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BIOFERTILIZER: A SUSTAINABLE TOOLS FOR MORDEN AGRICULTURE PRACTISE

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ABSTRACT

In the world Human population is increase day by day and due to that big issue create in food security for each people who living this World. The available of land for agriculture purpose is limited and it's reducing with time by time. We need to develop agriculture practice which increases the productivity of food and other product to meet the large demand of the population growth. Currently application of chemical fertilizer and pesticide for increase the crop production but its cause negative impact on environmental, human health and soil ecology, so it can need to develop new tools as biofertilizer which can reduce the adverse effect on soil ecology and environment. Microbes as biofertilizer contains Plant growth promoting rhizobacteria (PGPRs), endo- and ectomycorrhizal fungi, cyanobacteria and many other useful microscopic organisms led to improve nutrient uptake, plant growth and provide tolerance against abiotic and biotic stress. Biofertilizer is an alternative option for chemical fertilizer and chemical pesticides application in soil.

KEYWORDS: Chemical fertilizer, plant growth promoting rhizobacteria (PGPR), Biofertilizer, Microbial volatile organic compounds (MVOCs), Arbuscular mycorrhizal fungi (AMF).

INTRODUCTION

Soil management strategies are recently base on chemical fertilizers and pesticides but excessive use of chemicals damage the soil ecosystem which can support plant growth and productivity.(BhardwajD *et al.*,2014) Excessive inputs of chemicals like fertilizers, pesticides

and herbicides cause a negative effect on the nutritional value of yield and health of farm workers with consumers. Accumulation of toxic chemical in soils and absorbed by most crops from soil. Synthetic fertilizers have acid radicals like hydrochloride and sulfuric radicals which can increase the soil acidity in soil environment. Plants absorb highly intractable compounds that can lead to systematic disorders in humans and unenthusiastic impact on human health, Bioinoculants is an alternative option of synthesize fertilizer. It can improves plant growth promotion, pest disease and weed control. It is natural-based products being widely used to control pests and improve the quality of the soil, crop with human health. (Alori ET *et al.,* 2018) Microbial volatile organic compounds (MVOCs) use as bio-control agent to protect plants from pathogen and crop welfare. Bacterial and fungal microbial volatile organic compounds might provide an optional use of harmful chemical. (Kanchiswamy CN *et al*,.2015)Microbial Volatile compound produce by microorganisms it is eco-friendly, cheaper and effective for crop productivity and ecology. It is lipophilic compound derivative from microbial metabolic pathways with low molecular weight ($<300\ g\ mol^{-1}$), low boiling point and high vapor pressure that act as signal molecules over short and long distances of plant. This is a technology for future sustainable agricultural systems in view of rapidly declining phosphorus stocks and the need to more efficiently use available nitrogen (N).

Continues use of chemical fertilizers for soil fertility for improve crop productivity produce unexpected results in Soil environmental effects, nitrate and Phosphorus leaching into ground water and cause eutrophication in aquatic ecosystems. Integrated nutrient management systems are tried to maintain agricultural productivity and protect the Soil Ecosystem. Microbial inoculants are capable to maintain the Soil management and ecosystems.(Adesemoye AO et al.,2009) .Application of organic fertilization with chemical fertilization is a suitable method of providing crop plants with adequate amount of nutrients and soil environment friendly. Soil microbes are important for the Soil ecosystem growth-promoting rhizobacteria, arbuscular mycorrhizal fungi and endophytic bacteria can provide necessary nutrients for plant growth with yield production. Beneficial Microbes colonized on plant roots and inducing mechanisms by which plant growth increases. (Miransari M et al 2011).

P.N. Rajankar *et al* (2007) was isolated phosphate solubilization fungi and bacteria from saline area of Amravati district, they reported solubilize activity of fungi viz; Aspergillius

spp., Penicillium spp. and Fusarium spp. is higher compare to bacteria, viz; *B.subtilis*, and *B.megatherium*. biofertilizer prepared by these fungi should be helpful to reduce the salinity of soil by neutralization phenomenon, because these microorganisms release the acid in very small quantity in phosphate Solubilization.

Microorganisms use as Bioinoculants (Biofertilizer)

(A) Nitrogen fixing bacteria.

Nitrogen gas is very abundant in nature but plants cannot be utilizing it directly from atmosphere. Few range of organisms symbiotically associate with higher plants and non-symbiotically with plant can ability to fix biological nitrogen. About 386 x 1016 kg nitrogen exists in the Earth's atmosphere and returned to the earth every year by nitrogen cycle.

