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1. Biofertilizer Including Bacterial, Fungal AM/ VAM, Ectomycorrhizae, Cyanobacteria for Sustainable Agriculture

Tanmay Ghosh

Assistant Professor,
Department of Microbiology,
Dinabandhu Andrews College, Baishnabghata,
South 24 Parganas, Kolkata,
West Bengal, India.

Summary:

Modern agriculture involves usage of pesticides and chemical fertilizers with an essence of increasing the world's food production. Thus, these serve as a fast food for plants, causing them to grow more rapidly and efficiently. Fertilizers, though they are vital as a nutrient supplement to plants and comprised mainly nitrogen (N), potassium (K) and phosphorous (P), they also cause several health hazards. Researchers have found "Bio fertilizer" as an excellent alternative to chemical fertilizers which provide nutrients through the action of nitrogen fixation, solubilising phosphorus, and trigger plant growth through the synthesis of growth promoting essence.

Keywords: Biofertilizers, Microbiology, Soil, Cyanobacteria.

1.1 Introduction:

Biofertilizer can be defined as biological products containing living microorganisms that, when applied to seed, plant surfaces, or soil, promote growth by several mechanisms such as increasing the supply of nutrients, increasing root biomass or root area and increasing nutrient uptake capacity of the plant .Continuous application of chemical fertilization Leads to the decay of soil quality and fertility and might Lead to the collection of heavy metals in plant tissues, Affecting the fruit nutritional value and edibility (Farnia And Hasanpoor, 2015). In the recent years, many organic fertilizers have been introduced that act as natural stimulators for plant growth.

A particular group of organic fertilizers includes outcomes based on plant growth-promoting microorganisms identified as 'Biofertilizers'. These biofertilizers comprised efficient strains of nitrogen fixing or phosphate solubilizing microorganism.

Organic farming has appeared as a prime concern area globally in aspect of the growing demand for safe and healthy food, durable sustainability and issue on environmental pollution associated with random use of agrochemicals (Ghany et al.,2013).

Biological fertilization is based on the supply of organic inputs including fertilizers, organic wastes, domestic sewage, animal manure, and microorganisms, such as fungi and bacteria. The bio-fertilizers supply also enhance the productivity per area in a comparatively short time, consume smaller amounts of energy, reduce contamination of soil and water, increase soil fertility, and encourage antagonism and biological control of phytopathogenic organisms. Biofertilizers approach pose lots of such benefits from an economic, social, and environmental point of view (-Muñoz and Carmona-Garcia, 2012). From long-ago, the chemical pesticides and fertilizers have Played a vital role in improving agricultural production.

Although they have a short history in modern agriculture, their instant action and low cost managed to bring them quickly into the center of attention. Thus, their adverse effects on environment, plant, animal and human life have diverted the priority on ecofriendly plant protection (Patel et al., 2014). The term biofertilizer, depict everything from manures to plant extract (Aggani, 2013). Biofertilizer is a material which contains living microorganisms. When applied to plant surfaces, they promote plant growth by increasing the supply of primary nutrients to the host plant. Bio-fertilizers add nutrients through natural processes such as nitrogen fixation, solubilizing phosphorus, and stimulating plant growth along with the synthesis of growth-promoting substances.

The practice of organic manure does not only include the management of crop yields, but also plays a vital role towards exhibiting both direct, as well as indirect influence on the nutrient accessibility in soil by improving the physical, chemical and biological properties of soil and likewise enhances the utilization effectiveness of applied fertilizers (Kapoor and Pandit, 2015). Biofertilizer is an organic by-product containing living microorganisms arrested from plant roots or soil.

Choice of bio-fertilizer is becoming increasingly popular for the replacement of chemical fertilizer in order to lower the cost of crop production, enhance the growth and crop yield by increasing the nitrogen availability and by producing certain substances, such as auxin, cytokinin and gibberellins, which are helpful in the growth of plants. Microbial activity plays a key role in agriculture because they are very significant in the movement and availability of minerals required for plant growth and ultimately lower the use of chemical fertilizers (Verma et al., 2017).

