Introduction:

BRDC, a registered institution under the Societies Registration Act XII of 1993, Meghalaya within the ambit of Science & Technology Cell of the Department of Planning, Govt. of Meghalaya has completed 13 years of its service to the State of Meghalaya. The registered office of the BRDC is located at 5 ½ Mile, Upper Shillong, 793009, Phone No: 0364 – 2561530, Tele fax – 0364 – 2561530, Email: brdcshillong@gmail.com, website: www.brdc.gov.in. The BRDC is one of the associates of the Meghalaya Institute of Natural Resources under the aegis of the State Flagship Programme – "Integrated Basin Development and Livelihood Promotion Programme"

The Centre has the Governing Council with the Chief Secretary and Principal Secretary/ Commissioner & Secretary (Planning) as the Chairman and Vice Chairman respectively and other members. The Project Director, Science & Technology is the Member Secretary of the Governing Council.

The Centre's primary role is to disseminate Bio-resource technology as affordable technology to the rural communities through customization and scientific validation. The Centre possesses the main experimental farm of 3.08 acres located at Laitmynsaw village, Upper Shillong. Besides this, the Centre also has five Experimental farms of approximately one Hectare each at Mynkree, East Jaintia Hills; Sangsanggre, West Garo Hills; Zikzak, South West Garo Hills and Upper Shillong, East Khasi Hills districts. The farmlands at the above-mentioned districts have been apportioned by the Directorate of Horticulture during the year 2014. Action research, field experiments and trials on sustainable green technologies are being carried out in these farmlands, which also serve as demonstrations to the farming communities at the districts.

MANDATE

"Availing biotechnological opportunities and appropriating/ customizing such technologies into meaningful knowledge resources to conserve and sustainably use biological resources for promoting multiple livelihoods and local green economy"

OBJECTIVES

1. Promotion of customized /affordable green technologies for improved crop productivity, soil and environmental health
2. Studies, Action Research, Trials, experiments and Scientific Documentation
3. Promoting Ecosystem Conservation for Socio-economic development
4. Conservation and promotion of Traditional Knowledge and Practices as Heritage
5. Promoting the Indigenous System of Medicine
6. Scientific validation of the properties of plants with market – value.
7. Collaboration with Universities, R & D Institutions and other Government Organizations in designing & planning of collaborative projects related to biological

The Centre has been able to achieve the set goals and objectives in line with its mission and mandate. Apart from the various activities undertaken at community/ village/ farmers' fields, the Centre has provided trainings and capacity building and internship programmes to students from various educational institutions. The key activities/ initiatives pursued by the Centre are as follows:

- Promotion of Sustainable Green Technologies for Improved Crop Productivity, Soil and Environmental Health.
    - ✓ Hands on demonstration on production of different types of Composts
    - ✓ Organic Growth Promoter & Broad spectrum Bio-Pesticides
    - ✓ Production of Bio-inoculants & Bio-Control Agents
    - ✓ On-Lab production of Azospirillum and Mycorrhiza as biofertilizers.
    - ✓ Integrated Pest Management
    - ✓ On-Farm production of Azolla for improved crop productivity
    - ✓ Vertical farming
    - ✓ Energy Pillar Technology
- Field Trials And Experiments on Inputs and Bio-inoculants
- Establishment of Demonstration Units/Micro-Biotech Parks at Experimental Farms (Laitmynsaw, Zikzak & Sangsanggre
- Giving Back to Nature Programme
    - ✓ Micropropagation of indigenous orchids
    - ✓ Establishment of Community Orchid Parks and Sanctuaries.
- Documentation of Traditional Knowledge and Practices
- Promotion of the Indigenous System of Medicine
- Dehydrated Floral Craft Technology for rural livelihood promotion among women.

A. PROMOTING SUSTAINABLE GREEN TECHNOLOGIES FOR IMPROVED CROP PRODUCTIVITY, SOIL AND ENVIRONMENTAL HEALTH.

Sustainable Green Agricultural Technologies initiated by the Centre involves customized and affordable green technologies which seeks to provide required knowledge to farming communities on sustainable integrated conservation technologies, green inputs production and management practices to address sustained productivity, improved soil health, promotion of indigenous/ traditional crops biodiversity and environmental sustainability in their pursuits/endeavor of access to basic and improved multiple livelihood needs.

