Research Paper Management

Bio-Fertilizer use in Indian Agriculture

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ABSTRACT

In the wake of Green Revolution, which brought in massive gains in agricultural output yet it did not translate into a model for sustainable agricultural growth. Excessive dependence on chemical fertilizers with major emphasis on Nitrogen and Phosphorus, excessive use of pesticides has led to fall in soil fertility, water contamination and unsustainable burden on the ecological system.

Under this situation, bio-fertilizers offer great potential for not only improving soil fertility but also provide for efficient use of various recourses for increasing crop production on sustainable basis.

The present work aims to study the extent of bio-fertilizers use in the different states of India and its impact on agricultural production.

The study shows, both State and Central Governments have been promoting the use of biofertilizers through various practices. Even the growth rate of both production and consumption of biofertilizer in India is quite satisfactory, a very small percentage of estimated demand is justified with this production.

KEYWORDS Bio-fertilizer, Chemical fertilizer, Sustainability, Green Revolution.

INTRODUCTION

Green Revolution in India brought massive gains in agricultural output. However, it did not translate into a model for sustainable agricultural growth. This increase in agricultural production under Green Revolution was brought about mainly by the extensive use of chemical fertilizers, pesticides etc.

The effect of chemicals is usually direct and fast. Moreover the moderate price level and higher productivity make it more marketable to the farmers. However, excessive dependence on chemical fertilizers with major emphasis on Nitrogen (N) and Phosphorus (P) and excessive use of pesticides has led to fall in soil fertility, water contamination, polluted water basins, destroyed micro-organisms and friendly insects, making the crop more prone to diseases and unsustainable burden on the eco system. It reduces the colonization of plant roots with mycorrihizae and inhibit symbiotic N fixation by rhizobia due to high N fertilization. Nutrients are easily lost from soils through fixation, leaching or gas emission which lead to reduced fertilizer efficiency.

It can be said with certainty that sustainability can never be achieved as long as the agricultural practices continue with the use of massive chemical fertilizer. Under this situation, bio-fertilizers offer great potential not only for improving soil fertility but also for efficient use of various recourses for increasing crop production on sustainable basis. Bio-fertilizer is a special type of ingredients carrying microorganisms that make the soil available with some essential elements necessary for plant nutrition. '**Bio'** means living thing, naturally bio-fertilizers refer to living, microbial inoculants that are added to the soil.

They produce organic nutrients for the soil, are extremely beneficial in enriching the fertility of the soil and fight against the diseases. Biofertilizers are helpful in naturally available nutrient mobilization during harvesting(Venkatashwarlu, 2008). Again bio-fertilizer does not contain chemicals that are damaging to the fertile soil.

There is an increased emphasis on the use of bio-fertilizer world wide on the environmental ground. Biofertilizers are the organism that enrich soil quality with our any side effects The mail sources of biofertilizers are blue green algae, fungi, bacteria etc. Biofertilisers make nutrients that are naturally abundant in the soil or atmosphere available for use by plants and help to balance many of the negative effects of chemical based technology (Ghosh, 2004)

The most important and attractive nature if these with the plant is the mutual interdependence and both of the partners benefitted from each other. Biofertilizer can be placed as the best modern tools for sustainable agriculture or green agriculture.

With this back ground, the present work attempts to study the use of bio-fertilizer with respect to Indian agriculture.

METHODOLOGY

Objective

The specific objectives of the present work are

- to study the impact of bio-fertilizer use on agricultural production in India.
- to study the extent of bio-fertilizers use in the different states of India

Data sources

Secondary data has been collected from different reports and publications of CMIE, IFFCO, FAI, Agricultural Statistics at a glance etc.

Statistical tools used:

Exponential growth rates have been calculated for the present study. Linear regression model is used to capture the relationship between production of bio fertilizer and agricultural output considering state level cross section data for the year 2011-12.

$$B_p = a + bGDP_{agl} + u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where B_p is the biofertilizer production

GDP_{ag} state domestic product from agriculture

HISTORY AND IMPORTANCE OF BIO FERTILIZER

History of Bio-fertilizer

Biofertilizers differ from chemical and organic fertilizers in the sense that they do not directly supply any nutrients to crops and are cultures of special bacteria and fungi. The production

technology for biofertilizers is relatively simple and installation cost is very low compared to chemical fertilizer plants. Bio-fertiliser are the low cost source of plant nutrients, environment-friendly and have auxiliary role with chemical fertilizers.