Further, the use of bio-fertilizers can raise productivity per unit area in a short time, use smaller amounts of energy, reduce contamination of soil and water, increase soil fertility, and encourage antagonism and biological control of phytopathogenic organisms (Yasin et al., 2012). Biofertilizers are significant, not only for the decrease in quantity of chemical fertilizers, but also for better yield in sustainable agriculture. Bio fertilizer production is cheap and does not create pollution in the natural system (Farnia and Hasanpoor, 2015). In India, systematic study on biofertilizers was started by N. V. Joshi in 1920. Rhizobium was the first isolated from various cultivated legumes, and this was followed by vast research by Gangulee, Sarkaria and Madhok on the physiology of the nodule bacteria besides its inoculation for better crop production. Rhizobium and Blue Green Algae (BGA) are considered as the traditional biofertilizers, while Azolla, Azospirillum and Azotobacter are at the middle stage (Rahimi et al.,2014).

1.2 Biofertilizer:

A biofertilizer is a substance which contains living microorganism, when applied to seed, plant surface or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. Biofertilizers add nutrients through the natural process of nitrogen fixers, solubilizing phosphorus and stimulating plant growth through the synthesis of growth promoting substance. Some features of thebiofertilizer which improve the soil fertility are described below:

a. Biofertilizers are natural fertilizers that are microbial inoculants of bacteria, algae and fungi (separately or in combination).
b. Which may help biological Nitrogen fixation for the benefit of plants.
c. They help build up the soil microflora and there by the soil health.
d. Biofertilizer also include organic fertilizers (like manure).
e. The use of biofertilizer is recommended for improving the soil fertility in organic farming.

The biofertilizer (bio-manure) is a substance which contains living miniature life forms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the inside of the plant and advances development by expanding the inventory or accessibility of essential supplements to the host plant. Biofertilizers add supplements through the regular cycles of nitrogen obsession, solubilizing phosphorus, and invigorating plant development through the union of development advancing substances. The microorganisms in biofertilizers reestablish the dirt's regular supplement cycle and fabricate soil natural matter. Using biofertilizers, solid plants can be developed, while upgrading the maintainability and the strength of the dirt. Biofertilizers can be required to decrease the utilization of engineered manures and pesticides, however they are not yet ready to supplant their utilization. Since they assume a few parts, a favored logical term for such gainful microbes is "plant-development advancing rhizobacteria".

1.2.1 Biofertilizers in Today:

Biofertilizers give "eco-accommodating" natural agro-input. Biofertilizers like Rhizobium, Azotobacter, Azospirilium and blue green growth have been being used quite a while.

Rhizobium inoculant is utilized for leguminous harvests. Azotobacter can be utilized with crops like wheat, maize, mustard, cotton, potato and other vegetable yields. Azospirillum immunizations are suggested primarily for sorghum, millets, maize, sugarcane and wheat.

Blue green growth having a place with an overall cyanobacteria class, Nostoc or Anabaena or Tolypothrix or Aulosira, fix air nitrogen and are utilized as vaccinations for paddy crop developed both under upland and swamp conditions.

Anabaena in relationship with water greenery Azolla contributes nitrogen up to 65 kg/ha/season and furthermore improves soils with natural matter. Kelp is plentiful in different kinds of mineral components (potassium, calcium, phosphorus, minor components and so forth) thus they are widely utilized as excrement by individuals of waterfront areas. Ocean growth - compost likewise helps in separating muds. Fucus is utilized by Irish individuals as fertilizer for an enormous scope.

In tropical nations base mud of evaporated lakes which contain bountiful blue green growth is consistently utilized as compost in fields. The combination of ocean growth and blue green growth may fill in as optimal compost.

Figure 1.a: Blue green algae used in biofertilizer

1.2.2 Parts of Biofertilizers:

The parts of biofertilizers include:

a. Bio Compost: It is one of the eco-accommodating items made out of waste material delivered from sugar enterprises which are deteriorated. It is amplified with human-accommodating microorganisms, organisms, and different plants.

b. Tricho-Card: It is an eco-accommodating and nonpathogenic item utilized in an assortment of harvests just as in green and elaborate plants, like paddy apple, sugar stick, brinjal, corn, cotton, vegetables, citrus, and so forth It goes about as a useful destroyer and opposing hyper parasitic against eggs of a few bores, shoot, natural product, leaves, bloom eaters and different microorganisms in the field.

c. Azotobacter: It shields the roots from microbes present in the dirt and assumes an essential part in fixing the barometrical nitrogen. Nitrogen is a vital supplement for the plant and about 78% of the absolute climate involves nitrogen.

d. Phosphorus: Phosphorus is one of the fundamental supplements for plants development and advancement. Phosphate solubilizing microorganisms, hydrolyze insoluble phosphorus mixtures to the solvent structure for take-up by plants. Numerous parasites and microbes are utilized for the reason like *Penicillium, Aspergillus, Bacillus, Pseudomonas,* and so forth.

e. Vermicompost: It is an Eco-accommodating natural manure involves nutrients, chemicals, natural carbon, sulfur, anti-toxins that assistance to build the amount and nature of yield. Vermicompost is one of the handy solutions to work on the ripeness of the dirt.