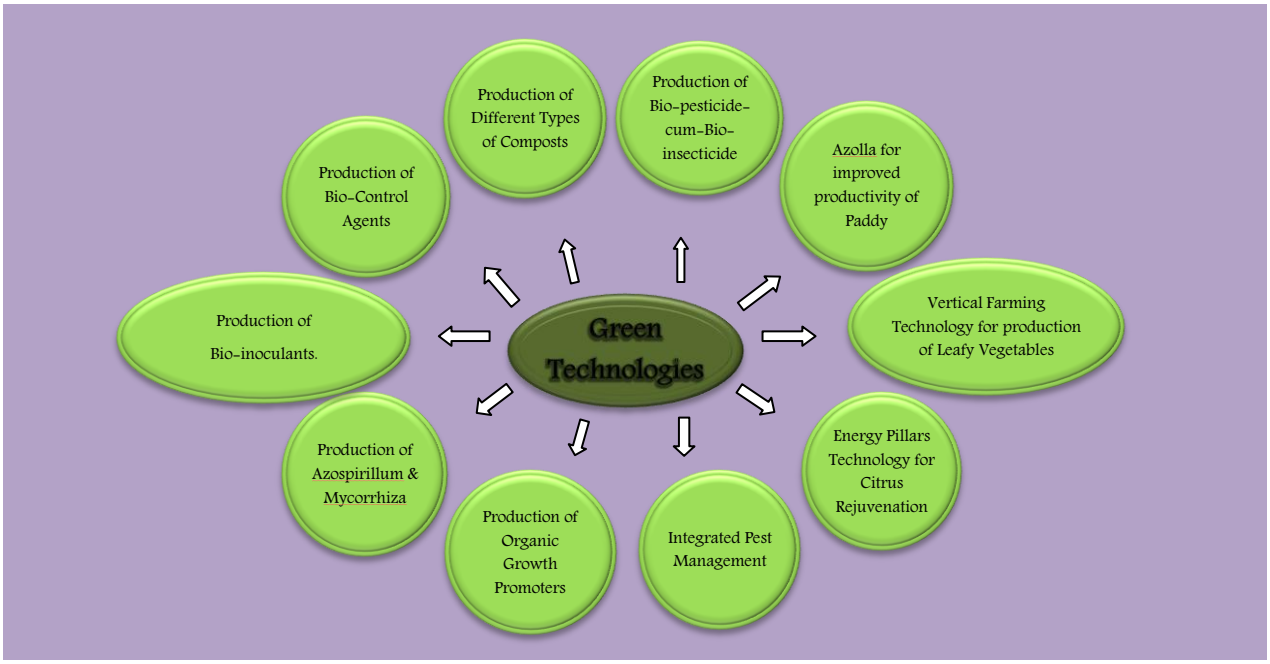
Mission:

Promoting sustainable models of agriculture and organizing farming communities with access to better income and improved livelihood.

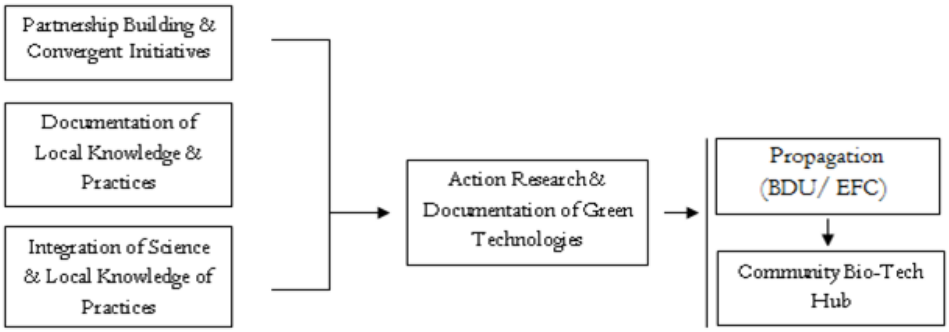
Objectives:

a. Establishing models of sustainable agriculture, and demonstrating successful technologies and scaling up the successes.
b. Integration of Science and technology with local knowledge / innovations / skills and practices.

