Ecoenterprises for Sustainable Livelihood

Decentralised Production of Biofertilisers – *Azospirillum* and Phosphobacteria

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PREAMBLE

This report brings out the process followed in establishing decentralised biofertiliser production unit for *Azospirillum* and Phosphobacteria as an ecoenterprise to create local employment opportunity for rural Women Self Help Groups (WSHGs). In December 2003 the Department of Biotechnology funded project "Low cost biofertiliser production units at the village level as employment opportunities for rural women" was initiated. The aim was to test and set up decentralised production unit with demystified technology at the village level which would be run by WSHG as a means of additional income generation so as to ensure rural job opportunities as well as supply good quality biofertliser to promote good agricultural practices locally. The aims were

- To create awareness on the advantages of using biofertilisers
- To mass multiplication of the strains isolated from the local agro-ecological niche
- To develop locally available carrier materials
- To enhance the capacity of the rural women in the production of biofertiliser and
- To establish a biofertiliser production unit at the village level which would be managed by the women.

Following this an explorative survey was conducted in two villages one at Kuttathuavarampatti, Kannivadi region, Dindigul dt. and the other at Keezhsathamangalam, Puducherry and these two places were chosen for the establishment of the low cost biofertiliser production units. The survey revealed that the regions around the two villages were primarily involved in agriculture where rice, sugarcane, cereals, cotton and pulses were grown in large scale. About 50 % of the population of these villages belong to small and marginal farmers and the other 50 % were landless agricultural labourers. To enhance the income generation and to create awareness for the utilization of biofertilisers, decentralised production units were set up in these villages as pilot initiatives. Establishing these units at the village level was expected to create a lot of awareness among the men and women farmers and thereby increase the use of biofertlisers due to the easy availability of quality material in their own villages.

I. LOW COST BIOFERTILISER UNITS – RATIONALE FOR THE ESTABLISHMENT

It hardly needs to be emphasized that in a country like India where land is a limited resource and soil fertility a limiting factor, the only way of increasing the resource base is through increased productivity and for this purpose use of external inputs play a vital role. For this reason, optimum use of inorganic fertilisers supplemented with farm manures, green manures, crop residue, industrial wastes and biological nitrogen fixation techniques is indispensable. This is more important in view of the fact that soil having low organic matter content is generally poor in fertility. Repeated use of chemical fertilisers destroys the soil biota, which is essential for good soil health. Agricultural land is also suffering from multiple nutrient deficiencies. This continuous nutrient depletion and imbalance can become staggering when we consider a future need of food production. India would need about 25 million tonnes of NPK in addition to 10 million tonnes of organic and bio-fertiliser sources to produce about 246 million tonnes of food grain required by 2010. Thus, food security in future also will be very much linked with efficient Integrated Plant Nutrient Systems (IPNS).

The objective of nutrient management strategies is to achieve the required crop yield in an efficient, economical and sustainable manner. There is a world-wide consensus now that sole dependence on chemical inputs based agriculture is not sustainable in the long run and that only IPNS involving a combination of fertilisers, organic and/or green manures, and biofertilisers are essential to sustain crop production, manage soil health and soil biodiversity. The economic burden and environmental cost of applying such a huge quantity of additional fertiliser is enormous. Even if a part of this increase in the need for nitrogen can be met from Biological Nitrogen Fixation (BNF) the likely savings are enormous. This is especially important for developing countries where farming will continue to be in the hands of small farmers.

The biofertiliser industry began production of inoculants in the 1970's. Initially imported cultures and carriers (peat) were used but with isolation of effective, indigenous cultures for all crops, these along with indigenously available carrier materials like lignite and powdered charcoal are used for the production of inoculants.

The biofertiliser demand for 2011 has been estimated at 30,000 tonnes. Use of eco-friendly biological software is an important criterion towards sustainable agriculture; the different types of biofertilisers consist of N_2 fixers (*Azospirillum, Rhizobium, Acetobacter,* blue green algae, *Azolla*), Phosphate Solubilising Bacteria (PSB) and fungi (mycorrhizae). Use of biofertiliser has steadily increased since the 1990s and at present the use of biofertilisers is about 10,000 tonnes/year. The production of biofertilisers in Tamil Nadu was reported to be 1400 t/year in 2006 by the Director of Agriculture, Chennai.

Soil management practices like correcting soil constraints, ameliorating nutrient deficiencies, recycling crop residues, application of Farm Yard Manure (FYM), composts. etc., are all crucial in ensuring successful biofertiliser performance. Increase in the success rate is being achieved by inoculation with Plant Growth Promoting Rhizobacteria (PGPR) mainly *Azospirillum*, *Pseudomonas* and *Bacillus* in major field crops, saving 25 % nutrients. Co-inoculation of *Rhizobium*, *Azospirillum*, Vesicular-Arbuscular Mycorrhiza (VAM) and Phosphorus Solubilising Bacteria have been found to be significantly better than their single inoculation. Inoculation with PSB or VAM was shown to save upto 8-10 kg P_20_5/ha in rice, wheat, groundnut, soybean and other crops.

When used properly, farmers have reported more vigorous crops (greenness), bolder grains and better yields. But the constraints are lack of timely availability of the inoculants at sowing time and supply of expired products. Insufficient extension efforts on utilization process have contributed to poor diffusion of biofertiliser technology. On the other hand the main constraints expressed by manufacturers are: unattractive carrier material, low shelf-life, lack of proper storage facilities, loss of quality on transportation, poor marketing, high risk and less profit discourages dealers. Adoption has been good wherever the manufacturer is doing "niche marketing".

Thus the aim of the pilot initiative was to address this problem through promoting decentralised production units, which would help the farmers have easy access to good quality inputs at the exact time when needed and also creates local employment opportunities.

