American Journal of

Plant Nutrition and Fertilization Technology

ISSN 1793-9445

Academic Journals Inc.

www.academicjournals.com

American Journal of Plant Nutrition and Fertilization Technology 4 (2): 33-40, 2014
ISSN 1793-9445 / DOI: 10.3923/ajpnft.2014.33.40

Potential of Biofertilizers in Crop Production in Indian Agriculture

[1]Saurabh Singh, [2]Bijendra Kumar Singh, [3]S.M. Yadav and [4]A.K. Gupta
[1]Department of Mycology and Plant Pathology,
[2]Department of Horticulture,
[3]Institute of Agricultural Science,
[4]DST-Centre for Interdisciplinary Mathematical Sciences, Banaras Hindu University, Varanasi, 2210105, India

Corresponding Author: Saurabh Singh, Department of Mycology and Plant Pathology, Banaras Hindu University, Varanasi, 2210105, India

ABSTRACT
The green revolution brought impressive gains in food production but with insufficient concern for sustainability. In India, the availability and affordability of fossil fuel based chemical fertilizers at the farm level have been ensured only through imports and subsidies. The government of India has been trying to promote an improved practice involving use of bio-fertilizers along with fertilizers. These inputs have multiple beneficial impacts on the soil and can be relatively cheap and convenient for use. Use of eco-friendly, bio-pesticides, bio-fertilizer and bio-controls is being encouraged in the field of agriculture. Bio-pesticides like neem and *Bacillus*-based pesticides such as Aureofungin, Kasugamycin, Validamycin, Streptomycin and Sulphate and Tetracycline Hydrochloride have been identified for controlling various insect pests and diseases in agriculture. Some parasites, predators, phyto-phagus insects and insect/disease pathogens have also been identified as major bio-control agents for the control of insect pests and diseases of various crops. Biological based product are most advanced biotechnology necessary to support developing organic agriculture sustainable agriculture, green agriculture and non-pollution agriculture.

Key words: Biofertilizer, BGA disease, microorganism

INTRODUCTION
The term biofertilizers or which can be more appropriately called 'microbial inoculants' can be generally defined as a preparation containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilising or cellulytic microorganisms used for application of seed, soil or composting areas with the objective of increasing the numbers of such microorganisms and accelerate certain microbial process to augment the extent of the availability of nutrients in a form which can be easily assimilated by plant. In large sense, the term may be used to include all organic resources (manure) for plant growth which are rendered in an available form for plant absorption through microorganisms or plant associations or interactions of 0.050 (Rao, 1999). According to an estimate, 240 million tonnes of food grains will be required to feed about 1 billion expected populations by 2000 A.D. in India and to achieve this milestone, a sizable quantity of mineral fertilizers will be required. The total fertilizer requirements of our country would be 23 million tonnes as against the present consumption level of 13 million tonnes per annum (Carrapico *et al.*, 2000). The problem is so acute that it is beyond any single type of nutrient source to accept the challenge of appropriate nutrient supply. Integrated use of all the sources such as mineral

fertilizers, organic manures, biofertilizers, etc. is the only alternate for improving soil fertility. The use of organic manures and mineral fertilizers is in practice but use of biofertilizer in agriculture is not very popular. Hence, there is a need to make its use popular. The increased cost of fertilizer production coupled with progressively increasing use of chemical fertilizers particularly needed by High Yielding Varieties (HYV) are adding to the cost of cultivation of crops and causing nutritional enhancement in Indian agriculture (Panwar and Singh, 2000). Recent energy crisis, rapid depletion of non renewable energy sources like nepenthe, natural gas, sulphur, etc., their production also releases pollutants. Nutrient potential from all organic sources in India is over 19 million tonne year^{-1} which is adequate requirement to meet 70% of the projected nutrient requirement for the decade ending 2000 A.D. But this potential is made up of more by contribution from bovine excreta and crop residues than from any other source which alone contributes about 14.8 million tonne year^{-1}. It has been estimated that almost 87% of cooking energy in India is derived from firewood, cow dung and agricultural waste and only 13% rest is from commercial sources (Kumar *et al*., 2010). Unless the firewood sources are expanded and a situation is created for facilitating social and economic access of the rural poor to the developed sources, the organic potential of the country would not become fully available for the crop production. Legume effect has been successfully utilised in green manuring.