Historically, the bio-fertilizers were initially identified by a Dutch scientist in 1888 there after bio-fertilizer use started with the launch of Nitragin by Nobe and Hiltner with a laboratory culture of Rhizobia in 1895 (Ghosh, 2004).Then subsequently Azotabactor, Blue green algae etc. were discovered. Among the resent discoveries the most popular bio-fertilizers are Azospirillum, Vesicular Arbuscular Microrrizae etc.

In India the first commercial production of bio-fertilizer started in 1956 under the supervision of N.V Joshi. India's Ninth Five Year plan document talked of environmentally sustainable agriculture among many modes of means to promote sustainable growth. A Scheme by the name of National Project on Development and Use of Bio-fertlizer (NPDB) was implemented by India Government for the production distribution and promotion of bio-fertilizers. A National Bio-fertilizer Development Centre was established at Ghaziabad to promote the training program related to the promotion of bio-fertilizer in India. The NIKU Bio Research Laboratory was established in the year 1997 at Pune. The initial name signifies N=Natural, I=Input, K=Complete and U=Utilization. The Tenth Plan document emphasized the use of bio fertilizers, bio-control agents, organic manures etc. with infrastructure support. Now the role of bio-fertilizer following principles of sustainable development is obligatory for all forms of Indian agriculture.

Important Bio-Fertilizers
There are wide varieties of biofertilizer in use. Some of the important biofertilizer are mentioned below with a brief explanation about the salient features of the product.

Rhizobium
Rhizobiums are symbiotic bacteria that fix atmospheric N_2 gas in plant root nodules and have a mutually helpful relationship with their host plants. The plant roots supply essential minerals and newly synthesized substances to the bacteria. It is reported that rhizobium can fix 50-300 kg N/ha.

Azotobacters
It is free living and non-symbiotic nitrogen fixing organism that also produces certain substances good for the growth of plants and antibodies that suppress many root pathogens.

They can fix 15-20 kg/ha N per year. Azotobacter can also produce antifungal compounds to fight against many plant pathogens. They also increase germination and vigour in young plants leading to improved crop stands.

Azospirillum
This is also a nitrogen-fixing micro organism beneficial for non-leguminous plants. Azospirillum transcend nitrogen enrichment through production of growth promoting substances.

Phosphate-solubilizing bacteria (PSB)
Under acidic or calcareous soil conditions, large amounts of phosphorus are fixed in the soil but are unavailable to the plants. Phosphobacterins can make insoluble phosphorus available to the plant. The solubilization effect of phosphobacterins is generally due to the production of organic acids that lower the soil pH and bring about the dissolution of bound forms of phosphate. PSB culture increased yield up to 200-500 kg/ha and thus 30 to 50 kg of super phosphate can be saved.

Vesicular arbuscular mycorrhiza (VAM)
VAM fungi infect and spread inside the root. They possess special structures known as vesicles and arbuscules. The plant roots transmit substances to the fungi, and the fungi aid in transmittingnutrients and water to the plant roots. The fungal hyphae may extend the root lengths 100-fold.

Plant growth promoting rhizobacteria (PGPR)
PGPR represent a wide variety of soil bacteria which, when grown in association with a host plant, result in stimulation of host growth. PGPR modes include fixing N_2, increasing the availability of nutrients in the rhizosphere, positively influencing root growth and morphology and promoting other beneficial plant–microbe symbioses. PGPR (Plant growth promoting Rizobectaria) is a special type of bacteria (Rhizo) colonizes in the rhizosphere (a thin layer of soil occupied by soil) very popular part of bio-fertilizer project over the world.

Blue Green Algae (BGA)
BGA are photosynthetic nitrogen fixers and are free living. They are found in abundance in India. They too add growth-promoting substances including vitamin B12, improve the soil's aeration and water holding capacity and add to bio mass when decomposed after life cycle.

Azolla
Azolla is capable of fulfilling the N requirements of the plant by the process of nitrogen-fixation.

The recommendations of different bio-fertilizer for different crops are shown in Table1.

Inoculation of biofertilizers
Biofertilizers are generally applied to soil, seeds or seedlings, with or without some carrier for the microorganisms. It creates extra cells which are unlikely to have a beneficial impact on the plant. In addition, the population of introduced micro-organisms will decline and be eliminated in a very short time, often days or weeks. The formulation of inoculums, method of application and storage of the product are all critical to the success of a biological product. Short shelf life, lack of suitable carrier materials, susceptibility to high temperature, problems in transportation and storage are biofertilizer bottlenecks that still need to be solved in order to obtain effective inoculation.

