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Biofertilizers for Crop Production and Soil Fertility

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In nature, there are a number of useful soil micro-organisms which can help plants to absorb nutrients. Their utility can be enhanced with human intervention by selecting efficient organisms, culturing them and adding them to soils directly or through seeds. The cultured micro-organisms packed in some carrier material for easy application in the field are called bio-fertilizers. Thus, the critical input in biofertilizers is the micro-organisms (Ajmal, 2018). Biofertilizer is a material which contains 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 (Sharma *et al*., 2022). Bio-fertilizer is technically living; it can be mutually beneficial in association with plant roots. Involved microorganisms could easily convert complex organic material into simpler compounds in order for plants to easily absorb them. It retains the natural habitat of the soil. Growth increases by 20-30%, substitute's chemical nitrogen and phosphorus by 25%, and enhances the plant growth. It can impart protection adverse to drought and some soil borne diseases. Biofertilizers are ready to use live composition of beneficial microorganisms, when it revised to seed, root or soil, it induces the availability and utility of the microorganisms and thus enhances the soil health (Antoun, 2012).

Benefits of biofertilizers

Bio-fertilizers are living microorganisms of bacterial, fungal and algal origin. Their mode of action differs and can be applied alone or in combination.

- Biofertilizers fix atmospheric nitrogen in the soil and root nodules of legume crops and make it available to the plant.
- They solubilise the insoluble forms of phosphates like tricalcium, iron and aluminium phosphates into available forms.
- They scavenge phosphate from soil layers.
- They produce hormones and anti-metabolites which promote root growth.
- They decompose organic matter and help in mineralization in soil.
- When applied to seed or soil, biofertilizers increase the availability of nutrients and improve the yield by 10 to 25% without adversely affecting the soil and environment.

Types and features of biofertilizers

Based on type of microorganis m, the bio-fertilizer can also be classified as follows:

- **Bacterial Biofertilizers**: e.g. Rhizobium, Azospirilium, Azotobacter, Phosphobacteria.

- **Fungal Biofertilizers**: e.g. Mycorrhiza
- **Algal Biofertilizers**: e.g. Blue Green Algae (BGA) and Azolla.
- **Actinomycetes Biofertilizer**: e.g. Frankia.

Bio-fertilizer are mostly cultured and multiplied it the laboratory. However, blue green algae and azolla can be mass-multiplied in the field.

Characteristics Features of common Biofertilizers

- **Rhizobium:** Rhizobium is relatively more effective and widely used biofertilizer. Rhizobium, in association with legumes, fixes atmospheric N. The legumes and their symbiotic association with the rhizobium bacterium result in the formation of root nodules that fix atmospheric N. Rhizobium population in the soil is dependent on the presence of legumes crops in field. In the absence of legumes, the population of rhizobium in the soil diminishes (Basu *et al*., 2021).
- **Azospirillum:** Azospirillum is known to have a close associative symbiosis with the higher plant system. These bacteria have association with cereals like; sorghum, maize, pearl millet, finger millet, foxtail millet and other minor millets and also fodder grasses.
- **Azotobacter:** It is a common soil bacterium. *A. chrococcum* is present widely in Indian soil. Soil organic matter is the important factor that decides the growth of this bacteria.
- **Blue Green Algae (BGA**): Blue green algae are referred to as rice organisms because of their abundance in the rice field. Many species belonging to the genera, Tolypothrix, Nostic, Schizothrix, Calothrix, Anoboenosois and Plectonema are abundant in tropical conditions. Most of the nitrogen fixation BGA are filamenters, consisting of chain of vegetative cell including specialized cells called heterocyst which function as a micronodule for synthesis and N fixing machinery.

List of commonly produced bio-fertilizers in India

Name	Crops suited	Benefits usually seen	Remarks
Phosphate Solubilizers	Soil application for all crops	5-30% yield increase	Can be mixed with rock phosphate.
Blue-green algae and Azolla	Rice/wet lands	20 -30 kg N/ha, Azolla can give biomass up to 40-50 tonnes and fix 30-100 kg N/ha	Reduces soil alkalinity, can be used for fishes as feed. They have growth promoting hormonal effects.
Micorrohizae (VAM)	Many trees, some crops, and some ornamental plants	30-50% yield increase, enhances uptake of P. Zn, S and Water.	Usually inoculated to seedlings.
Rhizobium strains	Legumes like pulses, groundnut, soybean	10-35% yield increase, 50-200 kg N/ha.	Fodders give better results. Leaves residual N in the soil.
Azotobacter	Soil treatment for non- legume crops including dry land crops	10-15% yield increase- adds 20-25 kg N/ha	Also controls certain diseases.
Azospirillum	Non-legumes like maize, barley, oats, sorghum, millet, Sugarcane, rice etc	10-20% yield increase	Fodders give higher/enriches fodder response. Produces growth promoting substances. It can be applied to legumes as co-inoculant.