1.2.3 Benefits of Biofertilizers:

- Biofertilizers are method for fixing the supplement accessibility in the dirt. For the most part Nitrogen insufficiencies.
- Since a bio-manure is actually living, it can cooperatively connect with plant roots. Included microorganisms could promptly and securely convert complex natural material into basic mixtures, so they are handily taken up by the plants. Microorganism work is in long length, causing improvement of the dirt fruitfulness. It keeps up with the regular living space of the dirt.
- It builds crop yield by 15 to 25%, replaces substance nitrogen and phosphorus by 28%, and invigorates plant development. It can likewise give security against dry spell and some dirt borne infections.
- It has additionally been shown that to create a bigger amount of yields, biofertilizers with the capacity of nitrogen obsession and phosphorus solubilizing would prompt the best conceivable impact.
- They advance shoot and root development of numerous harvests versus control groups. This can be significant while carrying out new seed development.
- Biofertilizers additionally advance solid soil, prompting more noteworthy cultivating maintainability.

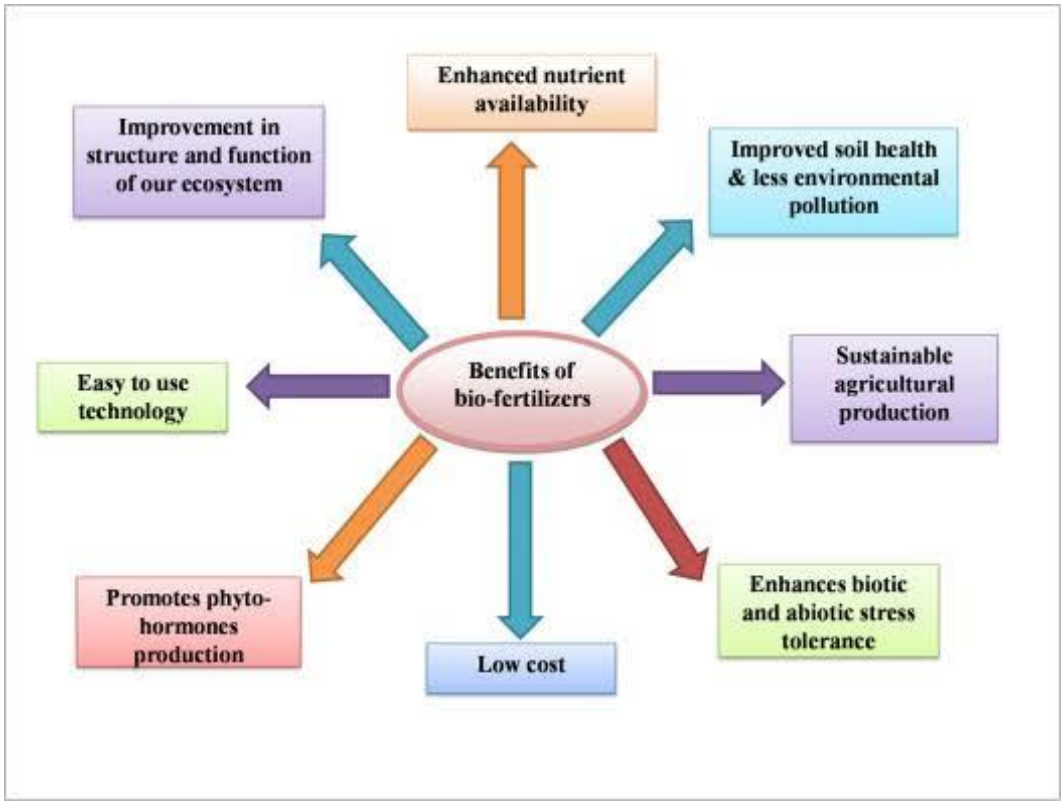


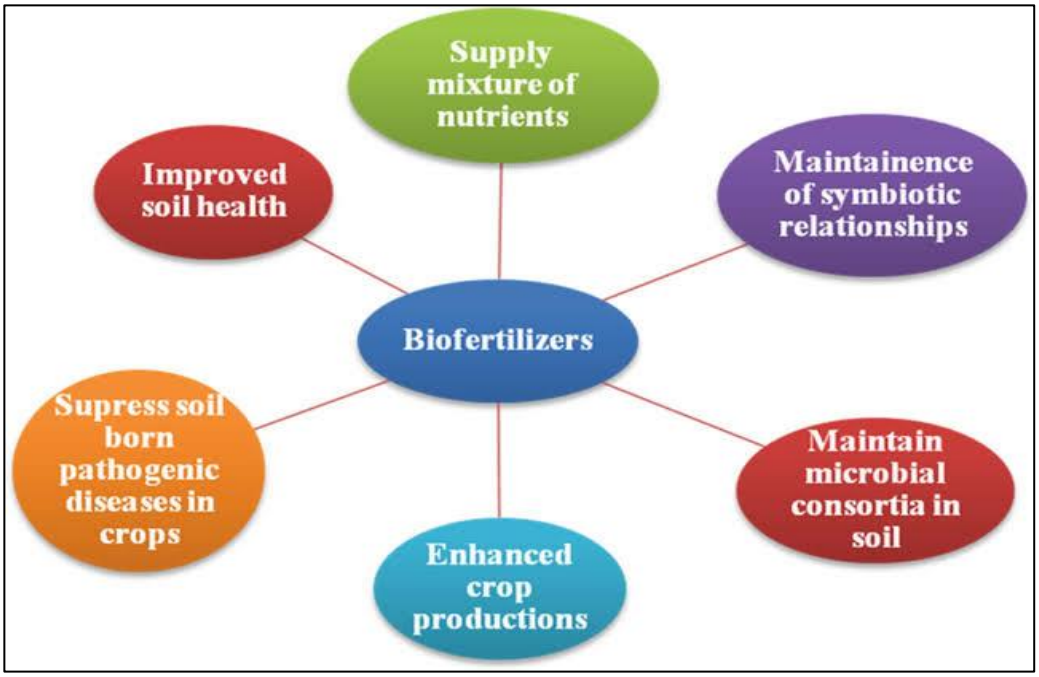
Figure 1.b: Benefits of bio-fertilizer

1.2.4 Application of Biofertilizer:

a. Seed Treatment: Every parcel (200g) of inoculant is blended in with 200 ml of rice slop arrangement. The seeds needed for one hectre are blended in the slurry to have uniform covering of the inoculants over the seeds and afterward conceal dried for 30 minutes. The treated seeds ought to be utilized inside 24 hous. One parcel of inoculant is adequate to treat to 10 kg seeds. *Rhizobium, Azospirillum, Azotobacter*and Phosphobacteria are applied as seed treatment.

