Bio-Fertilizers: A Source to Improve Soil and Human Health

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Conventional methods of increasing production still rely on using inorganic fertilizers. Because using inorganic fertilizers on a regular basis would not help enhance soil health, it is vital to utilize environmentally friendly fertilizers, including bio-fertilizers. To meet this food demand and ensure food security, it is equally important to ensure food safety for consumption. Food safety measures need to be put in place throughout the food production chain lines. One of the fundamental measures is the use of bio-fertilizers or plant growth promoters instead of chemical or synthesized fertilizers, pesticides and herbicides that poise several dangers to human and animal health.

Nitrogen (N), phosphorus (P) and Potassium (K) are considered as an essential nutrient and a major constituent for all living cells. Although, soil constitute these nutrients but for the production of adequate amount of food there is need of supply of additional nutrient through fertilizers but application of chemical fertilizers has a considerably negative impact on environmental sustainability. Bio-fertilizers are microbial cultures of specific soil micro-organisms that have been intentionally multiplied to increase soil fertility and crop productivity by fixing atmospheric nitrogen, mobilizing or solubilizing the fixed phosphorus and potassium in the soil and root nodules of legume crops and make it available to the plant. Because they are inexpensive and sustainable sources of nutrients for plants, bio-fertilizers offer an economical alternative to chemical fertilizers. It reduces the toxic substances through chemicals to reach the food material as it avoids the application of other toxic chemicals in combination of it. Because they adequately maintain the soil's health and lower environmental pollution by using fewer chemicals, bio-fertilizers are currently very significant.

Importance of bio-fertilizers

Following are the reasons for importance of bio-fertilizers

- Improve the soil texture and yield of plants.
- Eco-friendly and cost effective.
- Protect the environment from pollutants since they are natural fertilizers.
- They do not allow pathogens to flourish.
- Destroy many harmful substances present in the soil that can cause plant diseases.
- Effective even under semi-arid conditions.

Types of Bio-fertilizers

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

- **Bacterial Bio-fertilizers**: e.g. *Rhizobium*, , *Azotobacter, Azospirilium* and *Phosphobacteria*.
- **Fungal Bio-fertilizers**: e.g. *Mycorhiza*
- **Algal Bio-fertilizers**: e.g. Blue Green Algae (BGA) and Azolla.
- **Actinimycetes Bio-fertilizer**: e.g. Frankia

Azotobacter

These bacteria belong to the family of *Azotobacteriaceae*, aerobic, free living, and heterotrophic in nature. They are found in neutral or alkaline soils and *A. chroococcum* are the most common occurring species in arable soils. *A. vinelandii, A. beijerinckii, A. insignis* and *A. macrocytogenes* are other reported species. The population number of *Azotobacter* rarely exceeds of 104 to 105 g^{-1} of soil due to lack of organic matter and presence of antagonistic micro-organisms in soil.

Phosphate solubilizers

These bacterial species has the ability to solubilize insoluble inorganic phosphate compounds, which are tricalcium phosphate, dicalcium phosphate, hydroxyapatite, and rock phosphate. The examples among the bacterial genera with this are *Pseudomonas, Bacillus, Rhizobium*.

Potassium solubilizer

Potassium (K) solubilizing bacteria (KSB) have attracted the attention of agriculturists as soil inoculums to promote the plant growth and yield. The

KSB are effective in releasing K from inorganic and insoluble pools of total soil K through solubilization. K solubilization is done by a wide range of saprophytic bacteria, fungal strains and actinomycetes.

NPK Consortia

It is consortium of rhizobium, azotobacter and acetobacter, phospho bacteria- Psuedomonus and potassium solution- baciles bacteria which are atmospheric nitrogen and phosphorus fixing organisms. NPK consortia has higher efficiency in nitrogen, phosphorus and potassium fixing to the soil and provide it to plants.

Rhyzobium

These bacteraial inoculantions has for the ability of fixing atmospheric nitrogen in association with plants forming nodules in roots stem nodules. RHZ are restricted by their specificity and only certain legumes are benefited from this symbiosis. They are found in Rhizobiaceae, symbiotic in nature that fixes nitrogen 50-100 kg ha^{-1} in association with legumes only.

Vermi-compost and Vermi-composting as a Part of Bio-fertilizer

Vermi-compost may be defined as the product of composting using various worms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermincast. Vermi-composting technology also involves the biological conversion of organic wastes into vermin-casts and sometimes by the utilization of vermiwash utilizing earthworms. These earthworms always feed on the waste and the gut of the worm is the bioreactor where the vermicasts are generally produced.

Mass production of bacterial bio-fertilizer

- Isolated bacterial cultures are subculture into nutrient broth.
- Cultures are grown under shaking condition at 30 ±2 °C
- The culture incubated until it reaches maximum cell population of 1010 to 1011
- Under optimum condition this population level could be attained within 4-5 days for azospirillum and 6-7 days for azotobacter
- The culture obtained in flask is called Starter culture
- For large scale production, inoculum from starter culture is transferred in to large flasks/ fermentor and grown until required level of cell count is reached.

Mass production of fungal bio-fertilizer

- VAM spores are isolated
- These spores are mixed with sterilized soil
- Spore mixed soil is filled in pots
- Host plant is transplanted in pots
- It is kept in green house for 3-4 months
- Soil in the pot along with roots of host plant is moistened
- Dried till it attains 5% moisture
- Dried soil inoculants used for field application.

Carrier materials

The use of carrier material is necessary for good quality production of bio-fertilizers. Generally, farm yard manure, pit soil, lignite, vermiculture, press mud, charcoal and soil mixtures are used as carrier material. An ideal carrier material should be cheaper in cost, easily available, high organic matter content, toxic chemical free and more than 50% water holding capacity and easy to process.

Applications of bio-fertilizers

Seed treatment

Each packet (200 g) of inoculant is mixed with 200 ml of rice gruel or jaggery solution. The seeds required for one hectare are mixed in the slurry so as to have uniform coating of the inoculants over the seeds and then dried for 30 minutes in shed. 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 *Phospho-bacteria* are applied as seed treatment.

Seedling root dip

Five packets (1.0 kg) of the inoculants are required for one hectare and mixed with 40 litre 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 bio-fertilizers are mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

Bio-fertilizers 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.

Case study

Parmar and Sindhu (2013) observed that inoculation of K-solubilizing isolate HWP47 in wheat (*Triticum aestivum* L.) var. WH711 caused 51.46 % increase in root dry weight in soil at 60 days after sowing in pots. Similarly, 44.28 % increase in shoot dry weight was found in HWP47 inoculated plants. Addition of rock material along with inoculation of HWP47 isolate showed 22.35 % increase in root dry weight and 73.68 % increase in shoot dry weight. Isolates HWP15 and HWP47 also caused significant K uptake in the shoot tissues.

Precautions

- Bio-fertilizer packets should be kept in cool and dry place away from sunlight.
- Rhizobium should use for specified crop only.
- Right combination of bio-fertilizers should be used.
- Other chemicals like herbicide, insecticide should not be used with bio-fertilizer.
- 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.

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