A CASE STUDY

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Biofertilizers and its impact on CRP production in Parbhani district

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INTRODUCTION

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. Dependence on chemical fertilizers for future agricultural growth would mean further loss in soil quality, possibilities of water contamination and unsustainable burden on the fiscal system. 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. Consistent with current outlook, the government aims not only to encourage their use in agriculture but also to promote private initiative and commercial viability of production. This paper analyses available industry side data to find only a limited extent of success till date. There has been no accelerated growth in distribution with time, inadequate spatial diffusion and despite entry of small private units into the industry there is no clear indication of the success of privatization. The paper however argues that considering the social benefits promised the government has ample grounds to intervene to set up an effective market for the new product while encouraging private players. But the policy and the instruments of intervention need to be designed with care.

Failure of a market to build up calls for public intervention when the expected social gains from a relatively new product outweigh the costs whereas the private gains do not. Uncertainty about the product performance coupled with long periods of learning involved can lead to poor demand from end users who are farmers. Even in the context of market liberalization, the government has some role to play to induce a socially optimal investment level and set up an effective market so long as market information is imperfect. However the exact nature of the role and the policy instruments to be used must be decided with a clear understanding of the strengths and weakness of agents involved (Stiglitz, 1989). Biofertilizers make nutrients that are naturally abundant in soil or atmosphere usable for plants. Field studies have demonstrated them to be effective and cheap inputs, free from the environmentally adverse implications that chemicals have. Biofertilizers offer a new technology to Indian agriculture holding a promise to balance many of the shortcomings of the conventional chemical based technology. It is a product that is likely to be commercially promising in the long run once information becomes available adequately to producers and farmers through experience and communication.

There is an ongoing attempt to promote biofertilizer in Indian agriculture through public intervention, and in keeping with the spirit of the times, the policy motivates private sector and profit motive to propel the new technology. The question raised in this paper is how successful has the intervention policy been in Indian agriculture. 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 the following measures: (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. Over time as the industry emerges from infancy with public guidance, the following observations will be expected: (a) increasing sales volumes and diffusion across the country, (b) greater role of profit motivated private enterprise. Since information on farm level usage of biofertilizers or profitability of units are not reported till date, one way to get about is by following the secondary indicators as incorporated in (a) and (b).

Biofertilizers, more commonly known as microbial inoculants, are artificially multiplied cultures of certain soil organisms that can improve soil fertility and crop productivity. Although the beneficial effects of legumes in improving soil fertility was known since ancient times and their role in biological nitrogen fixation was discovered

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more than a century ago, commercial exploitation of such biological processes is of recent interest and practice.

The commercial history of biofertilizers began with the launch of 'Nitragin' by Nobbe and Hiltner, a laboratory culture of Rhizobia in 1895, followed by the discovery of Azotobacter and then the blue green algae and a host of other micro-organisms. Azospirillum and Vesicular-Arbuscular Micorrhizae (VAM) are fairly recent discoveries. In India the first study on legume Rhizobium symbiosis was conducted by N.V. Joshi and the first commercial production started as early as 1956. However the Ministry of Agriculture under the Ninth Plan initiated the real effort to popularize and promote the input with the setting up of the National Project on Development and Use of Biofertilizers (NPDB). Commonly explored biofertilizers in India are mentioned below along with some salient features.

Rhyzobium (RHZ):

These inoculants are known for their ability to fix atmospheric nitrogen in symbiotic association with plants forming nodules in roots (stem nodules in sesabaniamrostrata). RHZ are however limited by their specificity and only certain legumes are benefited from this symbiosis.

Azotobacter (AZT):

This has been found beneficial to a wide array of crops covering cereals, millets, vegetables, cotton and sugarcane. 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.

Azospirillum (AZS):

This is also a nitrogen-fixing micro organism beneficial for non-leguminous plants. Like AZT, the benefits transcend nitrogen enrichment through production of growth promoting substances.

Blue green Algae (BGA) and *Azolla:*

BGA are photosynthetic nitrogen fixers and are free living. They are found in abundance in India i. 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 is an aquatic fern found in small and shallow water bodies and in rice fields. It has symbiotic relation with BGA and can help rice or other crops through dual cropping or green manuring of soil.