II. ECOENTERPRISES FOR MULTIPLE LIVELIHOODS AND THE DELIVERY MODE

Women from small and marginal farm households and agricultural labourers with marginal annual income were targeted, mobilized and formed as WSHG with the following objectives:

- To inculcate the habit of savings and introduce internal crediting
- To enhance the skill and promote rural entrepreneurship
- To initiate/practice ecoenterprises to generate additional income and rural employment.
- To develop multiple livelihoods and achieve livelihood security

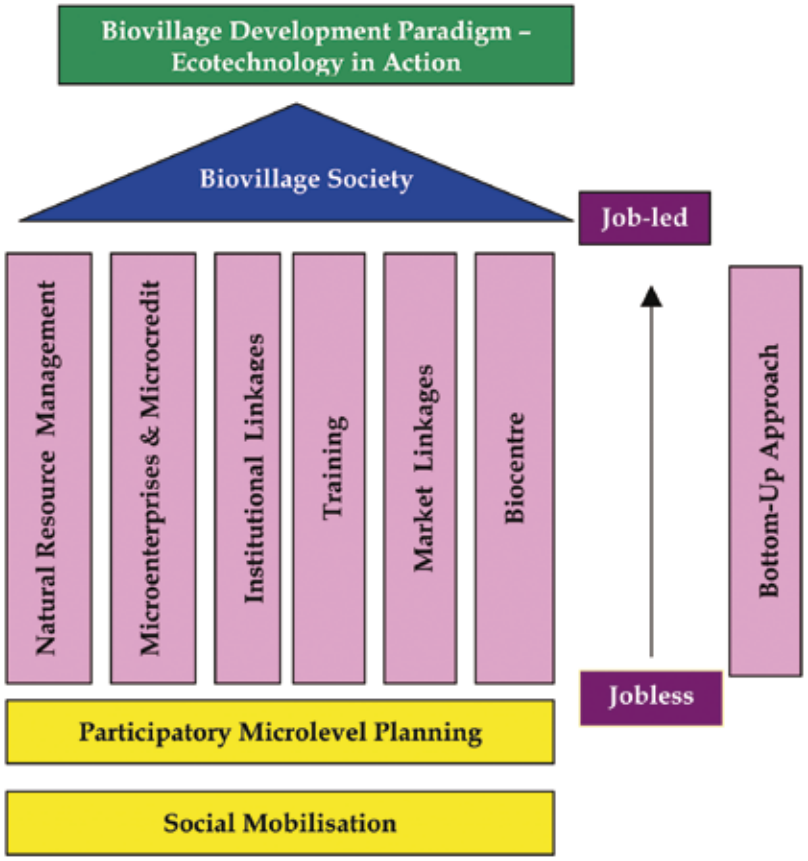

Fig.1 **Biovillage Paradigm**

The process starts with organization of village women, followed by group formation, training and capacity building, monitoring the various activities of the groups, identifying and establishing suitable ecoenterprises, collaborating with government and private development agencies, marketing firms and local commercial Banks.

Ecoenterprises and SHGs

Harnessing the benefits of science and technology is crucial to realize sustainable development in improving the living standards as envisaged in the UN Millennium Development Goals. Small scale enterprises are the second largest employment providers to the Indian workforce, next to agriculture. Though they provide employment, only 13 % are located in the rural areas serving rural populations. Currently, the employment opportunities in agriculture sector, especially for women, are declining due to modernization, agricultural intensification, change in cropping pattern, low income etc. Hence, it is essential to promote multiple livelihood opportunities in the rural sector, especially among women. Facilitating the access to technology as well as capacity building among rural poor will help to generate more employment opportunities and thus get higher income and diversify the livelihoods in rural areas. While entrepreneurship is recognized as an essential factor for economic growth, generally it does not help in conservation of nature. There is a need to mainstream environmental responsibility in entrepreneurship through ecopreneurship to overcome the irreversible environmental problems like climate change, biodiversity loss etc.

There is also a need to promote more green entrepreneurs due to the pull factor, namely, farmers' demand for environment-friendly products, which is an important opportunity for green ecopreneurship. It not only promotes environment-friendly products but also generates rural entrepreneurship among the rural women and men and creates eco-jobs in the rural areas.

Delivery System

Biovillage is an approach, which strengthens the capacity of the rural community to blend sustainable natural resource management with livelihood security through economically feasible, socially acceptable, ecologically viable and gender-sensitive interventions. This approach encourages a value addition process within the system, to generate sustainable eco-jobs and income in the village, based on principles that are pro-nature, pro-poor and pro-women. Biovillage is ecotechnology in action (Fig 1).

Biovillage model focuses on

- Enabling the community to understand the potentials of sustainable natural resource management
- Introducing various livelihood opportunities in on-farm and non-farm sectors, blending traditional knowledge with frontier technology
- Strengthening the human resource development through skill and knowledge empowerment
- Building grassroot institutions such as Self-Help Groups, Farmers Associations, Federations, etc. which will take up the development initiatives under the framework of Biovillage.

The activities include training, capacity building, field demonstrations, participatory research, strengthening the grassroot institutions and enhancing the multiple livelihood systems through optimum utilization of existing bio-resources. Under this approach encouragement is given to activities that do not affect soil, water or air; do not replace jobs; and do not affect the status of women. The essence of Biovillage lies in the community helping themselves in a sustainable manner and strengthening the forward-backward links within the rural economy. Thus, the Biovillage paradigm addresses the twin problems of development, *viz.* degradation of the resource base and endemic/persistent rural poverty.

MSSRF has integrated the concept of ecoentrepreneurship in the Biovillage programme. Ecopreneurship and microenterprises for generating livelihood opportunities and strengthening of grassroot institutions are the important aspects of the programme. Technological empowerment of the 'resource poor' is an integrated process, which involves the identification and adoption of environment-friendly and economically efficient technologies and interventions. It represents a Capacity building process that enhances the ability of the community to identify various options in livelihood strategies, technologies and sustainable management of natural resources, and to make an appropriate choice.

The ecoentrepreneurship is defined as the technical, managerial and marketing capacity of rural women and men to mobilize and organize themselves as entrepreneurs to produce environment-friendly products and services for sustainable development. Eco-jobs are defined as employment opportunities in the sectors that use natural resources efficiently and effectively without creating environmental instability.

With this framework, the establishment of the decentralised units was begun by a group of women members as an ecoenterprise to strengthen their livelihood

in the region of Kannivadi and later at Keezhsathamangalam. This document comprises the processes in enterprise identification, training, establishing the unit and marketing by the project team and group members.

