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Liquid Microbial Biofertilizers (LMF) for enhancing soil fertility – A Review

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ABSTRACT

The nutrients of biological origin added to the soil to enrich the soil fertility are called biofertilizers. Biofertilizers is a substance contains living microorganisms which promote the adequate supply of nutrients to the host plants and ensure their proper development of growth and regulation in their physiology. Biofertilizer reduce the use of chemical fertilizers in agriculture. They never cause pollution in air, water and land. Indiscriminate synthetic fertilizer usage has polluted the soil, water basins, destroyed micro-organisms and eco-friendly insects, made the crop more susceptible to diseases and depleted soil fertility at the primary levels as of today's scenario is to overcome these problems which is the main reason for this review. On this basis, Microorganisms have been emerged as the potential alternative for the productivity, reliability and sustainability of the global food chain. These review focuses on liquid biofertilizer technology providing reliable reason for their necessity, specificity and emphasizes the use of agriculturally important microorganisms in different combinations i.e., Liquid Microbial Consortium (LMC) is the only solution for restoration of soil health. Biofertilizers supply plant nutrients (NPK) nitrogen, phosphorus and potassium. It can be produced by using renewable wastes.

Keywords: *Biofertilizers, Liquid Microbial Consortium, supply, renewable wastes, plant nutrients, fertility.*

INTRODUCTION

Liquid biofertilizers preparation comprising requirements to preserve organisms and deliver them to the target regions to improve their biological activity (or) a consortium of microorganisms provided with suitable medium to keep up their viability for certain period which aids in enhancing the biological activity of the target site. Liquid formulation is a budding technology in India and has very specific characteristics and uniqueness in its production methods. Liquid biofertilizers are the microbial preparations containing specific beneficial microorganisms which are capable of fixing or solubilizing or mobilizing plant nutrients by their biological activity.

They are broadly classified into three groups.

1. Nitrogen Fixing Microbes (NFM)
2. Phosphorus Solubilizing Microbes (PSM) and Phosphate Mobilizing Microbes and
3. Potash Mobilizing Microbes

Liquid biofertilizer is increasingly available in the market as one of the alternative to chemical fertilizer and pesticide. One of the benefits from biofertilizer is a contribution from population of microorganism available. Traditionally liquid biofertilizer produced from fermentation of effective microorganism (EM) was recommended to be used within three months. Nowadays the production ready to use liquid biofertilizer from EM is becoming available in market.

Liquid bio-fertilizers

Why to produce bio-fertilizers?

In the carrier-based (solid) bio-fertilizers, the microorganisms have a shelf life of only six months. They are not tolerant to UV rays and temperatures more than 30 degrees. The population density of these microbes is only 108 (10 corers) C.f.u/ml at the time of production. This count reduces day by day. In the fourth month it reduces to 106 (10 lakhs) C.f.u/ml and at the end of 6 months the count is almost nil. That's why the carrier-based bio-fertilizers were not effective and did not become popular among the farmers. These defects are rectified and fulfilled in the case of Liquid Bio-fertilizers. The shelf life of the microbes in these liquid bio-fertilizers is two years. They are tolerant to high temperatures (55 degrees) and ultra violet radiations. The count is as high as 109C.f.u/ml, which is maintained constant up to two years. So, the application of 1 ml of liquid bio-fertilizers is equivalent to the application of 1 Kg of 5 months old carrier based Bio-fertilizers (1000 times). Since these are liquid formulations the application in the field is also very simple and easy. They are applied using hand sprayers, power sprayers, festination tanks and as basal manure mixed along with FYM etc.

Other advantages of Liquid Bio-fertilizers:

1. Special cell protectants or substances that encourage formation of resting spores or cysts.
2. Specialized nutrients that ensure longer shelf life, Better survival on seeds and soil andtolerance to adverse conditions.
3. Liquid formation ensures that the product is easy to handle and apply.
4. Organisms are stabilized during production, distribution and storage, the activity is enhanced after the contact and interaction with the target crops.
5. No loss of properties due to storage up to 55 degrees.
6. Greater potentials to fight with native population.
7. Dosages are 10 times lesser than the carrier-based bio-fertilizers.
8. Very high enzymatic activity since contamination is nil.