Phosphate solubilizing (PSB)/Mobilizing biofertilizer:

Phosphorus, both native in soil and applied in inorganic fertilizers becomes mostly unavailable to crops because of its low levels of mobility and solubility and its tendency to become fixed in soil. The PSB are life forms that can help in improving phosphate uptake of plants in different ways. The PSB also has the potential to make utilization of India's abundant deposits of rock phosphates possible, much of which is not enriched.

Responses and limitations:

Crude calculations of bulk and cost in terms of N presented in Table 1 on the basis of reported nitrogen equivalence indicates that biofertilizers are cheap and convenient relative to chemical and farm organic fertilizers (FYM) and therefore have considerable promise for crops like cereals, oilseeds, vegetables and cotton. However, it is safer to note that the nitrogen equivalences reported for biofertilizers are only indirectly approximated through controlled experiments since the way of accessing nutrients itself in indirect unlike nutrient *containing* chemical fertilizers and manures, and the comparative values of bulk and cost may not be realistic. Nevertheless, a crude estimation is attempted for indication of the potential without attaching significance to the magnitudes as such.

Biofertilizers have various benefits. Besides accessing nutrients, for current intake as well as residual, different biofertilizers also provide growth-promoting factors to plants and some have been successfully facilitating composting and effective recycling of solid wastes. By controlling soil borne diseases and improving the soil health and soil properties these organisms help not only in saving, but also in effectively utilising chemical fertilizers and result in higher yield rates.

However while positive responses have been observed in a wide range of field trials, there is remarkable inconsistency in responses across crops, regions and other conditions. Even for a given crop the range of response is quite high. For example in a sample of 411 field trials carried out across districts, plant responses to inoculation with Azotobacter in irrigated wheat was observed to be significant in 342 cases and ranged from 34 to 247 kg/ha. (Hegde and Dwivedi, 1994). Legume inoculation by *Rhizobium* is the most long established practice but the responses indicated by the All India Coordinated Agronomic Research Project in the cases of mungbean, uradbean, soyabean, cowpea and groundnut all under irrigated condition were significant only in a small proportion of locations tried and failed in others. Residual effect on soil pool was not noted in most cases. The

Table1: Relative cost of access to plant nutrient (N) crop fertilizer for 1 kg nitrogen

Type	Treatment Incoculant/unit	Weight kg	Price Rs./kg Bulk Cost 5	Weight kg Rs./kg
Biofertilizers				
Rice AZS seedling	2.5	29.12	0.13	3.64
Wheat AZT seed	1.5	34.37	0.75	2.58
Oilseeds AZT seed	0.2	34.37	0.01	0.34
Groundnut/Soybean RHZ seed	1.5	30.89	0.07	2.26
Maize/Sorgum AZS/AZT seed	0.5	29.12-34.37	0.025	0.73-0.86
Potato AZT soil/tuber	4.5	34.37	0.225	7.73
Vegetables AZS/AZT seed	0.5	29.12-34.37	0.25	0.73-0.86
Sugarcane AZT soil	4.5	34.37	0.225	7.73
Cotton AZT seed	0.8	34.37	0.04	1.37
Flowers AZS/AZT seedling	1.75	29.12-34.37	0.09	2.55-3.01
Chemical Urea soil	1000	4.8	2.17	7.96
Organic FYM soil	1000	0.14	555.56	79.37

Note: Vegetables - radish, spinach and ladysfinger; Oilseeds -Mustard sesamum
Flowers - merigold, other seasonal plantation and ornamental plants
Nitrogen equivalence of inoc./unit: AZS and AZT -20Kg N and RHZ-19-22Kg N;
Urea - 46% N; FYM – 3.6Kg NPK (2:1:1) per Tonne as per FAI. Unit weight of inoculant is as recommended dosage.
Important: The comparisons with Biofertilizers are only indicative as quantitative values are only approximations.