IMPORTANT ASPECTS ABOUT BIO FERTILIZER

- Biofertilizers are organisms that enrich the nutrient quality of soil. The main sources of biofertilizers are bacteria, fungi and cynobacteria (blue-green algae)
- Different types of biofertilizers Rhizobium Azotobacter Azospirillum Cyanobacteria Azolla Phosphate solubilizing microorganisms (PSM) AM fungi
- They help to get high yield of crops by making the soil rich with nutrients and useful microorganisms necessary for the growth of the plants. Biofertilizers have replaced the chemical fertilizers, as chemical fertilizers are not beneficial for the plants

A list of group of biofertilizers based on their nature and function is shown in Table 1.

Table 1: Group of Bio-fertiliser based on their nature and function

Groups	Examples
N_2 fixing biofertilizers	
Free living	*Azotobacter, Beijerinkia, Clostridium, Klebsiella, Anabaena* and *Nostoc*
Symbiotic	*Rhizobium, Frankia* and *Anabaena azollae*
Associative symbiotic	*Azospirillum*
P solubilising biofertilizers	
Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtilis, Bacillus circulans* and *Pseudomonas striata*
Fungi	*Penicillium* sp. and *Aspergillus awamori*
P mobilizing biofertilizers	
Arboscular mycorhiza	*Glomus* sp., *Gigaspora* sp., *Acaulospora* sp., *Scutellospora* sp. and *Sclerocystis* sp.
Ectomycorrhiza	*Laccaria* sp., *Pisolithus* sp., *Boletus* sp. and *Amanita* sp.
Ericoidmycorrhiza	*Pezizella*
Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for micro nutrients	
Silicate and Zinc solubilizers	*Bacillus* sp.
Plant growth promoting rhizobacteria	
Pseudomonas	*Pseudomonas fluorescens*

BIOFERTILIZER DEVELOPMENT

Waste gap cannot be filled up merely through the production of synthetic nitrogenous fertilizers due to scarcity of high cost of raw materials such as fossil fuels. Biological nitrogen fixation is the key to sustain agricultural productivity application of biofertilizers in the field and is the viable alternative. Biofertilizer, as a living fertilizer, composed of microbial inoculants or groups of microorganisms which are able to fix atmospheric nitrogen, the microorganisms are known as biological nitrogen fixers (Rajendra *et al*., 1998). They are grouped into free-living bacteria (*Azotobacter* and *Azospirillium*) and the blue green algae and symbionts such as *Rhizobium*, *Frankia* and *Azolla*. In fertilizer manufacturing factories, nitrogen is fixed industrially by means of the Haber Bosch process requiring H_2 gas at very high temperature and enormous energy. Industrially fixed nitrogen has been used precipitously. It was produced 4.0 lakh metric tonnes in 1905 (Rajasekaran *et al*., 2009). This was increased to 3.5 million tonnes of nitrogen fertilizer produced industrially. Meanwhile, the contribution of biologically fixed nitrogen has not changed. The estimate of chemically fixed nitrogen for 1976 is 42 million metric tonnes. It is projected that by 2000, if we continue to rely entirely on increased use of chemical fertilizers to achieve the food production level, more demand for fertilizer nitrogen results and around 100-200 million metric tonnes would be needed to produce at an average cost of rupees. Annually, the laboratory produces roughly 100-125 tonnes of biofertilzers and supplied to different agencies. We have marketing net work which includes distributors in every district place and appointed of salesmen. The government of India has recently sanctioned an amount of Rs. 20.00 lakhs as grant in-aid to equip the laboratory and enhance production upto 150 t year^{-1} (Rajasekaran and Sundaramoorthy, 2010). This grant will be used up for adding modern equipments such as fermenter, automatic filling sand bagging machine and laminar flow cabinate. Our laboratory is one of best laboratories in the state as far as expertise is concerned and also the quality of biofertilizers.

MATERIALS OF BIOLOGICAL ORIGIN

The materials of biological origin which are commonly used to maintain and improve soil fertility may be grouped into two main categories: (1) Biofertilizers and (2) Green manures. The soil organisms are classified into two broad groups i.e., soil flora and soil fauna. These are again subdivided depending upon their size such as micro and macro flora. Soil microflora includes bacteria, fungi, actinomycetes, algae, etc. Of these groups, bacteria are the most abundant followed by actinomycetes and fungi; algae are found under specific situations. The biomass and population of these microorganisms in soil are found under specific situations:

- The National Bio-fertilizers Development Centre, 6 Regional Centres produce and distribute bio-fertilizers
- The 58 Bio-fertilizers Production Units have been financed by the Department of Fertilizers with a total production capacity of 8,300 t annum^{-1} of bio-fertilizers

LABORATORY MANUFACTURES FOLLOWING IMPORTANT TYPES OF BIOFERTILIZERS

- **Rhizonik:** All types of *Rhizobium* species infecting cultivating crops. There are seven cross inoculation groups all are available for sale used for legume crops