Importance of Bio-fertilizer
From the literature survey, the following conclusions can be drawn regarding the impact of bio-fertiliuzer use:

- Reduce over dependence on chemical fertilizers and pesticides that has created problems in agriculture[Chaturvhedi, 2006]
- Farming with bio-fertilizer involves natural pesticides, resulting in -no reduction to nutrient value of vegetable.
- Nutritional quality significantly higher in the grown bio-fertilizer produced product[Pascale, S. De. et al,1995]
- Bio-fertilizer works as a vegetative and yield growth promoters []
- It is beneficial always in terms of soil fertility, ecological health etc.[]
- Helpful for Sustainable Agriculture[].

Table-1
Recommendations of different Bio-fertilizer for various crops

Bio-Fertilizer	Recommended Crops
Rizobium	Pluses, Oilseeds, Fodders
Azospirillum	Rice, Wheat, millets, maize, sorghum, sugarcane
Azotobactor	Rice, Wheat, millets, other cereals, cotton, vegetables, sunflower, mustered, flowers
Blue Green algae	Submerged rice
Azolla	Submerged rice with maximum temperature
PSM	All crops

Source: FAI, 2006-07

ANALYSIS OF DATA

Scenario of bio-fertilizer

There is no doubt chemical fertilizer and pesticides have played a definite positive role so far as increasing the productivity of Indian agriculture is concerned but that has been at the cost of low soil fertility, health hazards, environment pollution etc. Yield of food-grain in India, which was 644 k.g. per hectare in 1966-67, increased to 1636 k.g. per hectare in 2000-2001.One of the main important reason behind this was the increase in fertilizer consumption from 1.1 million ton to 13.56 million tonness during the same period. However, the sustainability part of it was not taken in to consideration. Now after much damage was done to the eco-cycle by this product, usage of bio-fertilizer & bio-pesticides, organic farming, biodynamic farming, low input agriculture, perm culture, sustainable agriculture integrated farming practices were initiates and are some of the practices that were started by the developed as well as the developing countries (Kolanu & Kumar, 2007) to make the agriculture sustainable. In India, based on the gross cropped area of around 190 million hectare, the potential demand of bio-fertilizers is estimated to be about 6,27,000 MT (Phadke, 2001). However, the production target was just 4.8% of it.

Both State and Central Governments have been promoting the use of the growth rate of chemical fertilizer (around 15%) continues to be higher than the growth rate of bio fertilizer (around 11%) in India. From 1992-93 to 20010-11 the increase in the production of chemical fertilizer was 12154.5 tonnes to 27790 and the figures are 2005 and 37997.61 tonnes respectively for bio-fertilizer (Table-2).

Table-2
Production of Chemical and Bio-Fertilizer in India

Year	Production of Chemical Fertilizer (tonnes)	Production of bio fertilizer (tonnes)
1992-1993	12154.5	2005
1993-1994	12366.3	3084
1994-1995	13563.8	5800.5
1995-1996	13876.1	6692.3
1996-1997	14308.1	7406.6
1997-1998	16187.8	7104.6
1998-1999	16797.5	5972.1
1999-2000	18069.7	5716
2000-2001	16702.3	6242.7
2001-2002	17359.7	9019.2
2002-2003	16090	7181.7
2003-2004	16800	8701.4
2004-2005	18398	10479
2005-2006	20340	11752.4
2006-2007	21651	15871
2007-2008	22571	20111
2008-2009	24909	25065
2009-2010	24686	20040
2010-2011	28122	37997.61

Sources: Agriculture at a glance, Directorate of Economics & Statistics, Ministry of Agriculture, Govt. of India, FAI

The region wise distribution of bio-fertilizers is more dispersed relative to chemical fertilizers (Table-3). The standard deviation of the distribution of bio fertilizer is calculated 28.33 and that of the chemical fertilizer is 8.4. As shown in Table-3, the distribution of bio- fertilizer in the Western region is the highest, 46%. Southern India has the second largest bio-fertilizer using region. In spite of the huge agricultural production base the distribution of bio-fertilizer in the Northern region is still very low only 5%.

Table-3
Region wise distribution of Chemical and Bio-Fertilizer (2005-06)

Region	Chemical Fertilizer (tones)	Bio-Fertilizer (tones)
East	3417(17%)	385.96(3%)
West	5077(25%)	5271.48(46%)
North	6420(32%)	544.44(5%)
South	5425(27%)	5155.74(45%)

Source: FAI
Note: Figures in the parentheses are the percentages

As shown in Table-4, even though the growth rate of both production and consumption of bio-fertilizer in India is quite satisfactory, there remain a huge gap between the installed capacity and production of bio fertilizer (Table-4) in India. Gap is also observed between the production and consumption level. It is quite surprising that the gap between installed capacity and production is diverging over the years.