b. Seedling Root Plunge: This technique is utilized for relocated harvests. Five bundles (1.0 kg) of the inoculants are needed for one ha and blended in with 40 liters of water. The root part of the seedlings is plunged in the answers for 5 to 10 minutes and afterward relocated. *Azospirillum* is utilized for seedling pull plunge especially for rice.

c. Soil Treatment: 4 kg every one of the suggested biofertilizers are blended in 200 kg of manure and kept for the time being. This blend is joined in the dirt at the hour of planting or planting.



1.3 Cyanobacteria:

These are blue-green microorganisms found in water and ashore. They additionally assist with fixing environmental nitrogen. Models are *Oscillatoria*, *Nostoc*, *Anabaena* and so on the advantageous relationship between the amphibian greenery

Azolla and Anabaena is vital for rice fields. In this affiliation, Anabaena gets carbon and nitrogen from the plant in return for fixed nitrogen. This adds natural make a difference to the dirt upgrading the fruitfulness of rice fields.

1.3.1 Blue Green Algae:

Blue green growth is alluded to as rice life forms as a result of their wealth in the rice field. Numerous species having a place with the genera, Tolypothrix, Nostic, Schizothrix, Calothrix, Anoboenosois and Plectonema are bountiful in tropical conditions. The majority of the nitrogen obsession BGA are filamenters, comprising of chain of vegetative cell including particular cells called heterocyst what work as a micronodule for blend and N fixing apparatus.

1.3.2 Utilization of Blue Green Algae:

- Algal culture is applied as dried chips at 10 kg/ha over the standing water in field rice.
- This is done two days subsequent to relocating in loamy soils and six days in the wake of planting in clayey soils.
- The field is kept water logged for not many days following algal application.
- The biofertilizer is to be applied for 3-4 sequential seasons in a similar field.