An overview of the various sustainable green technologies and the framework for propagation at the community/ village level is given in the Figures below;



FRAMEWORK FOR PROPAGATION OF GREEN TECHNOLOGIES



The various Sustainable Green Agricultural initiatives/ activities taken up by the Centre with the farming communities of the State are as follows:-

I. **Hands-On Demonstration on Composting:** As an effort to promote sustainable and green methods for agriculture in the State, the Centre is providing hands – on demonstrations on production of different types of composts such as Vermi Composting, NADEP Composting, Non–Soil Composting and Catalysed Non–Soil Composting to interested farmers. This initiative was undertaken to provide knowledge on production of affordable inputs from locally available resources with an intention to eventually reduce the use of chemical fertilizer in the State.

Hands-On Demonstration on Composting (Details at *Annexure-I*)		
District	Block	No. of Villages
East Khasi Hills	Mawsynram	1
	Mawkynrew	3
	Mylliem	2
West Khasi Hills	Mawthadraishan	6
	Mairang	1
	Nongstoin	1
	Mawphanlur	2
South West Khasi Hills	Ranikor	1
	Mawkyrwat	2
Ri Bhoi	Umsning	1
	Jirang	3
	Umling	1
East Jaintia Hills	Khliehriat	2
West Jaintia Hills	Laskein	5
	Amlarem	4
North Garo Hills	Resubelpara	4
South West Garo Hills	Zikzak	1
East Garo Hills	Samanda	2
	Songsak	1
South Garo Hills	Chokpot	4

Composting is a process in which organic substances are reduced from large volumes of rapidly decomposable materials to small volumes of materials which continue to decompose slowly. In the process, the ratio of carbon to other elements is brought into balance, thus avoiding temporary immobilization of nutrients. One of the many benefits of adding compost to the soil is that the nutrients in it are slowly released to the soil and are then available for use by plants.

The training was conducted at farmers' field in different villages across the State. Simultaneously, awareness was also conducted to educate the farmers about the hazardous effects of long term usage of chemical fertilizers in agriculture. Locally available biomass like agricultural and plant wastes, cowdung and other animal wastes are being used for production of the different types of composts.

In collaboration with District Basin Development Units & the Enterprise Facilitation Centres, about 1500 farmers from 20 Blocks across the State have been trained.

FigI: Hands on demonstration on Vermi-composting technique

Fig2: Hands on demonstration on Non- soil composting technique

Fig3: Hands on demonstration on NADEP, Vermi, Non-soil composting to School students

2. Berkely Hot Composting Method

Berkeley is a fast, efficient, high-temperature, composting technique which will produce high quality compost in 18 days. This fast method of composting was introduced by Robert D. Raabe, a plant pathology professor at the University of California, Berkeley. The common names for this method are "Berkeley method," "fast composting," or "hot composting."The Berkeley method produces more yields of finished compost than the traditional method. With a little more effort and hard work, one can establish usable, finished compost in as little as two to three weeks. Rather than waiting up to six months to a year or longer for the traditional compost to cure and be ready to use, one can have finished compost in under a month. Berkely composting works in such a short time period because of its having the right ratio of carbon to nitrogen, 30:1. For every unit of nitrogen used by the bacteria in compost, they also use about 30 units of carbon. To keep the pile working efficiently, the compost pile needs to be 30 parts carbon to 1 part nitrogen. The compost microbes and bacteria use the carbon for energy and the nitrogen for protein synthesis. Green materials are sources of nitrogen and include grass clippings, manure, vegetable waste, or green prunings. Brown materials are carbon sources and examples include straw, cardboard, dead leaves, dried grass, or paper.

Trial on Berkely Hot Method of composting was conducted at BRDC Experimental farm, Laitmynsaw, using Paddy straw as brown biomass, grass clippings and garden weeds and cow dung as green biomass. The biomass was chopped into sizes of 1 to 1.5 inch pieces to increase the surface area where the decomposing bacteria can act upon, thus enhancing the rate of decomposition. The ratio has been theoretically estimated below;

Particulars	C:N ratio
Paddy straw	70:1
Grass clippings and garden weeds	20:1
Cow dung	16:1

C.N Ratio: $\frac{\text{Paddy straw} + \text{Grass clippings} + \text{garden weeds} + \text{garden weeds}}{4}$

$$\frac{(70:1) + (20:1) + (20:1) + (16:1)}{4} = \frac{126}{4} = 33:1$$

The size of the compost pile has been setup at an optimum size of 1m x1m x 1m. To ensure that aeration takes place, twigs and branches are kept at the bottom of the compost pile for proper supply of oxygen to the aerobic decomposers. 50% moisture is being maintained. This is done by watering the compost pile from above till the compost is just moist enough when squeezed by hand.The temperature of the compost pile has been maintained between 55-65^{O}C.The heat is provided by the respiration of the microorganisms that are breaking down the organic matter. Alternate layer ofgreen and brown biomass is compiled along with cow dung slurry topping at every layer to generate optimum heat in thecompost pile. The compost pile is turned after 4 days from charging and after every two days thereafter till harvest. Monitoring has been carried out every alternate day for maintaining optimum temperatureand moisture.