- **Azonik (*Azotobacter chroococcum*):** It is non-symbiotic bacteria used for all cereals
- **Spironik (*Azospirillum brazilense*):** It is associative symbiont and most useful for grasses and similar type of crops
- **Phosphonive (Phosphate solubilizing inoculant):** This includes bacteria as well as fungi under field condition, they solubilize P and provide to plants
- **Sulphonik (Sulphur oxidising inoculant):** This biofertilizer includes bacteria and also fungi. The inoculant enhances the availability of sulphur under field condition
- **Phospho-sulphonik:** In this unique type of biofertilizer, both types are equally mixed, thereby, crops are benefited
- **Niku-2000 (Decomposing culture):** This inoculant degrades all cellylolytic and lignolutic organic matter, thereby, releasing nutrients to plants
- **Trichonik (*Trichoderma viridi*):** It is biological control agent. This biofertilizer restricts the growth of disease producing organism under field condition
- **Vermiculture:** Best quality vermiculture is produced and it is mixed with N-fixing inoculant and P solublizers so that nutrient value is increased

BIOFERTILIZING AGENTS AND PLANT DISEASE CONTROL

Bio fertilizing agents control the plant pathogenic fungi directly as well as indirectly. Directly they parasitize the pathogens; application of rhizobium culture on the legume seeds control seed borne fungi such as *Colletotrichum*, *Ascochyta*, *Helminthosporium*, etc. The rhizobia produce a toxic substance when they multiply on the seed and rhizosphere. Phosphate solubilising fungi such as *Aspergillus niger* and other *Penicilla* produce antibiotic substances and thus kill the pathogenic fungi. Indirect killing of the plant pathogens is achieved by producing healthy seedlings and phytoalexins. Application of mycorrhizae produce better root systems which overcome the attack of root rotting and soil borne pathogens. Numerous reports are available that applications of biofertilizers in the soil stimulate and augment the activity of saprophytic microorganisms.

BRIEF ACCOUNT OF BENEFICIAL MICROORGANISMS

***Rhizobium*:** Symbiotic N_2 fixation by *Rhizobium* in legumes contributes substancially to total biological nitrogen fixation. Rhizobium inoculation is well known agronomic practice to ensure adequate nitrogen of legumes in lieu of N-fertilizer. Different species of rhizobium are classified into two groups' viz., (1) Slow growing rhizobia (under the genus *Bradyrhizobium*) and (2) Fast growing groups (under the genus *Rhizobium*). Inoculation methods are necessary where seed treatment with fungicides and insecticides is needed or where seeds like groundnut and soyabean can be damaged when the inoculants is used with an adhesive. Direct contact with the acidic fertilizer can also be harmful for rhizobium. Apart from application with seeds, the normal carrier-based inocula can also be separately applied.

***Azotobacter* and *Azospirillum*:** Many genera and species of N_2 fixing bacteria have been isolated from the rhizosphere of various cereals. Thus mainly belong to *Azotobacter* and *Azospirillum* genera. These are free-living bacteria and fix atmospheric nitrogen in cereal crops without any symbiosis. They fix 15-20 kg ha^{-1} nitrogen per year. *Azotobacter* sp. also has ability to produce antifungal compounds against many plant pathogens.

Phosphate solubilizing microorganisms: Phosphorus is also one of the major elements required for plant growth and higher yields. This element is necessary for the nodulation by *Rhizobium* and even to nitrogen fixers, *Azolla* and BGA. The phospho-microorganism mainly bacteria and fungi make available insoluble phosphorus to the plants. The root fungus association or Mycorrhiza has high potential in accumulating phosphorus in the plants. Mixture of charcoal and soil is satisfactory material for these microorganisms in order to prepare commercial inoculants. It is reported that microphos cultures increase yield upto 200-500 kg h^{-1} and thus 30-50 kg superphosphate can be saved.

Vesicular Arbuscular Mycorrhizae (VAM): The symbiotic association between plant roots and fungal mycelia is termed as mycorrhiza (Fungal roots). These fungi are obligate symbionts and have not been cultured on nutrient media. VAM fungi infect and spread inside the root. They possess special structures known as vesicles and arbuscules. The arbuscules help in the transfer of nutrients from the fungus to the root system and the vesicles, which are saclike structures, store P as phospholipids. VAM have been associated with increased plant growth and with enhanced accumulation of plant nutrients, mainly P, Zn, Cu and S mainly through greater soil exploration by mycorrhizal hyphae.