Figure 1.c: Blue green algae

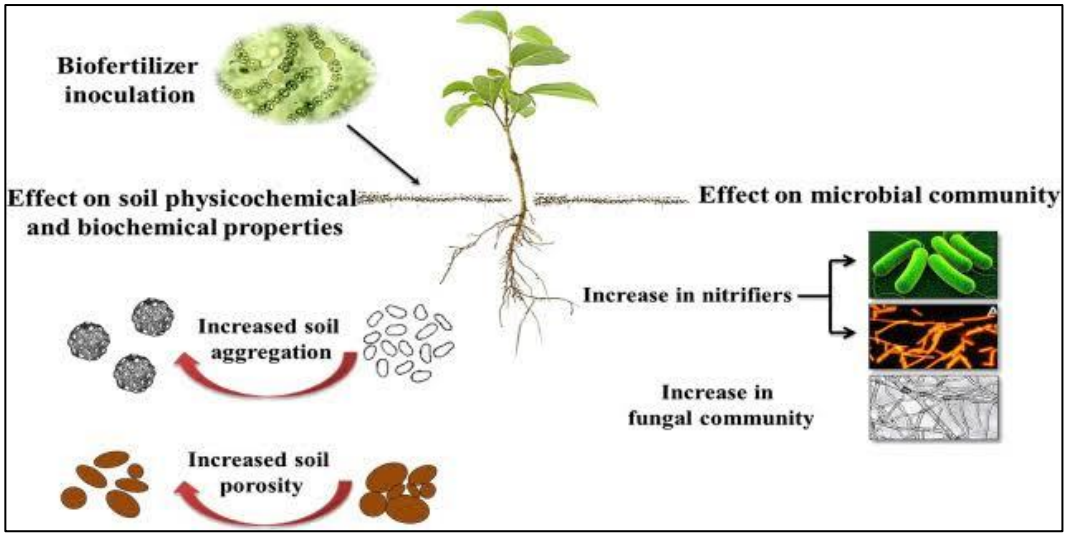


Figure 1.d: Role of green algae in plant

1.4 Azolla:

Azolla is a sort of seven types of oceanic plants in the family Salviniaceae. They are incredibly diminished in structure and specific, looking not at all like other commonplace plants however seriously taking after duckweed or a few greeneries.

Azollafiliculoides is one of only two plant species for which a reference genome has been distributed.

1.4.1 Utilization of Azolla:

a. Green Compost:

Azolla is applied @ 0.6-1.0 kg/m2 (6.25-10.0 t/ha) and fused prior to relocating of rice.

b. Double Yield:

Azolla is applied @ of 100 g/m2 (1.25t/ha), one to three days in the wake of relocating of rice and permitted to increase for 25-30 days. Azolla fronds can be joined into the dirt at the hour of first weeding.

Figure 1.e: Azolla

1.4.2 Fungi:

Advantageous affiliations exist among plants and growths as well. These affiliations are called ‘Mycorrhizae’.

The parasite in this affiliation retains phosphorus from the dirt and gives it to the plant. Plants that develop with these affiliations likewise show other worthwhile qualities, for example,

- Resistance to dry spell conditions and saltiness.
- Protection from root-borne microbes.
- A general expansion in plant development and advancement.

1.5 VAM:

Vesicular - arbascular mycorrhizas whose hyphae penetrate plant calls, producing structures that are either ballon- like (vehicles) or branching invagination as a means of nutrient exchange.

Arbascularmycorrhizal are found in 85% of all plant families and occur in many crop species.

The hyphae of arbascularmycorrhizal fungi produce the glyco - protein glomalin, which may be one of the major stores of carbon in the soil.

1.5.1 VAM Fungi (Vesicular Arbascular Mycorrhizae):

- Fungi formed VAM association with plants may belongs to ascomycetes, basidiomycetes and zygomycetes.
- All VAM fungi are obligate biotrophic, as they are completely dependent on plants for their survival.