Observation and Result:

The compost has been observed to produce a very foul smell at 5 Days after charging. This is due to the loss of nitrogen into the atmosphere through volatilisation. About 1 Kg of sawdust (brown biomass) has been added by sprinkling over the compost while turning in order to increase the carbon substrate for the microbes in order to tap the loss of nitrogen.

The moisture content of the compost was observed to have decreased at a faster rate in the first 10 days. This may be due to the heat generated by the microorganism while breaking down the organic matter.Watering has been done every alternate day while turning to keep it moist. The heat generated from the compost was very high during the first 7-10 days due to the breakdown of green biomass. After 12 days, about 10 Kg of green biomass (nitrogen substrate) has been added in order to maintain generation of heat in the compost pile.

Table 1: Observation table of the Berkely Hot Compost

Particulars	Compost pile 1	Compost Pile 2
Cover	Under thatch house	Under polythene sheet
Amount of green biomass	100 Kg	100 Kg
Amount of brown biomass	50Kg	50Kg
Cowdung	50 Kg	50 Kg
No. of turning	8 times	8 times
No. of days to harvest	18	17
Yield	139 Kg	143 Kg
Unit cost of production	Rs. 5.19/Kg	Rs. 4.8/Kg

Conclusion: The Berkely hot compost is indeed a fast composting method taking about 17-18 days which is feasible even in temperate regions of Meghalaya. The yield in terms of biomass is higher in Berkely hot compost as compared to other conventional composting methods. However, the composting method is labour intensive and requires continuous monitoring. The cost of production is lower in berkely hot compost prepared in an open area using polythene sheet as a cover which also enhances compost pile temperature in temperate areas.

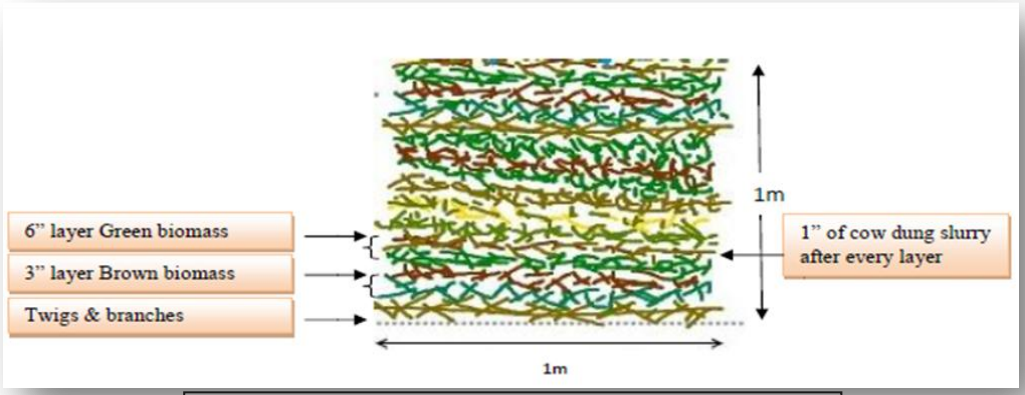


Fig 4: Diagram depicting Berkely Hot Composting Process

Fig 5: Berkely Hot Composting-Process: (a) Under Thatch House (b) Under Polythene Sheet (c) Compost pile after 18 days (d) Compost pile product after 17 days

3. On Farm Production Of Vermi-Wash

Introduction:

Vermi-wash is a ***liquid fertilizer*** collected after the passage of water through a column of worm activation which is very useful as a foliar spray. It contains **plant growth hormones** like auxins and cytokinin apart from nutrients such as nitrogen, phosphorus, potash and other micro nutrients and also **Nitrogen fixing bacteria** like Azotobacter sp., Agrobactericum sp. and Rhizobium sp. and some phosphate solublizing bacteria. It acts as a **plant tonic** and helps to reduce many plant diseases.