variance of responses is similar for AZT and AZS. Dryland agriculture constitutes a very large part of agricultural area in India and also houses the majority of the poor. More than 90% of coarse cereals, 80% of groundnut and 85% of pulses come from these regions. Low productivity, unpredictable climatic swings and low dosage of chemical fertilizers also characterise agriculture in drylands. Biofertilizers, particularly Rhizobium, could be a bridge between removals and additions to soil nutrients where farmers can scarcely afford costly inputs and that too in a risky environment. But consistency in gains again eludes the trials conducted by All India Coordinated Pulse Improvement Project. The responses usually depend on several environmental factors. The type of soil as easured by its water holding capacity, its levels of other nitrates, phosphate and even calcium and molybdenum (that help in protein synthesis in Rhyzobia) and the alkalinity, salinity and acidity of soil all affect the response. Higher dose of mineral nitrogen as starter suppresses nodulation, reducing response of Rhyzobium but phosphate deficiency can be an inhibitor also. The inadequacy of organic matter especially common in dryland agricult ure is a deterrent more for the non-symbiotic strains, which essentially depend on soil organic matter for energy.

Phosphobactrin response was found to be positive only in soils with high organic content and low available phosphorous. Soil water deficit and high temperature (hyper-thermia) are prominent abiotic factors that affect nitrogen fixation in dryland agriculture. Native microbial population opposes the inoculants. In general predatory organisms, often already present in the soil are more adapted to the environment and out compete the inoculated population.

Apart from environmental factors, deficiencies in handling procedure are a major cause of under performance in real life application. The high sensitivity to temperature and other external conditions of these ‘living’ inputs, calls for enormous caution at the stage of manufacture/culture, transportation/distribution and application. This involves investment and time in research (for more tolerant strains), packaging, storage and use of suitable carrier materials.

Government intervention in biofertilizer market:

To attain production targets, the Government of India implemented a central sector scheme called National Project on Development and use of Biofertilizers (NPDB) during the Ninth Plan for the production, distribution and promotion of biofertilizers. 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 and D and HRD related activities. Capacity creation and production was however encouraged through one time grant for new units. The financial assistance, given as grant-in-aid to the tune of Rs 13 lakh and now increased to Rs 20 lakh per unit and thrown open for all, was routed through the State governments but owing to delays in release of grants the onus is transferred to NABARD/NCDC. The public sector organizations form a bulk of the units in the industry, while similar units in the private sector are also coming forward. Different State governments also provide subsidies sometimes up to 50% of the sales realization but the manner of subsidization is rather unsystematic. In many cases the discrimination and manipulation in subsidizing lead to a lot of intra industry variation in prices. The government also plays a dominant part in marketing biofertilizers in three possible channels: (a) State government via District level Officers and Village level workers to faremrs, (b) State Marketing federation via cooperative bodies to farmers and (c) State Agro-industries.

Data:

The Fertilizer Association of India (FAI) periodically presents information compiled on capacity and distribution of biofertilizers by various units. In the absence of reported information on farm level use of the inputs, this can help in understanding the progress of the technology and its adoption in India. The period covered by the data is 1992-93 to 1998-99. The FAI report gives the distributions of different strains for recent years by states that can proxy for usage by farmers. For a better understanding of the demand for use, firm level information on capacity, distribution and prices would be more useful. However the FAI could not report for all existing producing units due to their non-responses and this irregularity is more for distribution and prices. So the inferences drawn in the present study are only based on the samples that report the required information. The FAI reports (1996, 1998, 2001) give information of annual distribution levels of various inoculants and their sale prices for consecutive years by firms. In addition the annual capacity as of March is provided for the three years 1995, 1997 and 1999.

Success of biofertilizer technology:

Government of India and the different State Governments have been promoting use of biofertilizers through grants, extension and subsidies on sales with varying degrees of emphasis. With time farmers too learn about the technology forming their perception on the basis of agronomic realities of their regions, the knowledge gained from experiences of farmers around them and including themselves and the information provided by different disseminating agents and form their own decisions of adoption. Above all the enterprise of the firms working through their marketing, research and development efforts would lead to the widespread use of the inputs once the prospect of profit is sensed. commercial appeal with the passage of time and government support.