Development Process and Approaches

The rural development projects implemented by JRD Tata Ecotechnology Centre of M.S.Swaminathan Research Foundation follow the Process Mode. The process of development is defined as mobilisation, organization, technology incubation, capacity building, systems management and role change. The process is not linear but cyclic.

Phase	Activities
Mobilisation	Socio-cultural activation, conscientisation, understanding each other
Organization	Creating platform, identifying the organization types, facilitating the communities to build organizations
Technology incubation	Identification of appropriate enterprises, participatory development and research
Training	Interactive learning; learning by doing, learning by evaluation
Technical support	Support in troubleshooting, technology upgradation, linking with experts and organisation
Systems management	Coordination for extension, networking with governmental departments, market agencies, academic institutions and other community based organizations.
Role change	MSSRF – from active facilitator to observer, and the local group/ grassroot organization playing a key role in defining the pathway of development and initiating developmental activities.

The selected activities follow the process mentioned earlier, and are selected in such a way that they should be:

- Economically viable
- Environmentally sustainable
- Socially equitable
- Energy efficient
- Employment generating

III. SOCIO-ECONOMIC PROFILE OF THE SITES

Two sites were selected to establish the unit *viz.*, Kuttathuavarampatti in the Kannivadi region of Dindigul district, Tamil Nadu and Keezhsathamangalam of Puducherry UT. The following are the broad factors for the selection of these two sites:

- The local agro-ecosystem, which has the potential to be used in cereals, cotton, pulses, sugarcane etc
- Relative awareness of the local farmers about the biological products
- Existing mode and available quantity in the local market and government extension service

Kuttathuvarampatti

Kuttathuvarampatti is a semi arid region located in the Reddiyarchatram Block in the Dindigul district of Tamil Nadu. It has 24 village panchayats. The total area covered is 33,025 ha. The total population of the block is 87,788. Of the total population 44,322 are males and 43,466 are females. The village is primarily agriculture based with a total area of 24,624 ha under cultivation, which includes both dry and irrigated lands. The members involved in agriculture are 29,568. The crops cultivated include lowland paddy, maize, vegetable and fibre crops as well as dryland pulses, millets and oil seeds in lesser quantities. Paddy and sugarcane are the two major irrigated crops grown in bulk. Statistical data for the year 2000-01 for the block indicates that the area under sugarcane cultivation was 12,000 acre, followed by 950 acres for paddy, 635 acres for maize, and around 5,000 acres for vegetables. Fruit crops like lemon, guava, hill banana and plantation crops like coffee are also cultivated in the mountain slopes located in the eastern side of the block. Working in the agricultural fields is the main livelihood adopted by the landless households. Agriculture labour is the main livelihood for these assetless households. The 'seasonality calendar' prepared by the men and women of the villages shows that the men have an average of 107 labour days and women 157 labour days and during the rest of the year both men and women of the hamlet remain unoccupied. Seasonal migration is a common practice. The rainfed crops are grown from October to December whereas the other crops are grown based on the underground water availability. The area is culturally heterogeneous; several communities with different occupations reside in the block. Among these communities Moopanars and Vetuvagoundars are the demographically dominant groups.

Keezhsathamangalam

Keezhsathamangalam is an arid region located in Villianur commune, Puducherry. It has 12 revenue villages. The total area covered is 12,490 acres. The total population of the commune is 1.12 lakhs. The commune is primarily agriculture based with a total area of 9,314 acres under cultivation, which includes both dry and irrigated lands. Nearly 2,156 acres of land is under non-agriculture use of which 452 acres is left as barren land. In this region paddy is the major crop intensively cultivated using ground water, normally with 2-3 harvests in a year. In addition, crops like sugarcane, pulses, groundnut, casuarina, tapioca, millets and oil seeds are cultivated in small amounts along with vegetables and flowers. The area is culturally heterogeneous; several communities with different occupations reside in the block but Keezhsathamangalam is culturally homogenous and the people belong to the schedule caste. Only about 7 % of the farmers of Keezhsathamangalam have land while the others are landless labourers.

These two villages fulfilled the criteria mentioned earlier and hence were selected for the establishment of the unit.

Use of Biofertiliser in the region

Before initiating the project, the agricultural extension office of Reddiyarchatram in Dindigul district was the primary source of supply of biofertilisers, especially *Azospirillum* and *Rhizobium*. The annual sales allotted to this centre is around 15-20 kg /year. They used to supply the products along with seed and other planting materials at subsidized costs. Access to Phosphobacteria was very limited, since it was available only in few commercial input centres. Apart from that the product was also of very poor quality. Due to these two factors awareness levels and practice was very low.

The use of biofertiliser by the farmers of the Keezhsathamangalam was moderate as the product was available at a subsidized rate from Pondicherry Agro Service and Industries Corporation Limited (Pasic) Puducherry. The farmers had the practice of using biofertilisers along with the recommended chemical fertilisers.

The project interventions helped to enhance awareness among men and women farmers of the region on different kind of biofertilisers and its crop specificity. A survey carried out during the year 2006 in Kuttathuavarampatti region indicates that 80 % of farmers who are either members of SHG federation/Farmers association indicated that they were aware of the technology and the products and have also been regularly using it. The unit is maintaining a list of potential farmers (nearly 70) who have been utilizing the products in the region as well as

in the nearby districts. During the last season the groups marketed nearly 20 % of the products locally. Similar conditions were observed at Keezhsathamangalam where the awareness on the use of biofertliser was increased by the initiation of the product when the local farmers came to the unit to buy the produce.

Considering the local cropping systems the initial focus was given to the production of *Azosprillum* and Phosphobacteria (details given in box) and proposed to add other biofertilisers production like *Rhizobium*, *Azotobactor* etc. later.

Azospirillum

Nitrogen fixing rhizobacteria *Azospirillum* has beneficial effects on both plant growth and yield of many crops and is of great agronomic importance. *Azospirillum* can utilize atmosphereic nitrogen and contribute to plant nitrogen nutrition, it can also improve the plant nutrient uptake and contribute towards the balance of the root environment through protection against pathogens and equilibrate nutrient flow in the soil. It can fix atmospheric nitrogen to the tune of about 15-20 kg/N/acre/year, which reflects in an increase in the crop yield by 15-20 %. It has the potential to reduce the consumption of chemical nitrogen fertiliser by 20-30 %.