The benefits of Vermi-wash are multiple. Apart from acting as a plant tonic, it also helps to reduce many plant diseases and enhances resistance to pest and diseases.. A mixture of Vermi-wash (1litre) with cow urine (1litre) in 10 liters of water acts as bio-pesticides and liquid manure. It improves the rate of photo-synthesis in crop / plant. It helps to increase the population of micro-organisms in the soil and therefore, increases the crop yield. It also enhances the rate of decomposition of compost.

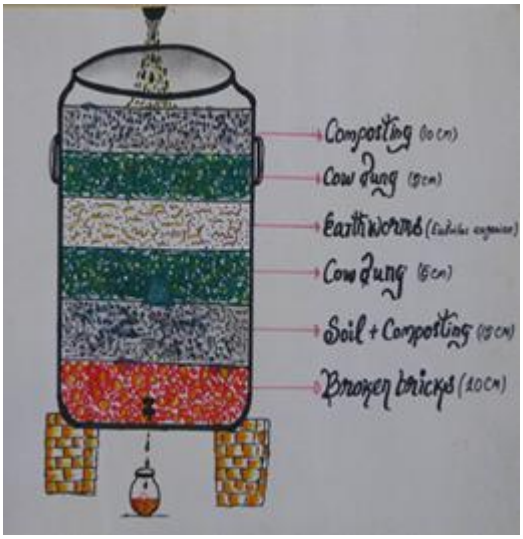


Fig6: Diagrammatic representation of Vermi-wash Unit

Vermi-wash can be used as a fertilizer before transplanting of seedlings or cuttings. The seedlings before transplanting are dipped in Vermi-wash solution which is diluted 5 times with water for 15-20 minutes and then transplanted. Similarly, the cuttings can also be dipped in the solution. It is effective as a **foliar spray**. Vermi-wash is diluted in water 5 times and sprayed on the foliage of crops. It provides the plant with vital nutrients and also helps to control plant disease. As a bio-pesticide, Vermi-wash can be used by drenching of soil. Vermi-wash is diluted 10 times with water and the soil is drenched with the solution to prevent some of the soil borne pathogens.

Fig7(a): Vermi-wash unit established at BRDC farm, Laitmynsaw

Fig7(b): Vermi-wash product

4. Hands On Demonstration On Production Of Bio-Pesticide-Cum-Bio-Insecticide/ Organic Growth Promoter:

For the purpose of promoting organic farming holistically in Meghalaya, one of the strategies adopted by the Centre is the use of indigenous and locally available plants/ botanicals having pesticidal and insecticidal properties for pest management.

The Centre is also promoting the use of Organic Growth Promoters prepared from vegetable wastes/peels in the form of solutions. The solution was used as a supplement by many farmers in many crops as foliar spray in which their efficacy had been assessed and found to be highly effective. Over 500 farmers from 30 villages covering 15 blocks across the State have been trained and capacitated on these technologies

Hands On Demonstration On Production Of Bio-Pesticide-Cum-Bio-Insecticide/ Organic Growth Promoter (Details at *Annexure-I*)		
District	**Block**	**No. of Villages**
East Khasi Hills	Mylliem	3
	Laitkroh	3
	Pynursla	1
	Mawsynram	1
	Shella – Bholaganj	1
	Mawkynrew	1
West Khasi Hills	Nongstoin	7
	Mawthadraishan	1
	Mairang	1
	Mawshynrut	1
South West Khasi Hills	Mawkyrwat	6
West Jaintia Hills	Amlarem	2
Ri – Bhoi	Umsning	2
	Umling	2
	Jirang	2

Fig8: Training on preparation of Broad spectrum biopesticides and Organic growth promoter

5. Hands On Demonstration On Vertical Farming Technology:

To promote cultivation/production of green leafy vegetables in urban areas as well as those areas where availability of cultivable land is the main constraint, the Centre have adopted a simple and low cost technology known as vertical farming technology using locally available materials such as gunny bag, bamboo, etc. which takes minimal space. Hands on demonstration have been provided to 14 villages from EKH, WKH, SWKH, EJH, WJH WGH, SWGH and NGH Districts in which about 400 farmers have been trained.