Nitrogen is an essential element for support of all life form. Present in as proteins, amino acids and many other organic substrates which derived from biological nitrogen fixation activity. Nitrogen gas is present 71% (Most abundant gas) in earth atmosphere but extremely unreactive so plant and animals cannot utilize it directly from atmosphere. (Egamberdieva *et al* (2008) many prokaryotes have abilities to utilize it by biological nitrogen fixing activity. Several microorganism may be symbiotic or free living in nature have ability to fix atmospheric nitrogen in soil. (Simon T., 2003)

Microorganism are capable to performing this activity because they have nitrogenase enzymes which carried out biological nitrogen fixing activity, it is based on ecological condition in association with specific nitrogen fixation capabilities of certain microbes and plant genotype. Biological nitrogen fixing activity may be variable with various climatic conditions. Nitrogenase activity is generally plant specific. Free living nitrogen fixer working as plant growth promoter. Plants are made up of carbon, oxygen and hydrogen which are available from air and water. Beyond these three elements, nitrogen is very important for plant growth. It is minimal as compared to other mineral nutrients; it is find out the intensity of the organic matter accumulation. Major source of soil nitrogen is the atmosphere where nitrogen gas occupies about 79% of the total atmospheric gases. Egorov, V.I., (2007).biological nitrogen fixation from the atmospheric can be estimated about 175 million metric tons per year or about 70% of all nitrogen fixed on the Earth per year and the remaining nitrogen is fix by some free micro-organisms like autotrophs or heterotrophs. unavailable gaseous form of nitrogen convert to available form by nitrogen fixation process and utilize it by plants and other organism. There are four way to fix nitrogen (i) bacteria in

symbiotic relationships with vascular plants, (ii) symbioses between *algae* and fungi (lichens) or plants, (iii) free living heterotrophic or autotrophic bacteria that are typically associated with soil and (iv) abiotic reactions occur without microbes in the atmosphere associated with lightening. Nitrogen fixing microorganisms have normally reported as plant growth promoters. they are free-living in soil, rhizosphere, rhizoplane and phylosphere bacteria that are beneficial for plants and capable of atmospheric nitrogen fixation, solubilize phosphorus and iron with enhance production of plant hormones.

Several free - living aerobic and anaerobic bacteria like azotobacter and clostridia are living in symbiotic relationship with higher plants. e.g. *Rhizobia* with legumes or *Azolla Anabaena Azollae* with *Azolla* and nitrogen fixing prokaryotes (e.g. *Azospirillum, Azotobacter, Enterobacter species*) have been found in rhizosphere of different plants likes sugarcane, maize, wheat, rice, grasses and others.

Potent nitrogen Fixing Bacteria

Azospirillum

They are free living facultative endophytic nitrogen fixing group bacteria which colonize on the surface of plant roots and make association with plats this is starting point stage of most ongoing BNF (Biological Nitrogen Fixation) programs with non-legume plants worldwide. *Azospirillum*, improve plants shoots and root directly, it can help to plant for uptake water and minerals from soil by root. (Gonzalez, L.J *et al* 2005).

Azotobacter

It is free living obligate aerobic nitrogen fixing bacteria. They have able to grow under low O_2 concentration. Azotobacters are wide spread in the soil of tropical, subtropical and temperate regions. These bacteria established close relationship with various wild and agricultural plants.(Doroshenko, E.V., *et al*., 2007).

Azolla Spp

It is water floating fern species and mostly grows in tropical and temperate ecosystems. Azolla have ability to fix atmospheric nitrogen through symbiosis relationship with blue green algae (Nostoc anabaena). It can use as potential nitrogen fixing organisms and apply as nitrogen source or nitrogen biofertilizer in wetland of rice.

Cyanobacteria

Marine water and terrestrial water ecosystem, cyanobacteria play a very important role in maintain nitrogen cycle. They are diverse group of prokaryotes and make complex association with green algae this association known as *cyanobacterial* mat. It can playing major role in biological nitrogen fixation in freshwater and marine ecosystems.

The diazotrophs are important source of nitrogen of the marine ecosystem by nitrogen fixing activity in marine and fresh water ecosystem. They can grow and fix nitrogen in many terrestrial environments from rainforests to deserts. *Cyanobacterial mat* can be use as biofertilizer in current agricultural activity.

