Biofertilisers are products that contain microorganisms essential for soil fertility and plant growth when added to the soil. A biofertilizer is a chemical that contains living microorganisms that colonize the rhizosphere or the interior of the plant when given to seeds, plant surfaces, or soil, and encourage growth by controlling the quantity or availability of primary nutrients to the plant host.

Biofertilisers supply nutrients to plants through natural processes such as nitrogen fixation, phosphorus solubilization, and the creation of growth-promoting chemicals. They help restore the soil's natural nutrient cycle and increase soil organic matter.

Healthy plants can be developed with the application of biofertilisers while also improving the soil's sustainability and health. Biofertilisers will likely decrease the need for synthetic fertilizers and pesticides, but they will not be able to completely replace them.

Types of Biofertilisers

Some important types of biofertilisers are as follows:

1. **Symbiotic Nitrogen-Fixing Bacteria**

   The symbiotic nitrogen-fixing bacteria like Rhizobium get food and shelter from the plants and provide them with fixed nitrogen in return. One of the most important symbiotic nitrogen-fixing bacteria is Rhizobium. Bacteria seek shelter and food from plants here. In exchange, they assist the plants by delivering free nitrogen.

2. A Loose Association of Nitrogen-Fixing Bacteria

Some bacteria aren’t related directly with the plants but live around them For example, A nitrogen-fixing bacterium called Azospirillum lives near the roots of higher plants but does not form a close bond with them. This is known as rhizosphere association because these bacteria collect plant exudate and use it as food. Associative mutualism is the name given to this phenomenon.

3. Symbiotic Nitrogen-Fixing Cyanobacteria

There are many symbiotic nitrogen-fixing cyanobacteria like liverworts, cycad roots, the bacteria released by fern plant decay, etc. Cyanobacteria or blue-green algae from a symbiotic relationship with numerous plants. Anabaena can be found in the fern's leaf cavities. It's in charge of nitrogen fixation. The fern plants decompose and release nutrients for the rice plants to use. Azolla pinnata is a fern that grows in rice fields, however, it has no effect on the plant's growth.

4. Free-Living Nitrogen-Fixing Bacteria

Free-living bacteria are found in soil, and they also perform nitrogen fixation. These include clostridium, azotobacter, and bacillus polymyxin.

They are nitrogen-fixing bacteria that live in free-living soil. Clostridium beijerinckii, Azotobacter, and other saprotrophic anaerobes are among them. Rhizobium and Azospirillum are the most extensively utilized forms of biofertilisers.

Components of Biofertilisers

The components of a biofertilizer are:

1. **Bio Compost:** It is eco-friendly and is produced from waste products coming from sugar industry. It also includes bacteria, fungi, and some plants.

2. **Tricho-Card:** This eco-friendly non-pathogenic product is useful for many crops and plants, as it plays the role of a productive destroyer against

the items that are harmful to the crop.

3. **Azotobacter:** It plays an important role in atmospheric nitrogen fixation and protects the plant roots from pathogens in the soil.

4. **Phosphorus:** To settle the exact level of need for nitrogen for a plant, and to determine the nitrogen level of the soil, phosphorus fertilizers are very helpful.

5. **Vermicompost:** Known for quickly improving soil fertility, these are probably the most eco-friendly fertilizers that contain vitamins, sulphur, hormones, organic carbon, and antibiotics required for the growth of the plant.

Importance of Biofertilisers

There are various uses of biofertilisers that prove their importance. They include – improving the soil quality, protecting the plants from pathogens, avoiding environmental pollution, destruction of harmful substances present in the soil, etc. Thus, biofertilisers are very important.

Applications of Biofertilisers

These are some important applications of biofertilisers:

1. **Seedling Root Dip:** Used for rice crops, the seedlings are planted in a waterbed for 8 to 10 hours, in this method.

2. **Seed Treatment:** In this process, the seeds are dipped in nitrogen-phosphorus mixed fertilizers. After drying them, they are planted as early as possible.

3. **Soil Treatment:** The mixture of biofertilisers and compost fertilizers is kept overnight and spread over the soil the next day. This treatment takes place before sowing the seeds.