Hands On Demonstration On Vertical Farming Technology (Details at *Annexure-I*)		
District	Block	Villages
East Khasi Hills	Mawsynram	1
West Khasi Hills	Nongstoin	1
	Mawthadraishan	1
South West Khasi Hills	Mmawkyrwat	1
East Jaintia Hills	Khliehriat	1
West Jaintia Hills	Laskein	2
West Garo Hills	Tura	1
South West Garo Hills	Resubelpara	1
North Garo Hills	Samanda	5

Apart from the above mentioned villages, the technology has been popularized among school students. Training programmes were conducted in collaboration with the District Basin Development Units and EFCs in Lawsiken Secondary School, Larem; Nongsynrieh village, SWKH; St Michael Higher Secondary School, Umsning; Pine Brook School, Umbang; Umsning Presbyterian Higher Secondary School, Umsning; Alpha Secondary School, Pahamsyiem, Umling; Morningstar Higher Secondary School, Nongpoh, Ri-Bhoi District and Mulum Lower Primary School, Laskein, WJH.

Fig 9: Hands –On demonstration of Vertical Farming to school students

6. Hands On Demonstration On Integrated Pest Management :

Incidence of pest infestation in fruits and other crops is highly common throughout the rural farming communities of the State. Insect/pest infestation is one of the main factors that affects the productivity of many crops and fruits, in particular. In order to address such infestation, hands on demonstration on Integrated Pest Management utilising customized bait traps, light trap, etc made out of affordable and locally available materials and wastes have been demonstrated in 4 districts (EKH, WKH, Ri Bhoi and WJH) covering 30 villages from 8 blocks in which about 450 farmers have benefited from this technology.

Hands On Demonstration On Integrated Pest Management (Details at *Annexure-I*)		
District	Block	Villages
Ri – Bhoi	Jirang	2
West Jaintia Hills	Amlarem	3
	Thadlaskein	4
	Laskein	2
EKH	Mylliem	2
	Mawphlang	14
	Mawryngkneng	2
South West Khasi Hills	Mawkyrwat	1

FigI0: Training on various Integrated Pest Management measures (viz. Yellow sticky trap, bait trap, pheromone trap, light trap for horticultural and agricultural plants

B. ACTION RESEARCH ON ENERGY PILLARS TECHNOLOGY:

Meghalaya is one of the major producers of oranges (*Citrus reticulate* or Khasi Mandarin) in the country. However, over the past decade, there has been a drastic decline in the productivity of oranges throughout the State which have negatively impacted the orange growers in the state particularly those who earn their livelihood from orange plantation. This has become a major problem in the State. In order to address this crisis encountered by the farmers, the Centre has initiated Action Research adopting Energy Pillars Technology (EPT) for Citrus rejuvenation in which hands on demonstrations and trainings were conducted in different District covering 21 villages from 12 Blocks. About 315 farmers have been capacitated on the technology.

Table 4: District / Block wise Hands on Demonstration on Energy Pillar Technology was conducted at different Districts (Details at *Annexure-I*)

District	Block	Village
East Khasi Hills	Mawkynrew	1
West Khasi Hills	Nongstoin	2
South West Khasi Hills	Mawkyrwat	1
West Jaintia Hills	Laskein	3
	Amlarem	2
	Thadlaskein	4
Ri-Bhoi	Jirang	4
North Garo Hills	Resubelpara	3
East Garo Hills	Songsak	1

A. Clearing of the area around the trunk

B. Digging of holes around the canopy

C. Filling the holes with biomass mixed with Organic Decomposer Solution

D. Mulching around the tree canopy

E. Prune and clean the tree trunk for pasting with organic fungicide

F. Spraying with organic growth promoter

Fig 11: A-E Steps in Energy Pillar Technology.

C. ACTION RESEARCH ON AZOLLA AS BIOFERTILIZER IN PADDY CULTIVATION:

Azolla is a tiny fresh water fern commonly found in ponds, ditches and rice fields. It has been used as a biofertilizer for rice in all major rice growing countries including India, Thailand, Korea, Brazil and West Africa. The nitrogen fixing activity is accomplished by the symbiotic relationship between fern and BGA, *Anabaena azollae*. It can fix 30-40 Kg N/ha/yr and increase crop yield up to 10-15%. In addition to N, the decomposed Azolla also provides K, P, Zn and Fe to the crops. It is also used as feed for poultry and fishes. Azolla is not well known to the rice growers in Meghalaya although it was found in many paddy fields across the State.

To many farmers, Azolla is considered as destructive weeds due to overcrowded condition which suppresses the growth of rice crop when grown as dual cropping. A proper awareness on application and utilisation method is required to promote the use of Azolla as a replacement for conventional fertilization in order to promote organic farming in the State.