Progress of the industry:

Based on the data for 1995, 1997 and 1999 it appears that the industry witnessed a steady increase in the number of units producing the input. Over the period of four years the number of units went up by 53% from 62 to 95 and further to 122 in 2002 (Ministry of Agriculture, GOI). The total capacity expanded by 102% going by the information on units reporting their capacities.

New private units joined the industry improving their numeric share while the public sector, after the initial burst slowed its pace. However, a deeper look would be more illuminative. The total distribution as reported by the unitsii on an annual basis increased over time at an impressive rate of over 50%. However it is clear that the bulk of the growth took place by 1992-95 of the sample period and stagnated thereafter. There are also changes in shares by types with moderate success in AZT and by far the best performance by PSB. The decline in RHZ indicates success in groundnut and pulses was below expectation. Table 2 gives the distribution and annual capacity of units deflated by the number of units. A measure of capacity utilized is obtained relating actual distribution (as opposed to production) to capacity.

The industry has been going through an adjustment of size as average capacity of a unit came down from 261.8 tonnes to 205.6. The capacity addition in the industry was less relative the addition of new units due to entry of lower sized new units. The average distribution also declined in the first two years possibly signaling the need for a down size and picked up subsequently. The average

Table 2 : Average capacity, distribution and capacity utilization of units

Year	Capacity (Tonnes)	Distribution (Tonnes)	Capacity utilisation
1994-95	261.8	111.3	0.43
1996-97	225.8	87.91	0.39
1998-99	205.6	94.37	0.46

Note: Calculated for only Units reporting Capacity, Distribution NBFDC and RBDCs are treated as single unit
Capacity utilization is measured as distribution divided by capacity
Capacity of 1994-95 is as of March 1995 and so on

capacity utilization has been poor but the down sizing may have arrested the declining trend.

Diffusion:

The chemical based fertilizer technology incorporated in the green revolution was successful by its rapid adoption rate but the unbalanced spread across the country, especially in the eastern region marks a crucial failure. The central government's role in the new biofertilizer technology would be justified by greater spatial dimension of the success.

Structure of industry and econometric analysis to explain distribution:

Based on the 50 units that reported capacity (details given in Appendix A-II), distribution and prices in 2009-2010, accounting for nearly 85% of distribution presents the structure of the industry. An econometric analysis will attempt to use this information to explain the distribution performance by the structural components of the industry. The capacity of a unit is defined by the various facilities of production including equipment for various operations, infrastructure and space. Labour and raw materials are essential variable inputs for actual production as summarized in Appendix A-I for a given capacity and using this general norm and the actual production levels, annual man-days of employment generated by a unit can be estimated. Due to the complex nature of the process involving laboratory culture of life forms, that requires definite combinations of space, equipment and time, there is little substitutability among the inputs.

Numerous studies on technological evolution emphasized the developmental role of a firm (Chandler, 1993) and the strength of its sales network, creating market and drawing market feedback, for its success. In general, firms with larger production facilities are expected to invest more on networks to understand and access the market but it is not uncommon for firms with larger distribution networks to act as marketing agents for smaller units who are lacking and in few rare cases like that of NAFED the distribution even exceeds capacityiii. The sales networking would be stronger also for concerns that are in some way already in the business of selling agricultural inputs. Since the exact scope and nature of the units or possibly their parent companies is not clear from the data, past experience in selling biofertilizers may be considered as an indicator of their marketing capabilities. Judging by the sample information, units that record a cumulative distribution of more than 100 tonnes over the previous 3 years are deemed to be enjoying greater selling experience and broad based net-workings. While the cumulative distribution performance takes care of 'le arning by doing' opportunity of the firm a possible additional characteristic could be the age or vintage of the unit, which also allows for 'learning by looking' opportunity. Since data on vintage is not readily available, those that existed and reported for March 1995 are classified as older units (VINT). Units that produce both nitrogen fixers and phosophate solubilisers are categorized as joint producers (JOINT). Production of biofertilizer started in India with significant government involvement with active participation of the public sector that is directed more by public policy and social objectives than 13 profit. The extent of commercial success would be indicated by the participation of private commercial units so long as market is free for entry. The private firms that reported can be categorized as private (PVT) and others that include universities, research institutes, cooperative, agro-marketing and other public sector organizations. Finally, the regional distribution of the firms is of interest in view of the tendency of concentration observed. Going by a size categorization of units based on sample average capacity of the units as the cut off size, less than 30% of units are classed as large, with majority being relatively small units. The share of private sector is much larger (64%) for the smaller units than the larger ones (36%). More than 70% of the large units are of longer vintage reiterating that new entry has been mostly in small units. About 70% of the small units came into being after March 1995. The small units show some tendency to specialize in either nitrogen fixers or phosphate solubilisers while all the large units produce both kinds. Both size categories show regional bias for west, followed by south, though smaller units have relatively greater presence in south as also in east where there is no presence of large units. The average capacity differs widely between the two categories, as does employment generation but large units record higher capacity utilization. Average price charged is marginally in large units.

