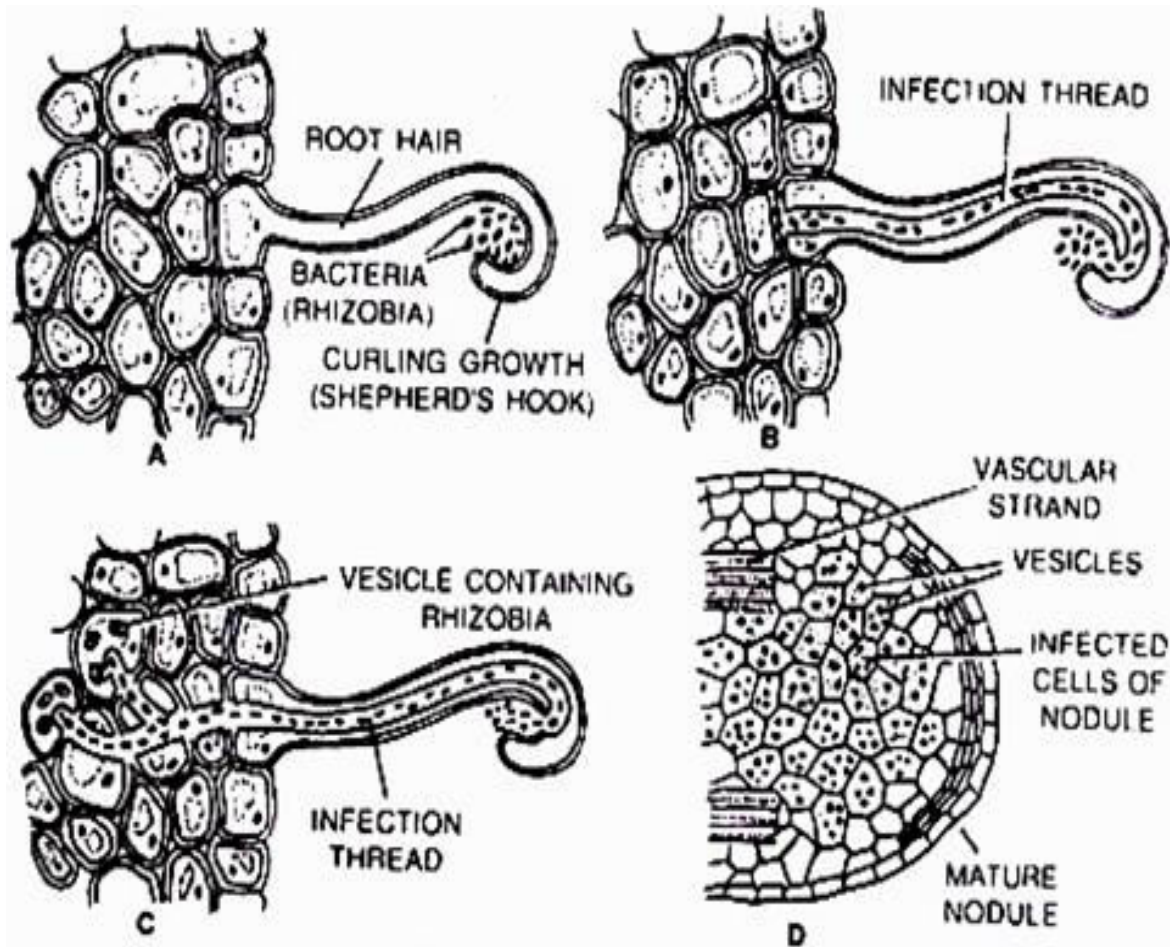


Fig. 5.1 Development of root nodule (nodulation) in legume.



- Genes directing specific steps in nodulation of a legume by a strain of Rhizobium are called **nod genes**.
- Genes responsible for N fixation are called **Nif genes**.