Fig 12: Azolla Production Unit at Experimental Farm.

On farm production of Azolla: Samples of Azolla were collected from paddy fields located at Nongjrong, EKH District and Liarkhla, Ri Bhoi District. They were multiplied and maintained at BRDC Experimental Farm, Laitmynsaw for generation of mother cultures. About 500 Kg of Azolla has been produced and distributed to different farmers across the State for trials.

District	Block	Villages	Production (quintal/ Ha)		% increased in Yield	Remarks
			Control	Treated		
East khasi Hills	Mawkynrew	Nongjrong	1.6	2.9	55.1 %	Farmers' willing to upscale the intervention in the ensuing cropping season
West khasi Hills	Mawthadraishan	Mawkohmoit	2.2	3.00	73.33 %	
West khasi Hills	Mairang	Nongrmai	-	-	-	On field production for ensuing season
West khasi Hills	Mawthadraishan	Rngisawlia	-	-	-	
		Umkrem	-	-	-	
Ri Bhoi	Umsning	Umdiker				
East Jaintia Hills	Khliehriat	Cham cham	-	-	-	Field trials affected due to excessive rainfall.
West Jaintia Hills	Amlarem	Shken pyrsit	-	-	-	
East Jaintia Hills	Laskein	Sahsniang	-	-	-	

Paddy at Sahsniang Village, East Jaintia Hills

Close view of Paddy with Grain

Intercropping with Azolla

Fig 13: Field Trials on Paddy with Azolla as fertiliser at Sahsniang Village, East Jaintia Hills

Paddy at Shkenpyrsit Village, West Jaintia Hills

Close view of Paddy with Grain

Fig 14: Field Trials on Paddy with Azolla as fertiliser at Skhenpyrsit Village, East Jaintia Hills

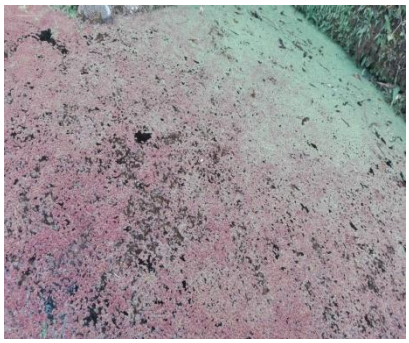


Fig 15: Multiplication of Azolla in farmer's Pond at Rngisawlia village, West Khasi Hills District

D. ACTION RESEARCH AND ON FARM TRIALS OF TOMATO (LAITKYNSEW VARIETY) AT MAWLYNGBNA VILLAGE:

Mawlyngbna under Mawsynram Block, East Khasi Hills District, is a village in which about 95% of the population derived their livelihood from farming activities which includes both agriculture and livestock. The community still practice organic farming in which the people have continued to practise this old age traditions. Intercropping system is very common in the village in which different crops are growing together in the same plot leaving no space vacant. The village experienced a subtropical warm climate with heavy rainfall stretching from April to September. Because of the heavy showers of rain, the ideal season for growing vegetables in the village is autumn to winter. As the climatic condition of Mawlyngbna is similar to that of Laitkynsew village which is the main producer of indigenous organic tomato, the trials on the cultivation of this tomato was undertaken at Mawlyngbna. To control powdery mildew, biopesticides such as *Trichoderma viridi* was used as seed treatment and foliar spray.

Fig 15: Laitkynsew Tomatoes

Sl.No.	Particulars	Observation
1.	Plant height till fruiting	0.6 - 2 meter
2.	Plant canopy till fruiting	90-130 cm
3.	No of branches/plant till fruiting	9-16
4.	No of leaves/plant till fruiting	29-38
5.	Flowering	Mid November continued till March
6.	No. of flower/plant	6-8
7.	Fruiting	Mid December continued till April
8.	No of fruits/plant	2-6
9.	Diseases infestation	Wilting was observed in some plants and it rejuvenate back after spraying with 5 % *Trichoderma* solution
10.	Fruit ripening	February
11.	Fruit diameter	4.5-13.7 cm
12.	Fruit weight	90- 570 g/ fruit
13.	Harvesting	It is plucked at physiological stage when the fruit turns pinkish in colour
14.	Yield/ha	10.8 tonnes

Farmers' voice:

According to Mr. Lam Tohtih, a farmer in whose farm the trial was conducted, this tomato is sweeter and juicier than any tomato that he has ever cultivated and it was the first time that such tomato was introduced in the village. He had never expected that the tomato would grow very well in the village and fetching a good market locally. According to him, the crop grows well when intercropped with garden pea, which also acts as a natural shade for the main crop. He also wanted to extend its cultivation commercially in the near future.