India is an agricultural based country. In order to feed the ever growing populations, India has to increase the per unit area productivity. According to United Nations, Food and Agriculture Organization (FAO) estimations, the average demand for the agricultural commodities will be 60% higher in 2030 than present time and more than 85% of this additional demand will be from developing countries. For over half a century, the world has relied on the concept of increasing crop yields to supply an ever increasing demand of food. Therefore, vertical expansion of food production is necessary. In order to increase the unit area productivity of agricultural land, the role of different crop nutrients in contributing increased crop yield is vital. Among the crop nutrient, nitrogen as well as phosphorus play an important role in increasing the crop productivity. Further, the nitrogenous chemical fertilizers are manufactured industrially using non-renewable petroleum products under high temperature and high pressure. Increase in petroleum cost day by day effects the cost of the chemical fertilizers. In addition, more than 50% of the applied N-fertilizers are somehow lost through different agricultural processes which not only lead to economical loss to the farmers and polluted environment consequently.

Application of microbialbiofertilizer

Microbial inoculants is not applied properly, the benefits from the biofertilizer may not be obtained. During application one should always remember that the most of the microbial biofertilizers are heterotrophic, i.e. they cannot prepare their own food and depend upon the organic carbon of soil for their energy requirement and growth. So, they either colonise in rhizosphere zone or live symbiotically within the root of higher plants. The bacteria which are colonised in the rhizosphere zone obtain their organic carbon compounds from the root exudes of the higher plants. The symbiotic ones obtain organic carbon directly from the root. So, microbial inoculants must be applied in such a way that the bacteria will be adhered with the root surface. So, in case of transplanting crops, the inoculant are applied through roots, and in case of the crops in which seeds are sown directly in the field, the inoculants are applied through the seeds so that they can colonize in the rhizosphere region when the young roots are emerged after germination of seed. On the basis of the above principal, the following inoculation methods have been developed:

1. Inoculation of the seeds by slurry inoculating technique
2. Inoculation of seeds by seed pelleting technique
3. Inoculation of the seedlings
4. Inoculation of the soil by solid inoculation technique.

Types of Liquid biofertilizers

Bacterial Biofertilizer

***Rhizobium* sp**

Scientific classification

Kingdom	:	Bacteria
Phylum	:	Proteobacteria
Class	:	Alphaproteobacteria
Order	:	Rhizobiales
Family	:	Rhizobiaceae
Genus	:	*Rhizobium*

Rhizobium sp is a soil habitat bacterium, which can able to colonize the legume roots and fixes the atmospheric nitrogen symbiotically. The morphology and physiology of *Rhizobium* will vary from free-living condition to the bacteroid of nodules. They are the most efficient biofertilizer as per the quantity of nitrogen fixed. They have seven genera and highly specific to form nodule in legumes, referred as cross inoculation group. *Rhizobium* inoculant was first made in USA and commercialized by private enterprise in 1930s and the strange situation at that time has been chronicled by Fred (1932). *Rhizobium* is the classical example of symbiotic nitrogen fixing bacteria. The bacteria colonise the legume root and form root nodules (nodular symbiosis) within which molecular nitrogen is reduced to ammonia that is readily utilized by the plant to produce valuable proteins, vitamins and other nitrogen containing compounds. It has been estimated that 40-250 kg N/ha/year could be fixed by the microbial activities of *Rhizobium*for various legume crops. When the plants die the fixed N_2 is released, making it available to other plants and this helps in fertilizing the soil.

***Azotobacter*sp**

Scientific classification

Kingdom	:	Bacteria
Phylum	:	Proteobacteria
Class	:	Gammaproteobacteria
Order	:	Pseudomonadales
Family	:	Pseudomonadaceae
Genus	:	*Azotobacter*

*Azotobacter*spis a free–living, gram negative, aerobic, nitrogen-fixing bacterium and is therefore being used as biofertilizer to replace chemical fertilizers. It grows from 28°C-30°C and a pH range 7.0 to 7.5. It uses sugar, alcohols and salts of organic acid for growth. Generally it fixes non–symbiotically about 10mg of atmospheric nitrogen/gm of carbohydrates (usually glucose) consumed. It is non-spore forming but can form cyst in adverse conditions and in older cultures grown with sugar as the carbon source. Of the several species of *Azotobacter* and *A. chrococcum* happens to be the dominant inhabitant in arable soils capable of fixing N_2 (2-15 mg N_2 fixed /g of carbon source) in culture media. The bacterium produces abundant slime which helps in soil aggregation. The number of *A. chrococcum* in Indian soils rarely exceeds 10 g soil due to lack of organic matter and the presence of antagonistic microorganisms in soil.