Table-4
Installed Capacity, Production and Despatches of Bio-Fertilizer in India

Year	Installed production Capacity (tonnes)	Total Production (tonnes)	Total Dispatches (tonnes)	Unutilized capacity percentage
1992-93	5400.5	2005	1600.01	62.87
1993-94	6125.5	3084	2914	49.65
1994-95	8114.5	5800.5	4988.9	28.52
1995-96	10680.4	6692.3	6288.3	37.34
1996-97	12647	7406.6	6681.4	41.44
1998-99	16446	5972.1	5065.5	63.69
2001-02	15439.0	9019.2	8429.3	41.59
2002-03	18679.5	7181.7	7029.9	61.55
2003-04	18632	8701.4	8357	53.30
2004-05	NA	10479	10428	-
2005-06	NA	11752	11358	-
2006-07	43495	15871	15745	63.51
2007-08	67162	20111	20100	70.06
2008-09	68804	25065	25000	63.57
2009-10	68078	20040.3	20000	70.56

Source: Bio Fertilizer Statistics FAI.

Among all the bio-fertilizer in India during 2006-07 production of PSB was observed maximum , 2920.42 tones (Table-5). Azolla is relatively new in use and its production was only 13.40 tonnes in 2006-07 though the figure was 25 tonnes in 2005-06.

Table -5 Year wise production of different Bio-fertilizer(tones) at all India level

Bio-Fertilizer	2001-02	2003-04	2005-06	2006-07
Rizobium	1841.54	1822.94	1548.53	1579.66
Azotobacter	1324.74	1386.75	1874.93	2037.75
Azospirillum	1275.50	1159.26	1228.75	1283.70
PSB	4502.22	4005.18	6075.52	6920.42
Azolla			25	13.40

Source: Bio Fertilizer Statistics FAI

Table 6 shows the state wise production of Bio-fertilizer in India for the year 2011-12. Maharashra is the state where the bio fertilizer production is maximum. Few states like J & K , etc. are still abort to starts bio-fertilizer production.

Table-6
State wise production of Bio-fertilizer in India,2011-12, (tones)

Maharashtra	8743.69
Uttar Pradesh	8695.08
Karnataka	5760.32
Tamil Nadu	3373.81
Madhya Pradesh	2309.6
Delhi	1617
Tripura	1542.85
Andhra Pradesh	1126.35
Haryana	914.41
Kerala	904.17
Punjab	692.22
West Bengal	603.2
Orossa	590.12
Pondichary	509.45
Gujarat	276.34
Uttraakhand	263.01
Rajasthan	199.78
Bihar	75
Assam	68.33
Nagaland	13
Jharkhand	8.38
Himachal Pradesh	1.29
J&K	0
Chandigarh	0
Goa	0
Mizoram	0

Source: Bio Fertilizer Statistics FAI

Simultaneous use of bio and chemical fertilizer

Even though bio-fertilizer is superior to chemical fertilizer in terms of sustainable agriculture, its immediately its complete replacement in place of chemical fertilizer is not possible. A modality of balanced path that involves combined use of chemical and bio-fertilizer can be evolved. Sundara et al. (2002) observed that the application of PSB, Bacillus megatherium var. phosphaticum, increased the PSB population in the rhizosphere and P availability in the soil. It also enhanced sugarcane growth, its yield and quality. When used in conjunction with P fertilizers, PSB reduced the required P dosage by 25%. In addition, 50% of costly superphosphate could be replaced by a cheap rock phosphate, when applied in combination with PSB. Young et al. (2003) studied the effects of a combined treatment of multifunctional biofertilizer plus 50% chemical fertilizer on lettuce yield. From his results it is observed that there was a 25% increase of lettuce yield for the treatment of ½ chemical fertilizer plus biofertilizer compared to that of the chemical fertilizer treatment, indicating that at least 50% of chemical fertilizer can be saved as multifunctional biofertilizer was used along with chemical fertilizer. Again an employment of multifunctional biofertilizer on rhizosphere microbial activity and the growth of water celery in a field showed that the dry weight of water celery in the treatment with 50% organic compound fertilizer with multifunctional biofertilizer was increased by 34% compared to the treatment with 100% organic compound fertilizer [Young. et. al, 2004].

Regression Result

Linear regression model is used to find out the relationship between production of bio fertilizer and agricultural output considering state level cross section data for the year 2011-2012. The following model is used.