Gluconacetobacter Diazotrophicus: it is a nitrogen-fixing and acetic acid bacterium which was first isolated from sugarcane plants. It is Gram negative bacteria belong to *phylum Proteobacteria* in section a-Proteobacteria, order *Rhodospirillales* and family *Acetobacteraceae*. Currently, three nitrogen-fixing genera and seven nitrogen fixing species, namely *Acetobacter nitrogenifigens, Gluconacetobacter kombuchae, Gluconacetobacter johannae, Gluconacetobacter azotocaptans, Gluconacetobacter diazotrophicus, Swaminathania salitolerans* and *Acetobacter peroxydans* (Saravanan, V.S., et al 2007).

(B) Phosphate solubilizing bacteria

Phosphorus is very essential element for major growth-limiting factor for plant nutrient and it can affect the overall growth of the plants by producing various kind of metabolic processes such as cell division, cell development, macromolecular biosynthesis, photosynthesis and respiration of plants (Shenoy V *et al*.,2005) approximately 95-99% of phosphorus is present in the form of insoluble phosphates and it cannot be easily utilize by plants directly (Kannapiran *et al.*,2011) P play an important biochemical role in energy storage, energy transfer, cell enlargement and several others vital biological important processes in the living plant. Unavailable/insoluble phosphate compounds can solubilize by organic acids and phosphatase enzymes which produced by plants and several microorganisms. Several group of soil microbial flora was reported for Converting insoluble phosphorous to solubilize form so plants can easily absorb phosphorous. According to several report examined that different bacterial species have ability to solubilize insoluble inorganic phosphate compounds such as tricalcium phosphate, dicalcium phosphate, hydroxyapatite and rock phosphate. the bacterial genera with this capacity are *Pseudomonas, Bacillus, Aereobacter, Flavobacterium and Erwinia Rhizobium, Burkholderia, Achromobacter, Agrobacterium, Micrococcus.* Compare

to other nutrients like N, P concentration in soil is very low ranges between 0.001 to 1 mg/l (Brady *N et al.*, 2002).

Soluble phosphate is highly reactive with other element which is available in soil so available form of P is very low. There are three types of P compounds available in soil: (i) inorganic compounds, (ii) organic compounds of the soil humus and (iii) organic and inorganic P compounds related with the cells of living matter. The microbial world can carry out huge amount of nutrient from the natural source and enrich the soil with important but limited nutrients. Microbial phosphate solubilizing potentiality increase the availability of soluble phosphates and also enhancing the availability of other trace elements such as iron, zinc etc. *Rhizobacteria* are able to solubilize soluble phosphates with releasing chelating organic acids. bacterial species are associated with the plant rhizosphere, called as rhizobacteria. They provide beneficial elements for plant growth. Phosphorus is very important element for plant development and growth productivity it may present about 0.2 % of plant dry weight. Bacterial species have ability to solubilize insoluble inorganic phosphate compounds, such as tricalcium phosphate, dicalcium phosphate, hydroxyapatite, and rock phosphate. Arbuscular mycorrhizal fungi (AMF) and phosphate solubilizing Pseudomonas bacteria (PSB) could potentially interact with each other, PSB solubilize phosphate into an available form and it is absorb by AMF which transport to plants. genetic manipulation of phosphate-solubilizing bacteria for improve their ability on plant growth may include cloning genes involved in both mineral and organic phosphate solubilization, their expression in selected rhizobacterial strains.

(C) Production and demand of Biofertilizer

Panda, H. (2011) reported that Rhizobium was the first isolated strain from legumes plant than extensive research done by Gangulee, Sarkaria and Madhok on the physiology of the nodule bacteria along with its inoculation for better crop production and it is milestone in research, production and promotion of biofertilizer in India.

Table 01: History of Biofertilizer in india (Panda, H.2011).

Year	Events
1920	First study on Legume-*Rhizobium* symbiosis by N. V. Joshi.
1934	Earliest documented production of *Rhizobium* inoculant by M. R. Madhok.
1939	Discovery of nitrogen fixation by Blue Green Algea (BGA) in rice field by P. K. Dey.
1939	Performance of *Azotobacter* in rice soil by B. N. Uppal.
1956	First commercial production of biofertilizer.

1957	Sen and Pal Study on solubilization of phosphate by microorganisms
1958	First attempt to standardize quality of legume inoculant by A. Sankaran.
1960	P. K. Dey and R. Bhattacharyya isolated new non-symbiotic N-fixing organism *Derxiagummosa*
1964	Spurt in demand of biofertilizer for soybean particularly in Madhya Pradesh.
1968	All India Pulse Improvement Project and Soybean Project set up by ICAR where *Rhizobium* study got priority.
1969	V. Iswaran Used Indian peat as carrier
1975	Coal use as carrier to peat (J. N. Dube)
1976	Indian Standard Specification for *Rhizobium*.
1977	Use of ISI mark for *Rhizobium*.
1979	beginning of All India Coordinated Project on BNF.
1979	ISI standard for *Azotobacter* inoculant.
1983	National Project on Development and use of Biofertilizer by Ministry of Agriculture, Govt. of India.
1985	First National Productivity award on Biofertilizer.
1988	Setting up of National Facility Centre for BGA at IARI.