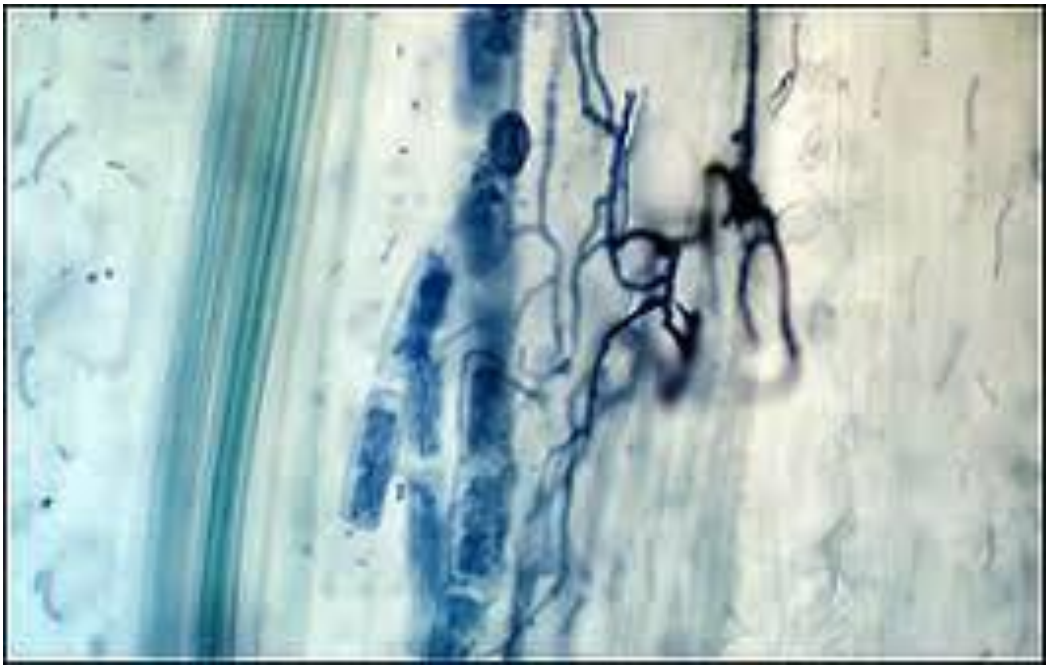


Figure 1.f: VAM fungi (vesicular Arbascular mycorrhizae)

1.6 Ectomycorrhizae:

- Ectomycorrhizal fungi from exchange mechanism outside of the root cells, extracellularly.
- Ectomycorrhizae (ECM) are association, where fungi form a mantle around roots. There is no hyphae penetration of cells. Fungi hypha is generally separate. A distinct Hartig's net is present between the cells.
- Xylem, epidermis, cortex and fungi sheath is present.
- Ectomycorrhizae or abbreviated EcM is a form of symbiotic relationship that occurs between a fungal symbiont, or mycobiont, and the roots of various plant species.

