ISBN: 978-93-94570-62-7

7. Microbes in Agriculture

Krishna Kumar Verma

Assistant Professor,
Department of Microbiology,
D. L. S. P.G. College,
Bilaspur Chhattisgarh.

Akhilesh Tiwari

Assistant Professor,
Department of Biotechnology,
Pandit Shambhunath Shukla University,
Shahdol Madhya Pradesh.

Abstract:

In agriculture, the soil is the basis of plant production and the microorganisms play a crucial role in forming the connection between the plant and the soil, so the microorganisms are very necessary to improve the quality of the soil for the growth of healthy plants.

Soil microorganisms are dynamic components of soil and perform many useful functions in the soil system. Biological transformations such as organic matter conversion and biological nitrogen fixation help microorganisms.

Apart from that, they help increase the availability of nutrients for plants. In general, one gram of soil with over 90 million bacteria helps plants absorb nutrients by easily converting unavailable nutrients into available nutrients. Microorganisms are very beneficial for plant growth from an agricultural point of view.

Biological stress is a major problem for farmers today, as an increase in the human population causes soil degradation and a declining microbial population. Ultimately, the use of hybrid seeds, high-yielding varieties, fertilizers, and frequent watering adversely affect plant growth. Therefore, this chapter describes the role of microorganisms in crop production.

Keywords:

Biological nitrogen fixation, fertilizers, biological transformation.

7.1 Introduction:

In modern agriculture, along with the use of hybrid seeds, high yielding varieties, chemical fertilizers and regular irrigation, the use of microorganisms as natural fertilizers is becoming the most popular field of agriculture in the present era. The harmful effects and high cost of chemical fertilizers make them unsuitable for agriculture.

It is estimated that by 2020, 28.8 million tons of nutrients are needed to produce 321 million tons of food grains. However, the amount of nutrients available is 21.6 million tons. There is a huge gap of 7.2 million tons between nutrient intake and elimination (Kalsoom *et al*., 2020).

Agricultural soil productivity can also be enhanced by soil microorganisms. Today, people use natural microorganisms to produce organic products that recycle nutrients and respect the environment (Vyas *et al.,* 2017).

Microorganisms are an integral part of soil and contribute to soil and plant health. Microorganisms can fix atmospheric nitrogen, solubilize and mobilize phosphorus, producing antibiotics and disease-fighting molecules. Due to these properties, they are used in agriculture as bio-fertilizers and bio-pesticides (Vyas *et al.*, 2017). Thus, we can say that microorganisms can improve crop nutrition and the ability of crops to resist biotic and abiotic stress. Thus, greater utilization of microorganisms in agricultural systems has the potential to allow reductions in the use of inorganic fertilizers, water, herbicides, and pesticides.

The biological role of microbes in agriculture

Biocontrol agents ← → **Biofertilizers**

7.2 Microbes as Biocontrol Agents:

Biocontrol agents are those organisms that are employed to control some harmful organisms like pests of plants.

Need for bio pesticides - presently pest control is generally done by the use of chemical pesticides and the trends are increasing year after year. These chemical pesticides are divided into several categories like weedicides, insecticides, rodenticides, etc. (Ruiu, 2018). But non-judicious use of these chemical pesticides has several ill effects;

- Improper use of pesticides may damage the crop and even useful flora and fauna of the area. So may decrease the production and neutrality of crops.
- These encourage the development of resistant strains.
- These kill both useful and harmful organisms indiscriminately.

So there is an urgent need for biological control to replace or supplement chemical control so that the ill-effect of chemical pesticides is reduced. These bio pesticides are of biological origin and again divided into categories like bio herbicides, bio insecticides, etc. Biological control involves the natural predation of pests. These have the following benefits;

a. These are non-persistent, non-toxic, and biodegradable.
b. These do not eradicate the pests but keep them at a manageable level through food chains and food webs so that the survival of beneficial predatory and parasitic insects is ensured. So these maintain the biodiversity and stability of the ecosystem.
c. These reduce our dependency on toxic chemical pesticides and decrease the chance of environmental pollution and degradation.

So, biocontrol involves a holistic approach. Examples;

A. Bio herbicides (Living organisms that control the weeds) (Radhakrishnan *et al.*, 2018)

a. The first bio herbicide was developed in 1961 and it was a mycoherbicide derived from a fungus ***Phytophthora palmivora*** which controls the growth of milkweed virus in citrus orchads.

b. Cohineal insect (***Cactoblastis cactorum***) is another example of bio pesticides which is used to control the growth of cacti.
c. **"Devine"** and **"Collego"** (fungal spore product) are recently used to control weeds.

B. Bio insecticides (Living organisms that control the pests) (Koul, 2011).

a. Lady bird beetle (Cocci Nella) – controls aphids
b. Dragonflies (sympetrum) – control mosquito hawk
c. Baculoviruses *Nucleopolyhedro* virus, *Entomopox* virus (for controlling grasshopper)
d. *Bacillus thuringiensis* – Produce **thurioside** and **Cry protein** (Kill larvae of some insects)
e. *Beauveria bassiana* – control forestry pests.