Table 02: Different types of fertilizer available and production in India.

Sl. No.	Groups	Examples
1. Nitrogen (N2) fixing Biofertilizers		
I	Free-living	*Azotobacter, Clostridium, Anabaena*, Nostoc
Ii	Symbiotic	*Rhizobium, Frankia, Anabaena azollae*
Iii	Associative Symbiotic	*Azospirillum*
2. P-Solubilizing Biofertilizers		
I	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus circulans, Pseudomonas striata*
Ii	Fungi	*Penicillium sp., Aspergillus awamori*
3. P-Mobilizing Biofertilizers		
I	Arbuscular mycorrhiza	*Glomus sp., Gigaspora sp., Acaulospora sp., Scutellospora sp., Sclerocystis sp.*
Ii	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
Iii	Orchid mycorrhiza	*Rhizoctonia solani*
4. Biofertilizers for Micro nutrients		
I	Silicate and zinc solubilizers	*Bacillus sp.*
5. Plant Growth Promoting Rhizobacteria		
I	Pseudomonas	*Pseudomonas fluorescens*

Source: Biofertilizers- types and their application, KrishiSewa

(D) Significance of biofertilizer

Ghosh, 2004 studied that biofertilizers provide nutrient to plant from the soil and atmosphere. it is cheap and effective inputs without damage of soil environment or ecosystem.(Sahoo *et al.*, 2014).

Vessey, 2003 suggested that biofertilizers are ecofriendly organic substance which has ability to convert unavailable element to available form for plants. So it can reduce the use of chemical fertilizer or alteration source of chemical fertilizer. Microorganisms established natural nutreint cycle and they maintain health of soil by increase soil fertility .biofertilizer try to fulfill nutrient requirement of plants and also controlling attack of pathogenic microbes to plants.

Ghosh, 2004 suggested that large part of agriculture land in india is dry land and majority of the poor people about more than 90% of coarse cereals, 80% of groundnut and 85% of pulses come from these regions. Dry land agriculture has low productivity; unpredictable climatic swings and low dosage of chemical fertilizers make less productivity of food. In this condition biofertilizers particularly Rhizobium, could be a bridge between removal and addition of nutrients in soil.

Mahdi *et al.*, 2010 referred that the inoculation of phosphate solubilizing bacteria in soils is needed to restore and maintain the effective microbial populations in the soil .they can solubilize chemically fixed phosphorus and make it available of nutrients to harvest good sustainable yield of various crops.

The following type's biofertilizers are available to the farmers in India:

1. Nitrogen fixer Microorganisms: *Rhizobium*, *Bradyrhizobium*, *Azospirillum*, *Azotobacter*, Acetobacter, Azolla and BGA.
2. Phosphorus solubilizer Microorganisms: Bacillus, *Pseudomonas* and *Aspergillus*.
3. Phosphate mobilizes fungi: VA-mycorrhiza (VAM) like *Glomus.*
4. K-solubilizer : *Frateuria aurantia*.
5. Silicate solubilzer microbe: *Thiobacillus thiooxidans*.
6. Plant growth promoting microorganisms as biofertilizers: *Pseudomonas sp*.

Bio-Fertilizer Recommended Crops

Rizobium: Pluses, Oilseeds, Fodders

Azospirillum:	Rice, Wheat, millets, maize, sorghum,sugarcane
Azotobactor:	Rice, cotton, vegetables, Wheat, millets, cereals, sunflower, mustered,
Blue Green:	Algae submerged rice
Azolla :	Submerged rice with maximum temperature
PSM:	All crops

(E) CONCLUSION

Excessive use of Chemical fertilizers causes soil pollution which makes negative impact on soil ecosystem and soil environment with animal health issue. Use of organic farming concept is an alternative way to reduce the negative impact of chemical fertilizer .biofertilizer application can improve crop productivity without use any chemical fertilizer but mixer of chemical fertilizers and biofertilizer also reduce dependence on chemical fertilizer. So in future it may a novel, Morden and alternative way to develop agriculture product without excessive use of chemical fertilizer.

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