Disadvantages of Fertilisers

- Chemical fertilizers are supplemented by biofertilisers, not substituted for them.

- Biofertilisers only improve crop productivity by 20 to 30 percent. Unlike chemical fertilizers, they do not result in a significant improvement in productivity.
- For specific crops, specific fertilizers are necessary. This is more applicable to microorganisms that live in a symbiotic relationship. If non-specific Rhizobium is applied as a fertilizer, root nodulation, and crop production will not rise.
- Strict aseptic precautions are required during the manufacture of microbial fertilizer. During microbial mass manufacturing, contamination is a common problem.
- Microbes are killed when exposed to sunlight for an extended period of time because they are light-sensitive.
- When stored at room temperature, microbial fertilizers must be used within six months, and when stored at chilling temperature, it must be used within two years.

Nitrogen Biofertilizers

This group fixes nitrogen symbiotically. Nitrogen biofertilizers help to correct the nitrogen levels in the soil. Nitrogen is a limiting factor for plant growth because plants need a certain amount of nitrogen in the soil to thrive. Different biofertilizers have an optimum effect for different soils, so the choice of nitrogen biofertilizer to be used depends on the cultivated crop. Rhizobia are used for legume crops, Azotobacter or Azospirillum for non-legume crops, Acetobacter for sugarcane and blue-green algae and Azolla for lowland rice paddies.

Phosphorus Biofertilizers

Just like nitrogen, phosphorus is also a limiting factor for plant growth. Phosphorus biofertilizers help the soil to reach its optimum level of phosphorus and correct the phosphorus levels in the soil. Unlike nitrogen biofertilizers, the usage of phosphorus biofertilizers is not dependent on the crops cultivated on the soil. Phosphatika is used for all crops with Rhizobium, Azotobacter, Azospirillum and Acetobacter.

Free-Living Nitrogen-Fixing Bacteria:

They live freely in the soil and perform nitrogen fixation. Some of them are saprotrophic, living on organic remains, e.g., Azotobacter, Bacillus polymyxa, Clostridium, Beijerinckia. They are further distinguished into aerobic and anaerobic forms.

The property of nitrogen fixation is also found in photoautotrophic bacteria, e.g., Rhizobium, Rhodopseudomonas, Rhodospirillum, Chromatium. Inoculation of soil with these bacteria helps in increasing the yield and cutting down on nitrogen fertilizers. For example, Azotobacter occurring in fields of cotton, maize, jowar and rice not only increases the yield, but also cuts down on nitrogen fertilizer to about 10–25 kg/ha. Its inoculant is available under the trade name of Azotobactrin.

Rhizobia are soil bacteria which are able to colonize the legume roots and fix the atmospheric nitrogen symbiotically. The morphology and physiology of rhizobia will vary from free-living conditions to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of fixed nitrogen. There are seven genera that are highly specific in forming nodules in legumes, referred to as a cross-inoculation group.

Azotobacter is a genus of heterotrophic free-living nitrogen-fixing bacteria present in alkaline and neutral soils. It is aerobic in nature, recommended for non-leguminous crops like paddy, millets, cotton, tomato, cabbage and other monocotyledonous crops. Azotobacter also produces growth-promoting compounds. Azotobacter performs well if the soil organic matter content is high. Response to

Azotobacter has been seen in rice, maize, cotton, sugarcane, pearl millet, vegetable and some plantation crops.

Free-Living Nitrogen-Fixing Cyanobacteria:

A number of free-living cyanobacteria, or blue-green algae, have the property of nitrogen fixation, e.g., Anabaena, Nostoc, Aulosira, Totypothrix, Cylindrospermum, Stigonema. Cyanobacteria are photosynthetic microorganisms. Therefore, they add organic matter as well as extra nitrogen to the soil. These chlorophyll-containing prokaryotic organisms fix atmospheric nitrogen.

Aulosira fertilissima is considered to be the most active nitrogen fixer of rice fields. Cylindrospermum licheniforme grows in sugarcane and maize fields. Cyanobacteria are extremely low-cost biofertilisers. Phosphate, molybdenum and potassium are supplied additionally.