***Azospirillum*sp**

Scientific classification

Kingdom	:	Bacteria
Phylum	:	Proteobacteria
Class	:	Alphaproteobacteria
Order	:	Rhodospirillales
Family	:	Rhodospirillaceae
Genus	:	*Azospirillum*

Azospirillumsp belongs to the Kingdom bacteria and is known to fix considerable quantity of nitrogen in range of 20-40 kg N/ha in the rhizosphere in non-leguminous plants such as cereals, millets, oilseeds, cotton etc. *Azospirillum*is considered as the efficient biofertilizer because of its ability of inducing abundant roots in several plants like rice, millets and oilseeds even in upland conditions. An estimated amount of 25- 30% chemical nitrogen fertilizer can be saved by the appropriate use of *Azospirillum*inoculants. The genus *Azospirillum*has three species viz. *A. lipoferum, A. brasilense*and *A.*

amazonense. These species have been commercially exploited for the use of nitrogen supplying biofertilizer. One of the characteristics of *Azospirillum*is its ability to reduce nitrate and denitrify.

Fungal Biofertilizers

Fungal biofertilizers comprise fungal inoculum either alone or in combination, exerting direct or indirect benefits on plant growth and crop yield through different mechanisms. Fungal biofertilizers, which have been used to improve plant growth by enhancing phosphorus absorption in plants, are phosphate solubilizing microorganisms. The commonly widespread fungi are *Penicillium, Aspergillus*and*Trichoderma*species. There are a number of biofertilizers available in the market. However, applications are based on their ability to supply and mobilize plant nutrients, control plant diseases and promote plant growth and development.

***Aspergillus*sp**

Scientific classification

Kingdom	:	Fungi
Division	:	Ascomycota
Class	:	Eurotiomycetes
Order	:	Eurotiales
Family	:	Trichocomaceae
Genus	:	*Aspergillus*

*Aspergillus*sp is a filamentous, cosmopolitan, black spore producing and ubiquitous fungus found in nature. It is commonly isolated from soil, plant debris, and indoor air environment. *Aspergillus* sp., soil-borne fungi, is serving as important phosphate solubilizers of the soil (Arcand and Schneider, 2006). These fungi are capable of solubilizing both organic and rock phosphates; co-inoculation of these two microbes will enhance the availability of phosphates to plants and in turn will reduce the requirement of synthetic fertilizers. *Aspergillusniger* is a fungus that has been studied because of its ability in solubilisation of inorganic phosphates through the production of acids (citric, gluconic, glycolic, succinic, and oxalic acids) and pH drop (Nahas*et al*., 1990 and Sperber, 1958). A soil isolate of the fungus, *Aspergillusniger* showed the high ability to solubilize both calcium and aluminium phosphates in culture medium (Barroso*et al*., 2005).

***Trichoderma*sp**

Scientific classification

Kingdom	:	Fungi
Division	:	Ascomycota
Subdivision	:	Pezizomycotina
Class	:	Sordariomycetes
Order	:	Hypocreales
Family	:	Hypocreaceae
Genus	:	*Trichoderma*