Appendix A-I:

Requirement of Some Inputs for Production of Biofertilizers:

Production capacity 75 tonnes/year equivalent to 375000 packets (each packet 200 grams)

Labour use

Number of working days 240 days

Number of shifts 1 = 8hours

Number of daily wage labour

Unskilled 3

Skilled 1

Total man hours per year

7680

Carrier for 1000 packets 120Kg (Peat, Lignite, Charcoal)

Equipment (Autoclave, Refrigerator, Hot air oven, microscope etc .)

Packaging material (LDPE, HDPE, Polypropylene).

Rooms for Inoculum, Carrier, Office.

Source: BioFertilizer Statistics 2009 2010

Appendix A-II:

Units considered for Regression Analysis accounting for 85% of Distribution 1998-99

Names of Units

<0.2% total distribution State

Micro Biological laboratory ,Pattambi Kerala

Pyrites, Phospahates and Chemicals, Amjhore Bihar

College of Agriculture, Marathwada Agricultural University, Parbhani Maharashtra

University of Agricultural Sciences, Dharwar Karnataka

Bharat Laboratory and Biological House for Agriculture, Dhule Maharashtra

Godavari Fertilizers and Chemicals Ltd., Secundrabad Andhra Pradesh

Lakshmi Bio-techs, Cuddalore Tamil Nadu

Regional Soil Testing Laboratory, Rajendranagar Andhra Pradesh

Ecosense Labs (I) Pvt. Ltd., Goregaon Maharashtra

Nodule Research Laboratory, BCKV, Mohanpur West Bengal

Bio Science Laboratories, Salem Tamil Nadu

Micro Bac India, Shyamnagar West Bengal

A.V.S. Agro Products, Ahmednagar Maharashtra

Institute of Nationla Organic Agriculture (INORA), Pune Maharashtra

Nav Maharashtra Chakan oil Mills Ltd., Pune Maharashtra

0.2% to 1% of total distribution

Biological Nitrogen fixation Scheme, College of Agriculture, Pune Maharashtra

Kisan Agro Chem, Dhanegaon Maharashtra

Magnum Associates, Chennai Tamil Nadu

Monarch Biofertilizers and Research Centre, Chennai Tamil Nadu

Samarth Bio Tech Ltd., Hubli Karnataka

K-Ferts Lab, Nanded Maharashtra

Samruddhi Agrotech, Pune Maharashtra

Rhizobium Scheme Deptt. Of Agriculture, Durgapura Rajasthan

Maharashtra Bio-tech Industries, Pune Maharashtra

Maharashtra Bio-tech Industries, Pune Maharashtra

Vasantdada Sugar Institute, Pune Maharashtra

Based on the data provided by the Fertilizer Association of India this study finds that despite efforts the use of the input as indicated by the distribution has not grown steadily over time, has been way below projected levels and the there has been practically no diffusion across states, with about 90% of use accounted by western and southern regions. There has been entry of new units and significant capacity built up but average capacity has come down with a marginal improvement in capacity utilization. Private commercial units though open to entry have not improved their share in distribution. A regression analysis suggests that given the same capacity and other relevant conditions a private unit distributes less than others casting doubt on the commercial success of the industry. The analysis also indicates there is no intrinsic advantage that accounts for the evident concentration of the industry in specific regions. The State governments' own initiative possibly had greater role in guiding the spread of the technology than the central government's schemes.

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