Symbiotic Nitrogen-Fixing Cyanobacteria:

Nitrogen-fixing cyanobacteria (blue-green algae) form symbiotic associations with several plants, e.g. cycad roots, liverworts, Azolla (fern), and lichenized fungi. Azolla is an aquatic floating fern, found in temperate climate suitable for paddy cultivation. The fern appears as a green mat over water, which becomes reddish due to excess anthocyanin pigmentation. The blue-green algae, cyanobacteria (Anabaena azollae), present as a symbiont with this fern in the lower cavities actually fixes atmospheric nitrogen.

Azolla pinnata is a small free-floating fresh water fern which multiplies rapidly, doubling every 5–7 days. The fern can coexist with rice plants because it does not interfere with their growth.

Anabaena azollae resides in the leaf cavities of the fern. It fixes nitrogen. A part of the fixed nitrogen is excreted in the cavities and becomes available to the fern. The decaying fern plants release this nitrogen for utilization by the rice plants. When a field is dried up at the time of harvesting, the fern functions as green manure, decomposing and enriching the field for the next crop.

Microphos Biofertilizers:

They release phosphate from bound and insoluble states, e.g., Bacillus polymyxa, Pseudomonas striata, Aspergillus species.

Mycorrhiza (Pl. Mycorrhizae, Frank, 1885):

The mycorrhiza is a mutually beneficial or symbiotic association of a fungus with the root of a higher plant. The most common fungal partners of mycorrhiza are Glomus species. Mycorrhizal roots show a sparse or dense wooly growth of fungal hyphae on their surface. Root cap and root hairs are absent.

Mycorrhiza is a potential biofertilizer which mobilizes P, Fe, Zn, B and other trace elements. It supplies moisture from far-off inches and is ideal for long duration crops. It can be stored up to 2 years and is dry powder resistant.

Depending upon the residence of the fungus, mycorrhizae are of two types— ectomycorrhiza and endomycorrhiza.

Ectomycorrhiza(= Ectotrophic Mycorrhiza):

The fungus forms a mantle on the surface of the root. Internally, it lies in the intercellular spaces of the cortex. The root cells secrete sugars and other food ingredients into the intercellular spaces that feed the fungal hyphae. The exposed fungal hyphae increase the surface of the root to several times. They perform several functions for the plant as follows:

- Absorption of water,
- Solubilisation of organic matter of the soil humus, release of inorganic nutrients, absorption and their transfer to root,
- Direct absorption of minerals from the soil over a large area

and handing over the same to the root. Plants with ectomycorrhiza are known to absorb 2–3 times more of nitrogen, phosphorus, potassium and calcium,

❖ The fungus secretes antimicrobial substances which protect the young roots from attack of pathogens. Ectomycorrhiza occurs in trees such as Eucalyptus, oak (Quercus), peach, pine, etc. The fungus partner is generally specific. It belongs to Basidiomycetes.

Endomycorrhiza (Endotrophic Mycorrhiza):

Fewer fungal hyphae lie on the surface. The remaining live in the cortex of the root, mostly in the intercellular spaces with some hyphal tips passing inside the cortical cells, e.g., grasses, crop plants, orchids and some woody plants. At the seedling stage of orchids, the fungal hyphae also provide nourishment by forming nutrient-rich cells called pelotons. Intracellular growth occurs in order to obtain nourishment because, unlike ectomycorrhiza, the cortical cells do not secrete sugars in the intercellular spaces.

Vesicular Arbuscular Mycorrhizal (VAM) fungi possess special structures known as vesicles and arbusculars. VAM fungi are intercellular, obligate endosymbionts and, on establishment on the root system, act as an extended root system. Besides harvesting moisture from deeper and faraway nitches in the soil, they also harvest various micronutrients and provide them to the host plants. VAM facilitates the phosphorus nutrition by not only increasing its availability, but also increasing its mobility. VAM are obligate symbionts and improve the uptake of Zn, Co, P and H2O. Its large-scale application is limited to perennial crops and transplanted crops. A single fungus may form a mycorrhizal association with a number of plants, e.g., Glomus.