***Azolla*:** *Azolla* is a floating fresh water fern inside which grows the nitrogen fixing BGA *Anabaena*. It contains 3.4% nitrogen and produces organic matter in soil. This biofertilizer is used for rice cultivation in different countries such as Vietnam, China, Thailand and Phillipines. This can be easily grown in cooler regions. There is need to develop tolerant strains to high temperature salinity and pests and disease-resistance for its wider adaption. Field trial indicated that rice yields are increased by 0.5-2 t ha^{-1} due to *Azolla* application. Recent studies have revealed potentialities of *Azolla* as a nitrogenous fertilizer in carp culture ponds. Application of different doses of *Azolla* in fish culture ponds shown that a minimum of 25 kg N ha^{-1} $year^{-1}$ could be provided through application of 10-12 t of *Azolla* ha^{-1} $year^{-1}$. There are six species of *Azolla*: *A. caroliniana, A. nilotica, A. mexicana, A. filiculoides, A. microphylla* and *A. pinnata*. It grows in ditches and stagnant water. This fern usually forms a green mat over water. The plant has a floating, branched stem, deeply blobbed leaves and true roots which penetrate the body of water. The leaves are arranged alternately on the stem. Each leaf has a dorsal and ventral lobe. The dorsal fleshy lobe is exposed to air and contains chlorophyll. It has an algal symbiont (*Anabaena azolla*) within the central cavity. *Azolla* is readily decomposed to NH_4 which is available to the rice plants. It has also been observed that N contents of rice receiving *A. mexicana* are 10 and 35 kg ha^{-1}, respectively higher than that in controls.

Blue green algae: Blue-green algae are known to fix atmospheric nitrogen. These have been found to be very effective on the rice and banana plantation. In field condition, overall increase in the gram yield of rice is amounted to about 586 kg ha^{-1}. In case of crops other than rice, algalization increased nearly 34% yield. India is one of the countries where agro-chemical conditions appear to be favourable where blue-green algae technology has been put forward. Field scale production of algae biofertilizer is also possible. The 20-25 kg dry algae can be obtained on 40 m field. Adopting this method, 15 t ha^{-1} of wet BGA can be obtained by the farmers. Farmers can also produce algae for count yard of the house.

PLANT GROWTH PROMOTING RHIZOBACTERIA (PGPR)

A group of rhizosphere bacteria that exert a beneficial effect on plant growth is referred as PGPR. They belong to several genera, e.g., *Actinoplanes*, *Agrobacterium*, *Alcaligenes*, *Amorphosporangium*, *Arthrobacter*, *Azotobacter*, *Bacillus*, *Cellulomonas*, *Enterobacter*, *Erwinia*, *Flavobacterium*, *Pseudomonas*, *Rhizobium* and *Bradyrhizobium*, *Streptomyces* and *Xanthomonas*. The plant growth promoting microorganisms improved potato growth and yield in short-but not long-rotation soils, primarily by suppressing cyanide-producing deleterious rhizosphere microorganisms. Large populations of bacteria established on planting material and roots become a partial sink for nutrients in the rhizosphere, thus, reducing the amount of C and N available to stimulate spores of fungal pathogens or for subsequent colonization of the root. In field trials with wheat, potato, sugar beet and zinnia conducted showed significant yield increases varying from 7-136% with an average increase of 7-35% in different crops over the control. Seed treatment with *B. subtilis* increased yield of carrot by 48%, oats by 33% and groundnut upto 37%.

STATUS OF BIOFERTILIZER IN INDIA

The present production capacity of different biofertilizers production units in the country is about 4500 t annum^{-1}. The maximum production capacity is in Agro Industries Corporation followed by State Agriculture Departments, National Biofertilizer Development Centre, State Agriculture Universities and private sector. Among the different states, changing composition of biofertilizer were found to be maximum in 2010-2011 (Table 2). Use intensity of biofertilizer and chemical fertilizer in India are shown in Table 3. Maximum production capacity is in Tamil Nadu followed by M.P., U.P., Gujarat and Maharashtra. The installed capacity of BF production in

Table 2: Changing composition of biofertilizers in India

	Year						
Biofertilizers	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011
Rhizobium	57.27	40.50	29.41	21.15	20.84	19.85	18.62
Azotobacter	13.00	22.20	18.47	18.46	15.51	17.30	17.74
Azospirillum	12.54	11.11	14.08	17.99	11.34	10.17	11.77
Nitrogen fixers	82.81	73.80	61.96	57.61	47.69	47.32	48.12
Blue green algae	0.00	0.00	0.06	0.04	0.01	0.02	0.04
Phosphate solubilizer	17.19	26.20	35.77	40.46	49.88	48.75	48.98
Acetobacter	0.00	0.00	2.21	1.90	1.13	1.06	1.00
Total (tones) % share	1600.01	2914.37	4988.90	6688.32	6681.44	6295.63	6700.30