Phosphobacteria

Several soil bacteria and fungi, notably species of *Pseudomonas* and *Bacillus* secrete organic acids that bring about the dissolution of the bound phosphates in the soil. P- solubilizing activity of these strains was associated with the release of organic acids and a drop in the pH of the medium. Different kinds of organic acids, namely citric acid, gluconic acid, lactic acid, succinic acid, propionic acid and three other unknown organic acids were produced from the cultures of these isolates. The utilization of phosphate-solubilising microorganisms (*Pseudomonas* and *Bacillus*), account for about 45 % of the total biofertiliser production and use.

IV. PROCESS OF GROUP SELECTION AND BRIEF SOCIO-ECONOMIC PROFILE OF THE MEMBERS

Selection of the WSHG Group

In both the regions, SHG federations have been consulted in identifying the suitable, interested SHGs to take up the biofertilisers production as an ecoenterprise. Kulumai is functioning in Dindigul district with nearly 150 SHGs and the Biocouncil in Pillayarkuppam of Puducherry with 300 groups since 2000. The primary objective of these two grassroot institutions is to facilitate and promote the multiple livelihoods among the rural men and women. Every month both the federations have SHG leaders meeting. During such meetings, the production technology, feasibility, utilization, relevance and benefits were explained to the SHG leaders about this enterprise and requested to share the same with the other members. At the beginning the leaders discussed with the respective members and in the subsequent meeting, the respective federations identified two such groups - Jhansi Rani WSHG, Kuttathuavarampatti in Kannivadi region of Dindigul district and Manimegalai WSHG of Keezhsathamangalam of Puducherry region. The federation predominantly used the following criteria to identify the SHGs:

- Members of the group are mostly agricultural labourers
- Socially and economically disadvantaged households
- Preferably women SHG that is three years old with good credit rating
- At least two of the group members should be semi-literates

Following this the respective federation leaders as well as MSSRF staff had a detailed discussion with the group members and explained the process involved and the role of members in taking it up as a collective group activity and gave examples by quoting models of already running units in the region.

Socio-economic profile of the group

Jhansi Rani WSHG was formed in October 2003. Initially the group had 14 women members. For the first six months, the group was involved only in internal credit and savings. The group members used the loan to strengthen their own family livelihood like agriculture, retail market, floriculture, dairy etc.

Baseline survey was conducted among the group members. Later while initiating the activity only ten members showed interest and their profiles are given here.

Table 1. **List of the members of the Jhansi Rani WSHG at Kuttathavarampatty, Kannivadi**

S.No	Name	Position in SHG	Age	Education	Occupation
1	Kulandai Therasa	President	40	B.A.	Agriculture labourer
2.	Ganachandira	Secretary	33	5 th	Agriculture labourer
3	Seviyar Theras	Treasurer	32	10th	Agriculture labour/ small farmer
4	Jeyanthi	Member	31	8 th	Agriculture labourer
5	Sirumani	Member	23	6 th	Agriculture labourer
6	Jeyasutha	Member	22	10 th	Agriculture labourer
7	Ritamary	Member	45	-	Agriculture labourer
8	Arbuthamary	Member	54	-	Agriculture labourer
9	Puspam	Member	25	10 th	Agriculture labourer
10	Stella Mary	Member	50	-	Agriculture labourer

Table 2. **List of the members of Manimegalai WSHG at Keelsathamangalam, Puducherry**

S.No	Name of the member	Position in SHG	Age	Education	Occupation
1	Rajalakshmi	President	19	BA	Studying
2	Bhanu	Secretary	25	10th	Labourer in a Company
3	Jeyalakshmi	Treasurer	18	10th	Labourer in a Company
4	Gomathy	Member	19	10th	Agriculture labourer
5	Sundramabal	Member	20	Illiterate	Agriculture labourer
6	Pallavi	Member	21	Illiterate	Agriculture labourer
7	Gunasundari	Member	35	Illiterate	Agriculture labourer
8	Muthu	Member	20	8th	House wife
9	Malarvizhi	Member	21	10th	Agriculture labourer

The average age of the group members in the case of Jhansi Ranis 30-40 years whereas the average age of Manimegalai group is around 18-25 years. In both the groups around 60 % are literates but almost 90 % are agricultural labourers in the first group and non-agricultural labourers in the second group. Similarly, the men in the respective groups are predominantly agricultural labourers and non-agricultural labours. Members in both the groups are homogenous, belonging to the Most Backward Community in Jhansi Rani group and Scheduled Caste in the case of Manimegalai group.

V. TRAINING AND CAPACITY BUILDING

Training and Capacity building programmes were organized based on the need of the group members. Various trainings given to them are

- Exposure visit
- Hands-on experience on the production process before initiating the process
- Learning by doing after establishing the unit while stabilization in the production process was on
- Group and account management training to leaders and
- Need-based training on the problems encountered during the production.

In addition, to enhance the awareness among farmers training and awareness programmes were organized in the Kannivadi region on biofertiliser and also through notices, brochures, projecting slides in theatres, during monthly meetings of the farmer's association etc.

Exposure visits

In order to get an initial idea about the enterprise as well as production systems, an exposure visit to both the groups were organized to nearby biofungicidal units. Jhansi Rani WSHG group were taken to the *Pseudomonas* production unit at K. Ramanathapuram village in Dindigul district and Manimegalai WSHG group were taken to Kodathur *Pseudomonas* production unit to familiarize them on the production technology. These are model units established by MSSRF. The members gained confidence and the various steps towards the establishment of the unit were taken up.

Intensive hands-on production

For the technical production, training the representatives from the Jhansi Rani WSHG and Manimegalai WSHG were given hands-on training. Four members from the Jhansi Rani WSHG and six members from the Manimegalai WSHG were selected and given 5 and 3 days intensive hands-on training respectively in the production of *Azospirillum* and Phosphobacteria in the microbiology laboratory

at MSSRF, Chennai. They in-turn trained the other members of the group at their own units with the support of the MSSRF staff after establishing the unit.