## **Factors affecting BNF**

- Type of legume
- Effectiveness of bacterial strain
- Inorganic N content
- Fertilizer N applied
- Adequate supply of P, K and secondary nutrients.
- Favorable environmental conditions (mainly temperature, moisture and pH)



- **Phosphate solubilizing microorganisms (PSMs)** are group of beneficial microorganisms capable of hydrolyzing organic and inorganic phosphorus compounds from insoluble compounds.
- **Phosphate solubilizing bacteria (PSB)** are beneficial bacteria capable of solubilizing inorganic phosphorus from insoluble compounds.

Eg : Bacillus and Pseudomonas



- The mechanism of P solubilization that is employed mostly by soil microorganisms includes:
  - (1) Release of complex compounds e.g. organic acid anions, siderophores, protons, hydroxyl ions,  $\text{CO}_2$ ,
  - (2) Liberation of enzymes
  - (3) The release of P during the degradation of substrate.

Fungal genera (*Penicillium* and *Aspergillus*), actinomycetes, and arbuscular mycorrhizal (AM) are also help for P solubilization.



# Mycorrhizae

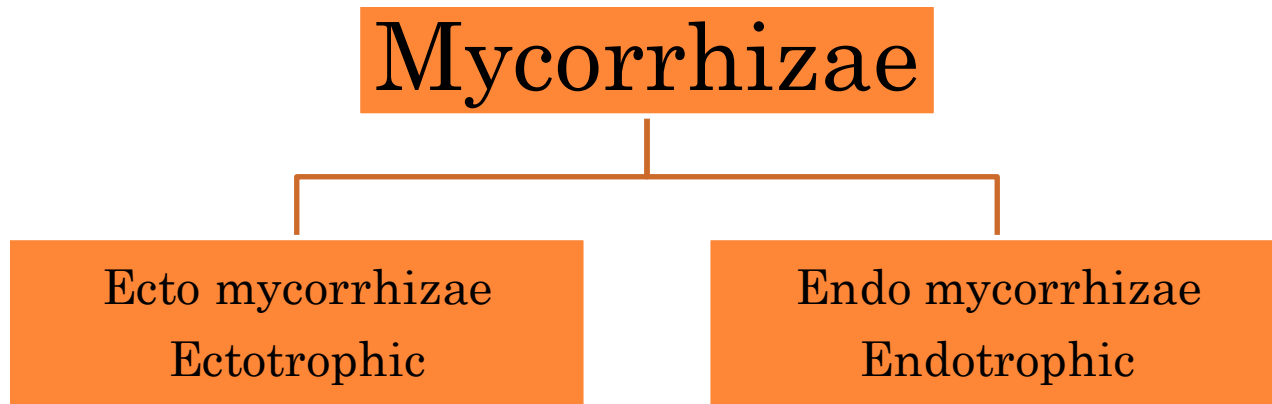
- The symbiotic association between numerous fungi and the roots of higher plants is called mycorrhizae which means fungus roots”.
- This association increases the availability of several essential nutrients to plants especially from low fertile soils
- This association provides sugars and other organic exudates from higher plants as food to the fungi.
- The fungi in turn provide an enhanced availability of several essential nutrients including P, zn, Cu, Ca, Mg, Mn and Fe.





- There are 2 types of mycorrhizal associations.

○



- **Ecto mycorrhizae** : The fungus forms a mantle or sheath over the surface of fine lateral roots of the host trees and sends some hyphae into the intercellular spaces of the outer cortex forming a so-called **Hartignet**. Eg: *Amanita* spp., *Boletus* spp etc.
- **Endo mycorrhizae**: Hyphae actually penetrate in to the cells of host plant. Eg: AM fungi



# Lichens

- It is a stable symbiotic association between a fungus (mycobiont) and algae (photobionts) and/or cyanobacteria.
- Where photosynthetic symbionts provide a source of carbon and surface protection from light and irradiation.
- The photosynthesizer benefits from the water and nutrients absorbed by the fungus.
  
- **Cyanella** : Unicellular symbiotic cyanobacterium living intracellularly called a cyanella (Endosymbiotic cyanobacteria).