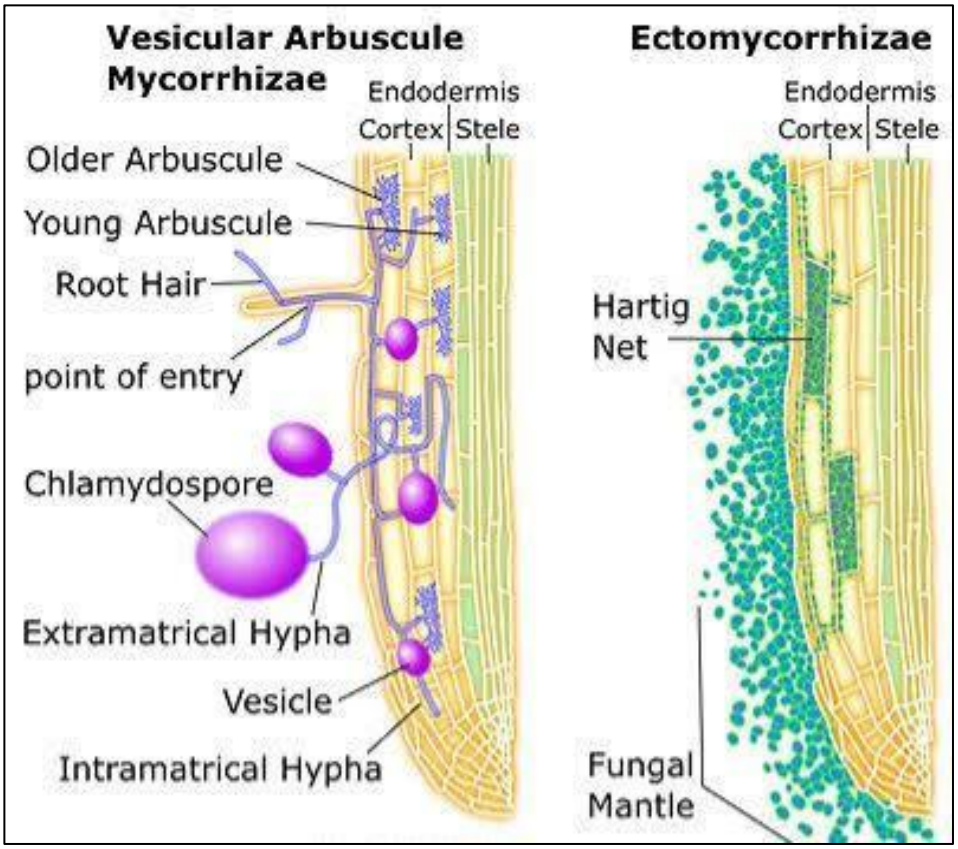


Figure 1.g: Ectomycorrhizae

1.6.1 Application:

- Increase nutrient uptake of plant from soil Nutrition and other elements: N, K, Ca, Mg, Zn, Cu, S, Fe.
- Significant role in nutrient recycling.
- Increase plant resistant to disease and drought.
- Stimulate the growth of beneficial microorganism.
- Increases uptake of water and sulphur from the soil
- Increase the concentration of cytokines and chloroplast in plants and protect plant during stress condition.

1.6.2 Bacteria:

The nitrogen-fixing knobs on the foundations of vegetables. This an extraordinary illustration of biofertilizers.

The knobs are shaped by the relationship of the bacterium 'Rhizobium' with the underlying foundations of these plants. This affiliation is gainful and is, consequently, called 'cooperative'.

The knobs help in fixing environmental nitrogen into natural structures which would then be able to be utilized as sustenance by the plants.

Adding Rhizobium societies to fields has become a typical practice to guarantee a sufficient measure of nitrogen in the dirt.

Different instances of microorganisms that go about as biofertilizers incorporate Azospirillum and Azotobacter. These microbes are free-living in the dirt. Azotobacter is normally utilized with crops like cotton, wheat, mustard, maize, and so on

1.7 Rhizobium:

Rhizobium is somewhat more successful and broadly utilized biofertilizer. Rhizobium, in affiliation mind vegetables, fixes climatic N.

The vegetables and their harmonious relationship with the rhizobium bacterium bring about the arrangement of root knobs that fix environmental N.

Fruitful nodulation of leguminous harvest by rhizobium to a great extent relies upon the accessibility of a viable mess for a specific vegetable.

Rhizobium populace in the dirt is subject to the presence of vegetables crops in field. Without vegetables the number of inhabitants in rhizobium in the dirt reduces.