The purpose was to train the members on various techniques involved in the production process to start a biofertiliser (*Azospirillum* and Phosphobacteria) production unit. The main points highlighted during the training were what are biofertilisers, types of biofertiliser (nitrogen fixers and phosphate solubilizers) and the advantages of using biofertilisers over the chemical fertilisers.

The methods of application, recommended dose and the interaction of these organisms with plants, their role in maintaining the soil health, etc. were also explained. The members were trained in handling the various instruments required for the biofertiliser production. The participants were given individual hands-on training on the following aspects.

- Weighing of the media constituents
- Media preparation
- Adjusting the pH of the medium for the optimal growth of the biofertiliser
- Sterilization of the media (agar and broth) and petriplates by autoclaving
- The principle and the use of laminar flow
- Maintenance of the mother culture
- Sub-culturing of the mother culture of *Azospirillum* and Phosphobacteria
- Observation of the growth of organisms
- Preparation of inoculum for the mass multiplication
- Mass production of *Azospirillum* and Phosphobacteria
- Formulation of biofertilisers with different carriers
- Curing and quality control
- Weighing and packing
- Precautionary steps to avoid contamination during packing
- The maintenance of the quality of the product
- Quality testing by Colony Forming Units (CFU) of the formulated product.
- Visit to a biofertliser unit at the Biotech Park for Women
- Business plan and microplan preparation

The members of the Jhansi Rani WSHG and Manimegalai WSHG were taken on an exposure visit to a biofertiliser production unit "Elbitech Innovations Limited", Biotech Park for Women, Siruseri. They were exposed to the different methods adopted for mass production and formulation of the different bioagents.

The Manimegalai and Jhansi Rani WSHG were trained on the preparation of a business plan and the budget for setting up the production unit with a capacity of 12 tonnes. The participants were also instructed on the importance of precautions to be followed during production, wearing of masks and gloves as a safety measure while mixing, curing and packing, which would also help to avoid contamination. The doubts and queries put forth by the participants regarding the finance to start the unit, the marketing facilities etc. were clarified and the session was concluded. Certificates were issued to the participants to enable them to get loans from local banks.

Third and fourth type of training was organized at the unit itself based on the need in the process. The group member's skill and capacity was constantly improved based on the need during the production process. A total of 158 training days have been given to the group members of the Jhansi Rani WSHG on the production techniques, maintenance of quality control, marketing and exposure visits. The members developed the capacity to become trainers and resource persons and they have inturn been acting as resource persons. A total of 158 training days were provided to the members of the Manimegalai WSHG.

Table 3. **Training and Capacity building programmes organized including dates, topic and no. of training days**

S.No.	Training details	Days	Members	Total Trainee days
1.	Production of *Azospirillum* at Microbiology Lab, Chennai	3	4	12
2.	Production and quality control of *Azospirillum* at the microbiology Lab, Chennai	10	10	100
3.	Marketing of *Azospirillum*	1	10	10
4.	Production of Phosphobacteria	2	10	20
5.	Quality management of biofertilisers	1	7	7
6.	TNAU production technology for Biofertilisers production	1	9	9
	Total			**158**

Farmers Meeting/Training programmes

In order to increase the awareness among men and women farmers, training and Capacity building programmes were organized. Training materials in the form of small booklets, notices, posters, slide shows in theatres, digital self-learning materials etc. were prepared and distributed. In the Dindigul district a field study was carried out in Reddiyarchatram block to assess the need, the benefits, shortcomings and the problems faced while using biofertilisers. The study was conducted with the help of farmers operating through the local farmer's association called 'Reddiyarchattaram Seed Growers Association (RSGA)', based at Kannivadi. Farmers meeting involving the farmers from Reddiyarchatram block, Kannivadi, Aalathuranpatti, Pudhupatti, Ottakovilpatti, Sirunayakkanpatti, Navapatti, Dharumapatti, Karisalpatti villages and the WSHG was organized. The programme was conducted on 10 March 2004 with the aim to create awareness on the use of biofertilisers. Based on the success of the first meeting a second meeting (Kulumai federation meeting) was organized on 12 May2004.

In addition, the farmers' association was involved in facilitating horizontal transfer of knowledge to men and women farmers and agricultural labourers by organizing training and Capacity building programmes on biofertiliser use. Resource persons from the microbiology laboratory and RSGA focused on the advantages of using biofertiliser, crop specificity and methods of application. Simple training manuals were developed in the local language, focusing on the biofertiliser types and methods of application. The farmers were provided with explanation the macro- and micronutrient requirement of the plants and the need to supplement nitrogen, phosphorus and potash as biological inputs for sustainable agriculture. The members were also educated about the importance of nutrient management and integrated crop protection and the methods to supplement nutrients like nitrogen and phosphorus as seed dressing, root dipping and spraying. On the whole 150 men and women participated in the awareness programmes. Similar programmes were carried out at Keezhsathamangalam too.

Mode of advertisement

To effectively reach wider audience, audio advertisement through mass media, *i.e.*, FM, and radio talk with the local farmers association were broadcast during the special agricultural programme sessions. Advertisement slides were screened in theatres (in and around the production unit in the district of Kannivadi, Oddanchatram, Sriramapuram and Vattapparai). Brochures in the form of leaflets and posters on the production technology of the biofertiliser (*Azospirillum* and Phosphobacteria), were prepared in Tamil and distributed widely through farmers

meetings at the block and district level. The Kulumai also promoted advertisement through radio. In addition to this to strengthen the awareness and to reach more number of farmers a 'biofertiliser day' was organized in collaboration with the Tamil Nadu Agricultural University, Coimbatore involving the state agricultural department, input dealers of the region, NGOs working in agriculture and rural development. A booklet on biofertiliser was written and published by the local farmer's association. Also season-based popular articles were written in the local news paper 'Seithicholai', which is managed by the farmer's association

Training to staff members

In order to further strengthen the capacity of the members and to establish a linkage with the Department of Microbiology, Tamil Nadu Agricultural University, Coimbatore two staff members from Kannivadi and Puducherry participated in the five days intensive training programme on 'Mass Multiplication of Biofertiliser Production Technology and Quality Control' at TNAU, Coimbatore. The training helped to further reduce the input cost, improve the quality as well as reduce the number of days required for culturing. The major themes covered in the training programme were preparation of culture media, isolation, characterisation, enumeration and purification and preservation of bacterial cultures of both *Azospirillum* and Phosphobacteria, mass production techniques of bacterial biofertiliser and economics of biofertilisers production, quality assessment, measuring N_2' fixation, methods of application of various biofertilisers and problems and constraints in biofertiliser production. Subsequent to the training, respective staff discussed with the group members the 'new learning's' and made the necessary changes in the production process to improve production efficiency as well as quality control. Capacity building programmes in establishing market links were organized by involving the WSHG members in the discussion and negotiation process.