Biofertilizers recommended for crops

- Rhizobium + Phosphotika at 200 gm each per 10 kg of seed as seed treatment are recommended for pulses such as pigeonpea, green gram, black gram, cowpea etc, groundnut and soybean.
- Azotobacter + Phosphotika at 200 gm each per 10 kg of seed as seed treatment are useful for wheat, sorghum, maize, cotton, mustard etc.
- For transplanted rice, the recommendation is to dip the roots of seedlings for 8 to 10 hours in a solution of Azospirillum + Phosphotika at 5 kg each per ha.

Application of biofertilizers to crops

Seed treatment: Each packet (200g) of inoculant is mixed with 200 ml of rice gruel or jaggery solution. The seeds required for one hectre are mixed in the slurry so as to have uniform coating of the inoculants over the seeds and then shade dried for 30 minutes. The treated seeds should be used within 24 hours. One packet of inoculant is sufficient to treat to 10 kg seeds. Rhizobium, Azospirillum, Azotobacter and Phosphobacteria are applied as seed treatment.

Seedling root dip: This method is used for transplanted crops. Five packets (1.0 kg) of the inoculants are required for one ha and mixed with 40 litres of water. The root portion of the seedlings is dipped in the solutions for 5 to 10 minutes and then transplanted. Azospirillum is used for seedling root dip particularly for rice.

Soil treatment: 4 kg each of the recommended biofertilizers are mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

Use of VAM Biofertilizer

- The inoculum should be applied 2-3 cm below the soil at the time of sowing.
- The seeds are sown or cuttings planted just above the VAM inoculums so that the roots may come in contact with the inoculums and cause infection.
- Bulk inoculums of 100gm is sufficient for one meter square area.
- Seedlings raised in the polythene bags need 5-10 g of bulk inoculums for each bag.
- At the time of planting of saplings, VAM inoculums is to be applied at the rate of 20g /seedling in each spot.
- In the existing tree, inoculums of 200g is required for each tree.

Use of Blue Green Algae (BGA)

- Algal culture is applied as dried flakes at 10 kg/ha over the standing water in field rice.
- This is done two days after transplanting in loamy soils and six days after planting in clayey soils.
- The field is kept water logged for few days immediately after algal application.
- The biofertilizer is to be applied for 3-4 consecutive seasons in the same field.

Use of Azolla

- **Green manure:** Azolla is applied @ 0.6-1.0 kg/m^2 (6.25-10.0 t/ha) and incorporated before transplanting of rice.
- **Dual crop:** Azolla is applied @ of 100 g/m^2 (1.25t/ha), one to three days after transplanting of rice and allowed to multiply for 25-30 days. Azolla fronds can be incorporated into the soil at the time of first weeding.

Tips to get good response to biofertilizer application

- Biofertilizer product must contain good effective strain in appropriate population and should be free from contaminating microorganisms.
- Select right combination of biofertilizers and use before expiry date.

- Use suggested method of application and apply at appropriate time as per the information provided on the label.
- For seed treatment adequate adhesive should be used for better results.
- For problematic soils use corrective methods like lime or gypsum pelleting of seeds or correction of soil pH by use of lime.
- Ensure the supply of phosphorus and other nutrients.

Precautions to take while using biofertilizers

- Biofertilizer packets need to be stored in cool and dry place away from direct sunlight and heat.
- Right combinations of biofertilizers have to be used.
- As Rhizobium is crop specific, one should use for the specified crop only.
- Other chemicals should not be mixed with the biofertilizers.
- While purchasing one should ensure that each packet is provided with necessary information like name of the product, name of the crop for which intended, name and address of the manufacturer, date of manufacture, date of expiry, batch number and instructions for use.
- The packet has to be used before its expiry, only for the specified crop and by the recommended method of application.
- Biofertilizers are live product and require care in the storage
- Both nitrogenous and phosphatic biofertilizers are to be used to get the best results.
- It is important to use biofertilizers along with chemical fertilizers and organic manures. Biofertilizers are not replacement of fertilizers but can supplement plant nutrient requirements.

Conclusion

In current agriculture practices, chemical fertilizers have reduced the fertility of soil, making it unsuited for raising crop plants. Additionally, the excessive use of these inputs has also led to severe health and environmental hazards such as soil erosion, water contamination, pesticide poisoning, falling ground water table, water logging and depletion of biodiversity. Biofertilizer spontaneously activates the microorganisms found in the soil in an effective and eco-friendly way, thereby gaining more importance for utilization in crop production, restoring the soils fertility and protecting it against drought, soil diseases and thus stimulate plant growth. Biofertilizers lead to soil enrichment and are suitable with long-term sustainability. Further, they pose no danger to the environment and can be substituted with chemical fertilizers. The application of bio-fertilizers can minimize the use of chemical fertilizers, decreasing environmental hazards, enhance soil structure and promote agriculture. Biofertilizers are cheaper and remarkable in affecting the yield of cereal crops. Bio-fertilizers being important components of organic farming play a key role in maintaining long term soil fertility and sustainability by fixing insoluble P in the soil into forms available to plants, thus increasing their effectiveness and availability. In context of both the cost and environmental impact of chemical fertilizers, excessive reliance on the chemical fertilizers is not a useful strategy in the long run due to the cost, both in domestic resources and foreign exchange; participate in setting up of fertilizer plants and maintaining the production.

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