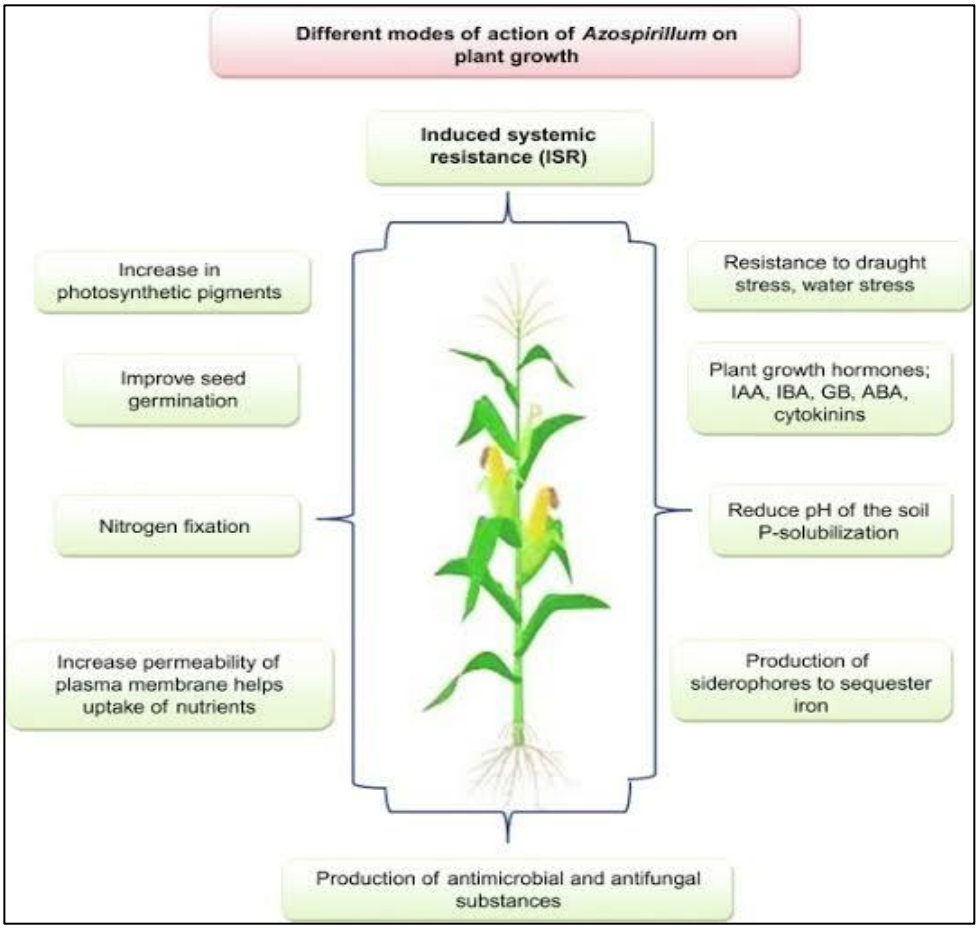
Figure 1.h: Rhizobium

Figure 1.i: Azospirillum

1.8 Azospirillum:

Azospirillum is known to have a nearby cooperative beneficial interaction with the higher plant framework.

These microorganisms have relationship with oats like, sorghum, maize, pearl millet, finger millet, foxtail millet and other minor millets and furthermore grain grasses.



1.9 Azotobacter:

It is a typical soil bacterium. A. chrococcum is available generally in Indian soil. Soil natural matter is the significant factor that chooses the development of this microorganisms.

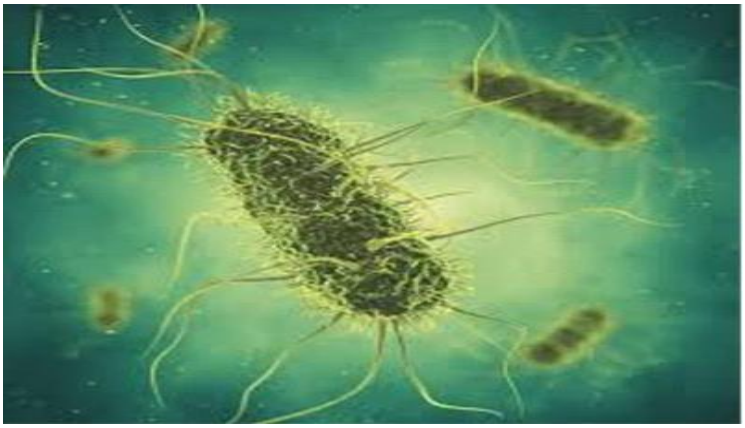


Figure 1.j: Azotobacter

1.10 Phosphate Solubilizing Bacteria:

Different sorts of microbes, purported phosphate-solubilizing microorganisms, for example, *Pantoeaagglomerans* strain or *Pseudomonas putida* strain, can solubilize the insoluble phosphate from natural and inorganic phosphate sources. Indeed, because of immobilization of phosphate by mineral particles like Fe, Al and Ca or natural acids, the pace of accessible phosphate (Pi) in soil is well beneath plant needs. What's more, synthetic Pi composts are additionally immobilized in the dirt, quickly, so that under 20% of added manure is consumed by plants. Along these lines, decrease in Pi assets, on one hand, and natural contaminations coming about because of both creation and utilizations of compound Pi compost, then again, have effectively requested the utilization of phosphate-solubilizing microbes or phosphate biofertilizers.

Figure 1.k: Phosphate solubilizing bacteria

1.10.1 Role of Phosphate Solubilizing Bacteria:

- Increasing the accessibility of other trace elements Fe, Cu, Zn and Mg
- Biocontrol of plant pathogen and production of plant growth hormones.
- Support resistance to abiotic stress and soil aggregation.

1.11 Conclusion:

The Biofertilizer have a significant role in agriculture. The microorganisms play an important role in Biofertilizer. They not only help in the growth of the plant but also the antagonistic effect of the other pathogens on the plant. The algae, fungi, Bacteria have major action in the microbial Biofertilizer. In comparison of chemical fertilizers, the biological fertilizers have major benefits upon the nature. They don't even prevent the pollution of chemical fertilizers but also increase the connection between the ecosystems. The fertilizers also help the plant growth and the soil fertility.

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