VI. ESTABLISHMENT OF PRODUCTION UNIT

As a follow up of the intensive training, the trained members discussed with the rest of the group members regarding the various aspects and explained the process and then jointly prepared the business plan to initiate the enterprise. The details are discussed in the chapter Vlll.

The group members of Jhansi Rani WSHG approached the community bank of Kulumai for the financial support and started identifying a suitable place for the unit. The members identified a suitable premises for establishing the unit and then negotiated with the house owner and entered into an agreement with him. Following this, the materials needed to establish the unit were jointly discussed with the members and for this an action plan was prepared and also followed up with monthly review meetings.

The biofertiliser production unit at Kuttathuavarampatti village was inaugurated on 16 February 06 and the unit started with the production of *Azospirillum*. The second unit at Keezhsathamangalam at Puducherry was established by following the steps of production of the first unit. Both the units were designed with a capacity to produce around 12 t per annum.

Demystification of the production unit

In order to reduce the cost of the production unit, and enable the women to handle things easily following simplification procedures has been adopted at the unit:

- Laminar flow chamber: In order to maintain the quality and at the same time reduce the contamination, make it more women friendly and simple, low-cost Laminar Air Flow chamber was fabricated to ease the inoculation purpose.
- For the mass multiplication of *Azospirillum*/ Phosphobacteria: Locally available, low-cost container, i.e. ½ litre horlicks bottle were used instead of culture flasks/fermentors.
- Carrier material: In order to avoid the purchase of external carrier materials the use of locally available FYM was composted using earthworms, used as a carrier material.

Further to this, to fine tune the production to the local conditions and to reduce the cost of production without compromising the quality, efforts were taken to

change the media composition with the use of alternative suitable chemicals and materials.

Isolation of efficient local strains

As a first step to understand the distribution of the PGPR in the rhizosphere region of Cluster bean, Brinjal, Banana, Chili, Crosandra, Bitter gourd the soil samples were collected and screened for efficient biofertiliser strains with high nitrogen fixing and phosphate solublising activity (*Azospirillum* and Phosphate solubilisers). A number of strains were isolated and among them *Azospirillum* strain Kaz 28 and Kaz 83 which showed high nitrogen fixing activity were selected for commercial production. Phosphobacteria strain Avr showing high phosphate solubilisation was also short-listed for production. The conditions for production were standardized for the strains isolated from the local ecological niche. These strains are maintained at the microbiology laboratory MSSRF as glycerol stocks and supplied to the units whenever required. Similarly the soil samples were collected from the specific ecological niche *i.e.*, from the agricultural fields of Kannivadi and Puducherry.

Azospirillum and Phosphobacteria were isolated from the soil samples by serial dilution technique on N_2 free medium and Pikovskaya's media respectively. The growth of *Azospirillum* was monitored by the change in colour of the medium from yellowish green to blue colour. This change was due to increase in the pH of the medium from acidic to alkaline and by the development of a white undulating pellicle. The growth of Phosphobacteria was observed by the development of colonies in Pikovskaya's medium, which developed a transparent zone around the colony due to the solubilization of phosphate by the production of organic acids. The population of the *Azospirillum* and Phosphobacteria were determined by the Most Probable Number (MPN) method *i.e.*, based on positive and negative growth of *Azospirillum*.

Confirmation of *Azospirilum*/Phosphate solubilisers

A loopful of medium was transferred to fresh NFb-semisolid medium. The change in colour of the medium from yellowish green to blue with the formation of pellicle indicates the growth of *Azospirillum*. Growth of *Azospirillum* on potato infusion agar as pink colonies usually wrinkled is characteristic of *Azospirillum*. Further the morphology was confirmed by microscopic studies. The *Azospirillum* strains isolated were tested for its nitrogen fixing ability by acetylene reduction method. The phosphate solubilisers that produced the maximum lysing zone in Pikovskaya's media were chosen for mass multiplication.

Maintenance of the culture

The efficient nitrogen fixing and phosphate solubilising strains used for the mass multiplication were maintained in the microbiology laboratory as slant cultures and as glycerol stocks and supplied to the units whenever required.

Mass multiplication of the biofertilisers

After getting the suitable strains for the region the production process was fine-tuned to suit the local conditions.

Process of starter culture/inoculum preparation

- The inoculum for the mass multiplication was prepared in Dobereiner's Malic acid with NH_4Cl (0.01 %) for *Azospirillum* and LB (Luria bertani broth) for Phosphobacteria.
- About 100 ml of the respective broth were prepared in 250 ml flasks and sterilized. A loopful of inoculum of the respective bioagents from the mother culture was inoculated into the respective flasks and incubated for 3-5 days.
- The growth in the flasks was observed by the change in colour in the case of *Azospirillum* and turbidity in the case of Phosphobacteria.
- This served as the inoculums for the mass multiplication of the *Azospirillum* and Phosphobacteria.

The required quantities of the respective broth were prepared (10-20 L) and dispensed 100 ml into horlicks bottles. They were autoclaved at 121 lb for 15 min and about 2-3 ml of the inoculum was inoculated into each flask under sterile conditions. The horlicks bottles were incubated for 4-6 days and during the time were shaken at regular intervals. When a good growth was observed the cells were harvested and mixed with the carrier material.

Change in the media composition

In case of *Azospirillum* mass multiplication, after adding all the ingredients as well as sterilization the colour of the media changed into blue before the growth of bacteria. To address this, the pH of the solution was tested and KNO_3 and a pinch of NaOH were added to bring it to the desired pH.