$B_p = a + bGDP_{agl} + u_t$

Where B_p is the biofertilizer production, GDP_{ag} state domestic product from agriculture.

As shown in table-7, it is observed that there is positive significant relationship between the bio fertilizer use and agricultural output.

Table 7
Regression result of equation 1

		t values	R^2	F Value
Intercept	-216.281	-0.30061	.46	14.58*
Coefficient	0.000835	3.818178*		

*Indicate significant at 1% level

Role of Govt in Bio-Fertilozer Promotion

Government of India has been implementing the scheme for the promotion of biofertilizers since 7th Five Year Plan. Under this scheme, one national centre and six regional centres have been established. The main function of these centres include the promotion of bio-fertilizer through training, demonstration and supply of 10 efficient culture for production of bio-fertilizers. The scheme also aims for giving grant upto Rs. 20 lakh per unit of 150 tonnes per year to set up bio-fertilizer producing units. Since inception bio-fertilizer production capacity of 10,525 tonnes has been envisaged by setting up 83 bio-fertilizer production units. Out of these units, 9 units have been sanctioned by the Department of Fertilizers under their scheme of providing financial assistance for the purpose and 74 units have been financed by Department of Agriculture & Cooperation. Another 39 units have been set up by different organizations and private entrepreneurs with a production capacity of 7,975 tonnes per year. The estimated total fertilizer production capacity in India is 18,500 tonnes per year, whereas estimated bio-fertilizer production is about 10,000 tonnes per year in the country.

The promotion of bio-fertilizer also needs extensive extension work to convince the farmers about the need of bio-fertilizer use for increase in productivity. Seminars on bio-fertilizers and micronutrients are regularly being organized by Govt. Of India which are attended by executives of fertilizer industries, agriculture research and extension specialists, academicians, administrators, policy makers and farmers. Marketing of bio-fertilizer is a very difficult task as they are not primary inputs like seed and fertilizer. Again, the farmers' acceptance to bio-fertilizer use has been far from satisfactory. This is the main reason why effective demand has not been created so far. Even if in few cases there is the demand of bio fertilizer but its limited to few varieties like Rhizobium, Azotobacter, and Phosphorus Solubilizing Micro-organism.

As observed from Table 4 still there is significant amount of unused capacity of bio fertilizer production. To create awareness amongst the farmers and to popularize the product emphasis has been given to the (1).Demonstration (2)Field Day, group discussions and (3) farmers' visits to Agriculture Universities and bio-fertilizer units, literature, publicity, seminar and training.

Besides farmares awareness there are also some other technical constraints of the promotion of bio fertilizer in India. Like: Marketing constraints , because of its short self life, lack of proper storage, consumer illiteracy, low awareness amongst consumers, inadequate guidelines to consumers, inadequate production/promotion effort.

Secondly Environmental constraints due to seasonal conditions, soil fertility, usage of high dose of chemical fertilizers, pesticides etc.

The Government of India and the various State Governments have been promoting the nascent biofertilizer market both at the level of the user-farmer and the producer-investor through (i) farm level extension and promotion programmes, (ii) financial assistance to investors in setting up units, (iii) subsidies on sales and (iv) direct production in public sector and cooperative organizations and in universities and research institutions. A National Biofertilizer Development Centre was established at Ghaziabad as a subordinate office of the Department of Agriculture and Cooperation with six regional centers. The purpose of the scheme covered organization of training courses for extension workers and field demonstrations and providing quality control services. Production and distribution of different biofertilizers were also undertaken but subsequently discontinued as the centers redefined their role towards R&D and HRD related activities.

CONCLUSION

There is no doubt that bio-fertilizers are the potential tools for sustainable agriculture not only in India but also globally. The use of bio-fertilizer in preferences to chemical fertilizer is always welcome taking into consideration the sustainability of agriculture and its eco benefits. It is beneficial also in terms of soil fertility, ecological balance etc. As, the use of bio-fertilizer, till so far, is grossly inadequate in India, more emphasis on its production, consumption and also proper distribution need to be taken into consideration. The Government of Indian has made substantial investments in biotechnology research, still more investments are required to achieve the target. The problem related to adverse climatic situation, soil condition, production technologies, storage, awareness among the farmers are also some of the important areas that need to be addressed. The recent global summit meet on climate change at Copenhagen has sustainable agriculture as one of its core discussion area within the aimer of climate change and green house effects. Hopefully with more awareness and demand from the consumers for bio-fertilizer produce will result in farmers opting for bio-farming. This would make batter marketing zone as well as render our planet as better place to live.

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