*Trichoderma*species are common in soil and root ecosystems and are ubiquitous saprobes and they are easily isolated from soil, decaying wood, and other organic material. There are several reports on the use of *Trichoderma*species as biological agents against plant pathogens. *Trichoderma* species have been used as biological control agents against a range of pathogenic fungi e.g. *Rhizoctoniaspp*., *Pythiumspp*., *Botrytiscinerea*, and *Fusarium*spp. *Phytophthorapalmivora*, *P. parasitica*and different species can be used, e.g. *T. harzianum*, *T. viride* and *T.virens*. Among them, *Trichodermaharzianum*is reported to be most widely used as an effective biological control agent. *Trichoderma*species have been very successfully used as mycofungicides because they are fast growing, have high reproductive capacity, inhibit a broad spectrum of fungal diseases, have a diversity of control mechanisms, are excellent competitors in the rhizosphere, have a capacity to modify the rhizosphere, are tolerant or resistance to soil fungicides, have the ability to survive under unfavourable conditions, are efficient in utilizing soil nutrients, have strong aggressiveness against phyto pathogenic fungi, and also promote plant growth (Tang *et al*., 2001; Benítez*et al*., 2004; Vinale*et al*., 2006). They also have a high level of genetic diversity (Harman *et al*., 2004; Harman, 2006). However, *Trichoderma*species are the most common fungal bio control agents and are commercially formulated as bio fungicides, biofertilizers, and soil amendments.

***Penicillium*sp**

Scientific classification

Kingdom	:	Fungi
Division	:	Ascomycota
Class	:	Eurotiomycetes
Order	:	Eurotiales
Family	:	Trichocomaceae
Genus	:	*Penicillium*

*Penicillium*sp is a large genus of fungi that are present in the air, in soil and frequently on bread. Different species of these fungi produce many types of secondary metabolites, ranging from the antibacterial drug penicillin to the antifungal drug griseofulvin, along with many compounds that are toxic to humans and animals. Several species are plant pathogens and cause fruit to rot, and one type causes a human disease in areas of Asia. Other species of these fungi have commercial uses, such as being used to produce several different types of cheese or various types of industrial chemicals. It is frequently the first type of mould to colonize water damaged houses and can cause serious illnesses in the inhabitants.

GREEN GRAM (*Vignaradiata*L.)

Kingdom	:	Plantae
unranked	:	Angiosperms
unranked	:	Eudicots
unranked	:	Rosids
Order	:	Fabales
Family	:	Fabaceae
Genus	:	*Vigna*
Species	:	*Vigna radiata*L.

The mung bean (*Vignaradiata*L.), alternatively known as the mungbean, green gram, or mungSanskrit mudga, is a plantspecies in the legume family. The mung bean is mainly cultivated in Pakistan, India, China, Korea, and Southeast Asia. It is used as an ingredient in both savory and sweet dishes. Mung bean is sometimes grown for fodder as hay, straw or silage. It is particularly valued as early forage as it outcompetes other summer growing legumes such as cowpea or velvet bean in their early stages. The mung bean plant makes valuable green manure and can be used as a cover crop.

The mung bean is one of many species recently moved from the genus Phaseolus to *Vigna* and is still often seen cited as *Phaseolusaureus* or *Phaseolusradiatus*. These are all the same plant.

Skin colour of mung bean can be classified into dark green, olivine, green black these three kinds, seed skin can be classified as lustrous and unpolished(dark green).The best grade is the one lustrous, big size round shape and easy broken when boiled. Mung Bean is a traditional food source of our Chinese people. Vitamins, calcium, irons and phosphorus ratio higher than crude rice. So it got good values both as food and as medicine in the hot summer, mung bean soup are nice drinks for local folks to drive away heat.

CONCLUSION

Liquid Bio-fertilizers have a distinct advantage in terms of cost saving on chemical fertilizers in addition to yield advantage. Chemical fertilizers otherwise may have negative effects on soil as well as human health, change the soil chemistry and these soils no longer support plant growth in the long run. The utilization of microbial products has several advantages over conventional chemicals for agricultural purposes.

Microbial products are considered safer than many of the chemicals now in use, neither toxic substances nor microbes themselves will be accumulated in the food chain, self-replication of microbes circumvents the need for repeated application, target organisms

seldom develop resistance as is the case when chemical agents are used to eliminate the pests harmful to plant growth and properly developed biocontrol agents are not considered harmful to ecological processes or the environment. Plant growth-promoting rhizobacteria (PGPR) are naturally-occurring soil bacteria able to benefit plants by improving their productivity and immunity.

Limitation of biofertilizers

1. Biofertilizers never mix with chemical fertilizer.
2. Biofertilizers are doing never applied with the fungicides, plant ash at a same time.
3. Not exposed to direct sunlight.
4. Stored at room temperature not below 0 and 35ºc.

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