**MODERN AGRICULTURAL PRACTICES; USE OF BIOFERTILIZERS**

**INTRODUCTION**

It is estimated that more than 100 million tons of fixed nitrogen are needed for global food production. The use of chemical or synthetic fertilizers is the common practice to increase crop yields. Besides the cost factor, the use of fertilizers is associated with environmental pollution.

Scientists are on a constant look for alternate, cheap and environment- friendly sources of nitrogen and other nutrients for plants. The term biofertilizers is used to refer to the nutrient inputs of biological origin to support plant growth. This can be achieved by the addition of microbial inoculants as a source of biofertilizers.

As the population is increasing day by day, especially in developing countries like India, the stress on agriculture is also increasing continuously. With the development, the land area under farming is not increasing but decreasing and this has posed extra burden for agriculture. Therefore, the land available for agriculture should be economically utilized for maximum results.

Most of our agricultural lands are deprived of either one mineral or the other. These minerals are essential for the growth and development of plants. One of the nutrients for any type of plant is nitrogen. Nitrogen is a major element required by the plant for growth and development. The nitrogen is provided in the form of chemical fertilizer. Such chemical fertilizers pose health hazards and pollution problem in soil besides these are quite expensive, bringing the cost of production much higher. Therefore, biofertilizers are being recommended in place of chemical fertilizers. Biofertilizers are the formulations of living microorganisms, which either are able to fix atmospheric nitrogen in the available form for plants (nitrate form) by living freely in the soil or associated symbiotically with plants.

Although nitrogen fixers are present in the soil, enrichment of soil with effective microbial strains is much beneficial for the crop yields. Use of composite biofertilizers can increase soil fertility. It has been proved that biofertilizers are cost effective, cheap and renewable source to supplement the chemical fertilizers.

**BIOFERTILIZERS**

Microorganisms employed to enhance the availability of nutrients, *viz*., nitrogen (by fixing atmospheric N2) and phosphorous (solubilizing soil phosphorous), to the crops are called biofertilizers. Of these, biological nitrogen fixation offers an economically attractive and ecologically sound route for augmenting nutrient supply. A biofertilizer is a substance which contains living microorganisms which, when applied to seed, plant surfaces, 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. Thus various species of *Rhizobium* for legumes, blue-green algae or cynobacteria and *Azolla* for wet land rice, and *Azotobacter* or *Azospirillum* for several crops can play significant role in agriculture. On the other hand, the phosphatic biofertilizers, including the bacteria, *Thiobacillus, Bacillus,* etc. and the mycorrhizal fungus *Glomus* help in increasing the solubility or availability of nutrient Phosphorous, which is already present in the soil in sparingly soluble forms. These microorganisms, however, do not bring in Phosphorous from outside. Therefore, in a way, they deplete the soil Phosphorous reserves but considering the low utilization efficiency of phosphatic fertilizers, P-solubilizing biofertilizers can play an important role in improving the efficiency of utilization of Phosphorous residues left in the soil.

Biofertilizers broadly includes the following categories:-

* Symbiotic Nitrogen Fixers
* Asymbiotic Nitrogen Fixers
* Phosphate Solubilising Bacteria
* Organic Fertilizers.

**SYMBIOTIC NITROGEN FIXERS**

The diazotrophic microorganisms are the symbiotic nitrogen fixers that serve as biofertilizers. E.g. *Rhizobium* sp and *Bradyrhizobium* sp. Many attempts are being made to genetically modify the symbiotic bacteria for improving nitrogen fixation.

**Green manuring**

It is a farming practice wherein the leguminous plants which are benefited by the symbiotic nitrogen fixing bacteria are ploughed into the soil and a non-leguminous crop is grown to take benefits from the already fixed nitrogen. Green manuring has been in practice in India for several centuries. It is a natural way of enriching the soil with nitrogen, and minimizing the use of chemical fertilizers. *Rhizobium* sp can fix about 50-150 Kg nitrogen/hectare/annum.

**Rhizobium**

It is a symbiotic nitrogen fixing bacterium living in the soil. It is gram negative, motile, aerobic, and rod – shaped. Rhizobium associated with root nodules of legumes can fix atmospheric nitrogen. *Rhizobium* inoculants are used for leguminous crops, mostly for papilionidae members. *Rhizobium* plays a very important role in agriculture by inducing nitrogen – fixing nodules on the roots of legumes such as peas, beans, clover and alfalfa. This symbiosis can relieve the requirements for added nitrogenous fertilizer during the growth of leguminous crops. The rhizobia invade plant roots and induce a nodule in which the bacteria reduce atmospheric nitrogen to ammonia and supply the plant with nitrogenous compounds. Only one non – legume, the woody plant Parasponia species, can be nodulated by and utilized nitrogen fixed by the bacteria.

**Azolla**

* *Azolla* is an aquatic fern, which contains an endophytic cynobacterium *Anabaena azollae* in the leaf cavities providing a symbiotic relationship. *Azolla* with *Anaebaena* is useful as a biofertilizer. But due to certain limitation, the use of *Azolla* has not become popular. *Anabaena* in association with water fern *Azolla* contributes nitrogen up to 60 Kg/ha/season and also enriches soils with organic matter.
* *Azolla* plant requires adequate supply of water.
* It can be easily damaged by pest diseases.
* *Azolla* cultivation is labour intensive.