Source: Fertilizers association of India

Table 3: Use intensity of biofertilizers and chemical fertilizers (in India agriculture)

	Year		
Location	2008-2009	2009-2010	2010-2011
South	125.21	18.46	0.05
North	130.43	22.32	0.01
West	60.82	4.91	0.06
East	70.63	18.32	0.01
Total	477.13	100.01	0.13

Source: Fertilizers association of India different fertilizer industries is about 400 t annum^{-1}. Main BF producing companies are GSFC, MLF and SPIC etc. Some more fertilizer companies (IFFCO, KRIBHCO, NFL, RCF etc.) are likely to start production soon and many more are planning to join the biofertilizer business. Based on the area under different crops and dose of biofertilizer to be applied, the National Biofertilizer Development Centre (NBDC), Ghaziabad and Biotech Consortium India Ltd., (BCIL) have estimated the total requirement of biofertilizers (*Rhizobium*, *Azotobacter*, *Azospirillum* and Blue Green Algae) to be about 5.07 and 3.44 lakh tonnes, respectively. The recent estimated potential demand of different kinds of biofertilizers by Government of Tamil Nadu are *Rhizobium* 35 thousand tonnes; *Azospirillum* 482 thousand tonnes; *Azotobacter* 162.61 thousand tonnes; Blue-Green Algae 267.72 thousand tonnes, *Azolla* 20.38 thousand tonnes and phosphate solubiliser 275.51 thousand tonnes. The total of all these amounts to be 12.44 lakh tonnes which is significantly higher than the estimates of NBDC and BCIL, mainly because they did not indicate phosphate solubiliser and their estimates for *Azospirillum* were also low. Production technology of biofertilizer is relatively simple and its installation cost is very low compared to chemical fertilizer plants. Most of the biofertilizer units lack in this respect. Those who have very good organised marketing network have done excellently well. For example, fertilizer company like GSFC has more than 200 farm information centres-cum-depots situated in remote areas. In order to provide BF upto village level, GSFC has established its own distributor's network. MLF and SPIC have also well organised themselves in this respect. It is found that biofertilizer like *Rhizobium* can supply 20-25 kg N ha^{-1}. Considering the prospects of biofertilizers in the country, the biofertilizer development centres are being established both in government and private sector. It is possible to establish joint venture in biofertilizer agro based industry.

HOW TO INCREASE THE BIOFERTILIZER PRODUCTION

- Organising field demonstrations on bio-fertilizers by National and Regional Centres. To manufacture best quality biofertilizers and make them available to farmers at very reasonable price
- To provide a suitable technology for sugar factories to convert the press mud and spent wash into good compost
- To supply efficient decomposing cultures to sugar factories
- To provide consultancy service to Municipalities to convert city garbage into best organic matter
- To extend new technology to farmers through farmers rallies, radio talks and T.V. programme
- To produce best quality vermiculture and supply to farmers
- To identify plant diseases and suggest suitable control measures
- To identify fungal cultures and supply them to colleges
- To provide consultancy service to green houses and tissue culture laboratories in respect of diseases

REFERENCES

Carrapico, F., G. Teixeira and M.A. Diniz, 2000. *Azolla* as a biofertiliser in Africa: A challenge for the future. Revesta Cincies Agraries, 23: 120-138.

Kumar, V., A. Chandra and G. Singh, 2010. Efficacy of fly-ash based bio-fertilizers vs perfected chemical fertilizers in wheat (*Triticum aestivum*). Int. J. Sci. Technol., 2: 31-35.

Panwar, J.D.S. and O. Singh, 2000. Response of *Azospirillum* and *Bacillus* on growth and yield of wheat under field conditions. Indian J. Plant Physiol., 5: 108-110.

Rajasekaran, S. and P. Sundaramoorthy, 2010. Response of organic manures and biofertilizer on germination, growth and yield of selected leguminous corps. J. Ecotoxicol. Environ. Monit., 20: 161-168.

Rajasekaran, S., P. Sundaramoorhty, K.S. Ganesh and L. Baskaran, 2009. Response of organic manures on growth and yield for Turmeric (*Curcuma longa*). Geobios, 36: 83-85.

Rajendra, P., S. Singh and S.N. Sharma, 1998. Interrelationship of fertilizers use and other agricultural inputs for higher crop yields. Fertilizers News, 43: 35-40.

Rao, D.L.N., 1999. Biofertilizer situation in India and future thrusts. Indian Council of Agricultural Research (ICAR), pp: 1-3.