By considering the cost and availability of Fe EDTA, $FeSo_4$ was used and instead of using the trace elements solution, the ingredients were purchased separately and added to the media.

During the log phase it grows without nitrogen but during subsequent phases it needs nitrogen for better growth. In the industrial production process using

fermentors, fresh air is passed over the media (which contains 78% of N), but here since horlicks bottles are used, instead of providing fresh air, NH_4Cl was added in the media itself @1g/litre, which acts as a nitrogen source to enable growth.

In Phosphobacterial mass multiplication, instead of nutrient broth (consists of peptone, glucose, yeast extract and NaCl), the ingredients such as peptone (50 %), glucose (50 %), yeast extract (prepared locally) and NaCl were added separately in order to reduce the cost. But here initially they faced the problem that there was no growth of bacteria and instead bubbles were seen on the media. It was then discovered that while preparing the yeast extract the yeast was not sterilized properly and later this was rectified. In the case of yeast extract preparation 10 g of yeast is added with 100 ml of hot water and filtered. In this process, during mass multiplication the contaminated bottles produced a bad smell. The members identified the problem and discarded the contaminated bottles.

Growth Duration

The normal duration of the *Azospirillum* is 72 h in fermentors, but in this kind of decentralised production under static conditions the growth took around 80 h. Based on the demand in order to reduce the growth duration 1.5 % inoculum is used against 1 % of inoculum. While in Phospho bacteria the growth period extended in this method by about 6 h (24 h in the fermentor and 30 h in this decentralised process).

Testing the efficiency of the strains

In order to test the efficiency of the strain in the unit itself the members normally use indicators like growth rate of the bacteria as well as growth of a slight layer above the media. If necessary they inoculate the bacteria in the soil and plant monocotyledons like maize and rice seedlings and from these plants the roots are taken, washed properly and cut into small pieces. It is again inoculated into semisolid malic acid media in test tubes in replicates. Based on the intensity of the blue colour change of the media, they monitor the virulence of the strains.

The efficiency of phosphate solubilsation by the Phosphobacteria was estimated using soil extract agar instead of tricalcium phosphate (5g/L). One kg of soil was mixed with 1L of water and autoclaved and to the extract obtained CaC_{12}, $CaCo_3$, $MgSo_4$' Glucose' NH_4So_4' $FeSo_4$' yeast extract and 1g of $CaCo_3$ were added and the pH was adjusted to 7.0 and sterilized. The Phosphobacteria was inoculated in this medium and incubated for 7 days and observed for transparent zones and around the colonies. The efficiency of the Phosphate solubilising activity was based on the size of the transparent zone.

Preparation of the carrier material

Good carrier material should possess the following criteria:

- Locally available at cheap cost
- High organic matter content good water holding capacity (50 %)
- No toxic substance
- Easy to process and friable

Vermicompost fulfilled all the criteria listed earlier. As an additional activity and to generate additional income and to procure low-cost carrier material vermicomposting pits were set up at the backyard of the production units. The vermicompost obtained were used as carrier material for the formulation of the biofertilisers.

Vermicompost obtained from the vermicomposting pits were sieved and used. The bioagents and the vermicompost were mixed at the ratio of 1:3 and shade dried till the water holding capacity of the vermicompost was about 20-30 %. The cured material was packed in polythene covers (200 g) and sealed using an electric sealer.

The polythene bags were marked with the name of the product, name of the manufacturer, strain number, recommended crops, method of inoculation, date of manufacture, expiry date, price and full address of the manufacturer.

Quality Control

Serial dilution method has been used to determine the Colony Forming Units (CFUs) in each batch. From the production after thorough mixing through random sampling a small quantity is taken by the quartering method and tested for its CFUs in the concentration of 10^6 to 10^{10}. Separate register is maintained for quality check details and materials are passed for packing only when the lot contains 1 $x10^{10}$. Meanwhile, once in a quarter, random samples from the production is taken and checked for its consistency in quality at the microbiology laboratory of Chennai as well as at the unit by the professional staff.

Quality certification

The Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore certified the quality of the formulated product of *Azospirillum* and Phosphobacteria. In addition, as per the Fertiliser Act, efforts are being taken to get the necessary licenses for the registration of the production unit at the state/ district level. Apart from these initiatives are taken to get the TNGST (Tamil Nadu Govt. Sales Tax) number and certificate from the organic certification bodies (through Regional centre for Organic Farming, Bangalore or through private organic certifying agencies) as a marketing tool.

In both the units the contamination rate was very high in the initial phase of production. In case of *Azospirillum* in the initial stages it was around 80 % and 30 % in case of Phosphobacteria. Now it is around less than 5-10 % in case of *Azospirillum* and less than 5 % in the case of Phosphobacteria. Since the establishment of the first unit and training provided on the production of both *Azospirillum* and Phosphobacteria and their marketing strategies, a total of 638 labour days has been generated from February 2006 to December 2006 and a total of 2,511 kgs of the product has been produced by them and marketed. A total of 1,200 kg vermicompost was also produced and sold after using the needed portion for carrier material.

The Members of the Manimegalai WSHG have produced a total of 50 kgs of *Azospirillum* and 50 kgs of Phosphobacteria. Twelve kgs of the produce have been sold to the local farmers. A total of 1,300 kg vermicompost was produced. 50 kg were sold, and the remaining was used as a carrier material for the formulation of the biofertilisers.

Table 4. **Quantity of biofertiliser (kg) produced by WSHG/ Month**

Month	Jhansirani WSHG	Mannimegalai WSHG
February 2006	50	-
March 2006	94	-
April 2006	201	-
May 2006	278	-
June 2006	299	-
July 2006	221	-
August 2006	240	-
September 2006	900	-
October 2006	178	-
November 2006	50	-
December 2006	00	-
January 2007	100	
February 2007	00	
March 2007	00	
April 2007	00	15
May 2007	00	35
Stock	00	00
Total	**2,611**	**50**

The production of *Azospirillum* and Phosphobacteria got stabilized in Kuttathuavarampatti group. The second unit at Keezhsathamangalam is under the process of stabilization.