7.2 Microbes as Biofertilizers:

Constant leaching and harvesting of crops deprive the soil of mineral content. It is estimated that different crops in India remove about 4.27 million tonnes of Nitrogen, 2.13million tonnes of phosphorus, 7. 42 million tonnes of potassium, and 4.8 million tonnes of calcium every year. The total consumption of fertilizers in India was about 1.98 million tonnes in the year 1969-70.

Which increased to more than 16.80 million tonnes till now. Fertilizers are inorganic materials containing elements in the form of soluble or readily available chemical compounds. In common, fertilizers are sometimes called chemical or artificial, or inorganic manures (Nosheen *et al.*, 2021)

7.2.1 The Ill Effects of Chemical Fertilizers:

a. These are expensive.
b. Their manufacture depends upon the dwindling resources of energy.
c. Their production releases pollutants.
d. These are lost readily when applied in the field by surface run-off and thus pollute soil and other water resources.

Biofertilizers are organisms that can bring about soil nutrient enrichment. The main sources of biofertilizers are bacteria, cyanobacteria, and fungi (Fuentes-Ramirez *et al*., 2005; Rao, 1982).

a. **Legume – Rhizobium symbiosis**: - Rhizobium fixes nitrogen in the presence of leghaemoglobin and nitrogenase enzyme by using the nitrogen fixing gene (nif). Rhizobium show species-specific symbiotic relationships with the member of the family Leguminosae (*R. meliloti* with alfalfa group, *R. legumiosarum* with pea group, *R. phaseoli* with bean group, etc.)
b. **A loose association of nitrogen-fixing bacteria**: - *Azospirillum lipoferum* has been reported in Brazilian grasses and maize.
c. **Free-living bacteria: -** *Azotobactor* and *Beijerinckia* (Obligatory aerobes), *Clostridium* (Obligatory anaerobes), *Rhodospirillium* and *Chromatium* (Photosynthetic).
d. **Azolla-Anabaena symbiosis: -** Among the symbiotic cyanobacteria *Anabaena azollae* occurs as an endophyte in the leaves of *Azolla pinnata*.
e. ***Anabaena cycadae*:** These cyanobacteria live in the coralloid roots of gymnosperm *Cycas*.
f. **Anabaena and Nostoc –** free living cyanobacteria.
g. **Mycorrhizae** – It refers to the symbiotic association between the fungus and roots of higher plants such as Ectomycorrhizae, Endomycorrhizae, and VAM (vesicular-arbuscular mycorrhizae).

Table 7.1: List of some Biofertilizers

Biofertilizers	Target crops
Rhizobium	Leguminous crops
Azotobacter	Wheat, Maize, Cotton, Mustard, and Vegetables
Azospirillum	Cereals crops and Sugarcane
Cyanobacteria	Rice
Azolla	Rice
VAM	Nursery raised crops and orchard trees

(Anand and Masthihole, 2020)

Table 7.2: Nitrogen-Fixing Bacteria

Category	Example
Symbiotic	Rhizobium – legume symbiosis Rhizobium – Parasponia (non-legume) symbiosis Frankia- Trees (e.g. Alder, Casuarina) Azolla- Anabaena Azotobacter paspali – Paspalum notatum
Free living	
Aerobic	Azotobacter Beijerinckia Cyanobacteria (e.g. Nostoc, Anabaena, Tolypothrix, Aulosira)
2.Facultative	Klebsiella pneumoniae Bacillus polymyxa
3. Anaerobic	Clostridium Desulfovibrio Rhodospirillum Rhodospeudomonas Desulfotomaculum Desulfovibrio Chromatium Chlorobium
Associative	Azospirillum Herbaspirillum Acetobacter Diazotrophicus Azoarcus

(Anand and Masthihole, 2020)

7.3 Bibliography:

1. Anand, B. Masthihole, D. L. (2020). *Organic Farming*. Agrimoon.
2. Fuentes-Ramirez, L. E., Caballero-Mellado, J. (2005). Bacterial biofertilizers. *PGPR: Biocontrol and biofertilization*, 143-172.
3. Rao, N. S. S. (1982). *Biofertilizers in agriculture*. AA Balkema.
4. Nosheen, S., Ajmal, I., Song, Y. (2021). Microbes as biofertilizers, a potential approach for sustainable crop production. *Sustainability*, *13*(4), 1868.
5. Ruiu, L. (2018). Microbial bio pesticides in agroecosystems. *Agronomy*, *8*(11), 235.
6. Koul, O. (2011). Microbial bio pesticides: opportunities and challenges. *CAB Rev*, *6*, 1-26.Radhakrishnan, R., Alqarawi, A. A., Abdallah, E. F. (2018). Bioherbicides: Current knowledge on the we
7. ed control mechanism. *Ecotoxicology and environmental safety*, *158*, 131-138.
8. Kalsoom, M., Rehman, F. U., Shafique, T. A. L. H. A., Junaid, S. A. N. W. A. L., Khalid, N., Adnan, M., Ali, H. (2020). Biological importance of microbes in agriculture, food and pharmaceutical industry: A review. *Innovare Journal Life Sciences*, *8*(6), 1-4.
9. Vyas, R. V., Panpatte, D. G., Jhala, Y. K., Shelat, H. N. (2017). Wonders of microbes in agriculture for productivity and sustainability. In *Microorganisms for Green Revolution* (pp. 1-23). Springer, Singapore.