**ASYMBIOTIC NITROGEN FIXERS**

The asymbiotic nitrogen-fixing bacteria can directly convert the gaseous nitrogen-to-nitrogen-rich compounds. When these asymbiotic nitrogen fixers die, they enrich the soil with nitrogenous compounds, and thus serve as biofertilizers e.g. *Azotobacter* sp, *Azospirillum* sp.

**Blue-green algae (cynobacteria)**

Blue-green algae multiply in water logging conditions. They can fix nitrogen in the form of organic compounds. The term algalization is used to the process of cultivation of blue-green algae in the field as a source of biofertilizer.

Blue-green algae, besides fixing nitrogen, accumulate biomass, which improves the physical properties of the soil. This is useful for reclamation of alkaline soils besides providing partial tolerance to pesticides. Cynobacteria are particularly useful for paddy fields. The most common blue-green algae are *Azotobacter* sp and *Azospirillum* sp.

**Azotobacter**

It is a free-living, heterotrophic, nitrogen fixing bacteria and it is an obligate aerobic bacteria. *Azotobacter* is the most studied and best example of free living aerobic nitrogen fixers. *Azotobacter* can be used with crops like wheat, maize, mustard, cotton, potato and other vegetable crops. It is used for nitrogen fixation and inoculation of plants due to its rapid growth and high level of nitrogen fixation. Through *Azotobacter* inoculation yield increased ranges from 2-45% in vegetables, 9-24% in sugar cane, 0-31% in maize, sorghum, mustard etc. Research on *A.chrococcum* species in crop production has manifested it significance in plant nutrition and its contribution to soil fertility. Being, soil bacteria Azotobacteria genus synthesizes auxins and cytokinins and these growth materials are the primary substances controlling the enhanced growth.

**Azospirillum**

It is a free-living, heterotrophic nitrogen fixing bacteria and it is an obligate aerobic bacteria. It is a gram negative motile bacteria. Azospirillum inoculats are mostly recommended for sorghum, millets, maize, sugar cane and wheat. *Azospirillum* is nitrogen fixing bioinoculant suitable for all crops except legumes. *Azotobacter* and *Azospirillum* are also used as biofertilizers in a combined form of both. It is a plant growth promoting bacteria. It was shown to exert beneficial effect on plant growth and crop yield.

**PHOSPHATE SOLUBILIZING BACTERIA**

Phosphate solubilizing microbes (PSB) are an aggregation of helpful microscopic organisms capable of hydrolyzing natural and inorganic phosphorus from insoluble compounds. Phosphorus (P) is one of the major fundamental macronutrients for plants and is applied to soil as phosphate biofertilizer.

**ORGANIC FERTILIZERS**

There are several organic wastes, which are useful as fertilizers. These include animal dung, urine, urban garbage, sewage, crop residues and oil cakes. A majority of these wastes remain unutilized as organic fertilizers. There exist a good potential for the development of organic manures from these wastes.

**USE OF BIOFERTILIZERS**

* Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphate and stimulating plant growth through the synthesis of growth-promoting substances.
* The microorganism in bio-fertilizers restores the soil’s natural nutrient cycle and builds soil organic matter.
* Through the use of biofertilizers, healthy plants can be grown while enhancing the sustainability and health of the soil.
* They are extremely advantageous in enriching soil fertility and fulfilling plant nutrient requirements by supplying the organic nutrients through microorganisms and their byproducts.

**BENEFITS**

* Microorganisms in biofertilizers could readily and safely convert complex organic material in simple compounds, so that plants are easily taken up. Microorganism function is in long duration, causing improvement of the soil fertility. It maintains the natural habitat of the soil. It increases crop yields by 20-30% replaces chemical nitrogen and phosphorous by 25% and stimulates plant growth. It can be also provide protection against drought and some soil-borne diseases.
* Bio-fertilizers are cost-effective relative to chemical fertilizers. They have lower manufacturing costs, especially regarding nitrogen and phosphorous use.
* Fertility of the soil is increased year after year.
* Free from environmental pollution.
* Besides nutrient supply, some other compounds, which promote plant growth, are also produced.e.g. Plant growth hormones, antibiotics.
* Biofertilizers increase physico-chemical properties of the soil, soil texture, and water holding capacity.
* Reclamation of saline or alkaline soil is possible by using biofertilizers.
* Biofertilizers improve the tolerance of plants against toxic heavy metals.
* Plants can better withstand biotic and abiotic stresses and improve in product yield.

**LIMITATIONS**

* Biofertilizers cannot meet the total needs of the plant for nutrient supply.
* They cannot produce spectacular results, as is the case with synthetic fertilizers.

Considering the advantages and disadvantages of biofertilizers, a realistic and pragmatic approach can be adopted, that is, to use combination of biofertilizers and synthetic fertilizers for optimum crop yield.