VII. BUSINESS PLAN AND MARKET LINKAGES

Preparation of business plan

Following the technical training and exposure visits members discussed the same in their group meetings. MSSRF facilitated the group in the business plan preparation based on the pre-market survey in the region, the area under cultivation as well as crops grown, availability of the biofertilisers in the market and access to the farmers. The plan prepared by the group members is provided here. The group members submitted the proposal along with business plan to the 'Friends of MSSRF' Community Banking programme, Chennai for financial support. This request is only to leverage the financial support taken from formal financial banks in the respective areas.

Marketing linkages

The sustainability component is viewed in four dimensions *viz.*, technical, market, finance and organizational management aspects to successfully evolve as a model ecoenterprise. Technical support is being established with TNAU, Coimbatore for the quality control of efficient strains. Efforts are also taken to link them with local agricultural department, input dealers, and wholesale distributors, NGOs facilitating sustainable agriculture and District Rural Development Agency (DRDA) for the market links. Though the unit is self-managed, in order to further strengthen the unit and the carrier material production credit links were established with local service banks through DRDA. For the effective functioning of the unit continuous training and Capacity building programmes are being organized on group management especially leadership, accounts and record maintenance, and to further build up entrepreneurial capacity. Market linkages were established at different levels, *viz.*, local farmers, plantation farmers in the Megamalai and lower Palani hills, district watershed farmers association, regional input dealers, NGOs promoting organic and sustainable agriculture in the region like Kudumbam, AME foundation, Low External Input Sustainable Agriculture (LEISA) network etc. and state level bio-products distributors like Nithya bio-products.

- SHG members directly sell the product to the local farmers
- Marketing tie up with local fertilisers shop (Kannivadi and Dindigul) and tie up with some fertiliser dealers (Coimbatore and Erode)

S.No	Machineries	Amount (Rs)
1	Autoclave	25,000
2	Pressure Cooker	4,000
3	Poly bag sealer	1,500
4	Weighing balance	3,000
5	Gas connection	4,000
6	Culture room	10,000
7	Shaker	25,000
8	Flask	1,000
9	Beakers and Glass wares	1,000
10	Plastic buckets and other expenses	2,000
	Total	**76,500**
12	Purchase of Raw materials	43,000
13	Marketing Expenses	5,000
14	Labour wages	22,000
	Total	**70,000**

Total Unit Cost:

Working Capital Requirements:	70,000
Marketing expenses:	5,000
Fixed Assets:	76,500
Total	**1,51,500**

Means of Finance:

SGSY loan	150,000
Group Contribution	1,500
Total	**1,51,500**

Expenditure:

Particulars	Per month	Per year
Raw material purchase	1,600	7,200
Electricity and Building rent	1,000	12,000
Interest	1,375	16,500
Depreciation	300	3,600
Labour wages	1,800	22,000
Travel expenses	400	4,800
Total	**6,425**	**71,600**

- Creating awareness through community learning centres, and distribution of handbills and Pamphlets to the local farmers. They explain the salient features of their products in local SHG meetings
- Promoting the product to plantation crops farmers at Pandri and Adalur hills
- Market tie-up with fertiliser manufacturing companies and marketing companies (Nithya Bio-products, Synergy Biocon)
- Discussing with the Project officer, DRDA and the Joint director of Agriculture to get Government orders
- They participate in local exhibitions, farmers' trainings and conferences
- Discuss with other NGOs for marketing tie-ups.

Net profit estimated

Income: 500 kg x Rs.20=Rs.10,000 per month

Profit : Rs.10,000- Rs. 6,425 =Rs. 3,575 per month

Profit per year=Rs.42,900 for one product. At present two products are produced in each of the unit and in future efforts are underway to add one more product.

VIII. KEY LEARNING'S

This initiative clearly indicates that in order to take the benefits of improvements in Science and Technology and use it for poverty reduction it is essential to fine-tune and simplify the technology to suit the local region and this provides the scope to develop the technology in scale neutral mode and enable access to rural men and women.

The process of decentralisation needs to be done in a participatory manner in a result-based approach mode in order to identify the constraints and evolve suitable site-specific strategies.

Such decentralised production units/enterprises will support the group as an additional income generating activity in addition to their primary livelihood.

The method of training and capacity building needs to cover multidimensional aspects including the technology, management, leadership, as well as entrepreneurship. The training methods need to follow pedagogic approach, which provides the scope for 'learning by doing' as well as learning through mistakes and errors.

The market links at the multiple levels is very crucial in making the unit sustainable and maintain good group dynamics

Diversification of the products based on the cropping system is also equally important in order to meet the farmer's requirement.

Finally, innovative partnership between universities, NGO's and CBO's of this kind could be a good delivery mode for such technology transfer.

Hands-on training on *Azospirillum* and phosphobacteria production at the Microbiology lab, MSSRF to the WSHG members

Preparation of growth media for *Azospirillum*

Serial dilution technique

Innoculation of *Azospirillum*

Hands-on Training on Azospirillum and Phosphobacteria production at MSSRF to the Mannimegalai SHG members

Culture maintenance

Inoculation in liquid media

Mixing with carrier material: vermicompost

Awareness and capacity building programmes training on Biofertiliser by RSGA

Two-day awareness program with the farmers from the villages under Reddiarchatram block, *Kannivadi, Aalathuranpatti, Pudhupatti, Ottakovilpatti, Sirunayakkanpatti, Navapatti, Dharumapatti, Karisalpatti*

Capacity building and exposure visit

Exposure visit to Elbitech innovations limited

Inauguration of the LCB unit at Kuttathuavarampatti managed by Jhansi Rani WSHG

Inauguration of the LCB unit at Keezhsathamnagalam managed by Mannimegalai WSHG

Azospirillum and Phosphobacteria production Unit run by Jhansi Rani WSHG Kuttathuavarampatty Kannivadi

Production unit and Members of the Jhansi Rani SHG

Media preparation and sterilisation

Mass multiplication

Formulation of the product

Weighing and sealing of the Formulated product

Vermicomposting pit

Azoboost and biophos

Azospirillum and Phosphobacteria unit at Keezhsathamangalam run by Mannimegalai WSHG Puducherry

Members of the Mannimegalai SHG

Preparation of media

Inoculation

Mass multiplication of *Azospirillium*

Weighing of formulated product

Vermicompost pit