Fig 16: Mr. Lam Tohtih, Mawlyngbna

District	Block	Villages	No. of Farmers	Status	Remarks
EKH	Mawsynram	Mawlyngbna	Tomato	Trial was done with I farmer out of which 130 Kg of tomato was harvested.	For the next growing period (September 2016) about 30 farmers will take up cultivation.

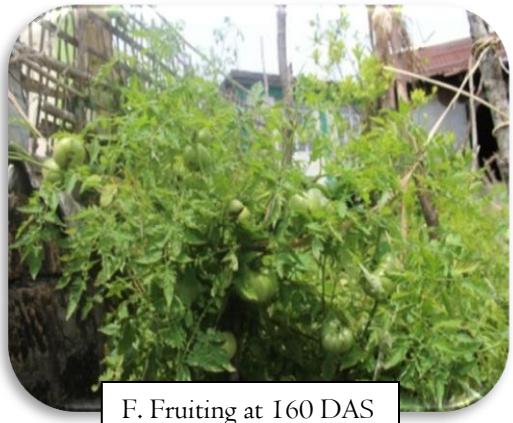
A. Tomato growing plot

B. Plant showing wilting

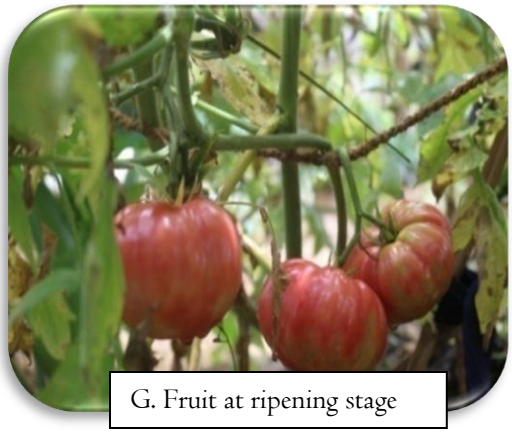
C. Rejuvenated plant after treatment with Trichoderma

D. Tomato plant attaining height of 2.0 m

E. Fruiting at 120 DAS



F. Fruiting at 160 DAS



G. Fruit at ripening stage

Fig 17: Tomato Field Trials at Mawlyngbna Village

E. ACTION RESEARCH ON BIO-INOCULANTS AND BIO-CONTROL AGENTS:

The use of bio-inoculants (bio-fertilizers & bio-pesticides) and bio-control agents are gaining importance as supplementary source of pest management tools in agriculture, forestry, horticulture and in public health programmes. Increased emphasis is being given by the Government Agencies, Non-government agencies to promote the use of bio-inoculants and bio-pesticides. In organic farming use of bio-control agent and bio-pesticides are emerging as most viable pest management strategy. Excessive use of chemical pesticide also exposes farmers to serious health risks and has negative consequences for the environment, and sometimes for crop yields. Often less than one percent of chemical pesticides applied actually reaches a target pest organism; the rest contaminates the air, soil and water.

Goal:

- Introducing green technology for sustainable pest and disease management, thereby reducing the use of chemical inputs and to provide livelihood opportunities to the village community.

Objective:

- Selection and production of bio inoculants and bio control agents.
- Awareness promotion on the importance and applications of bio inoculants and bio control agents.
- To conduct field trials at farmers field
- To capacitate the farming communities on mass production of bio inoculants and bio control agents

I. On-Lab Production of Bio-Inoculants:

The Centre has taken up on-Lab production of Bio control agents, Bio-pesticide and Bio-fertilisers (Details at ***Annexure-II***) since 2014 as part of the sustainable green technologies programme to promote and adopt Green Integrated Pest Management (IPM) to the Farming communities. The following Bio-pesticides, Bio-fertilisers and Bio control agents are being produced and carried out in the Laboratory.

a) Bio-Pesticides

i. ***Trichoderma viride***: ***Trichoderma*** is a free-living fungus which is commonly found in soil and root ecosystems. It is highly interactive in root, soil and foliar environments. Cultures of Trichoderma have been developed as a biological mean for plant disease management especially the soil borne related diseases.

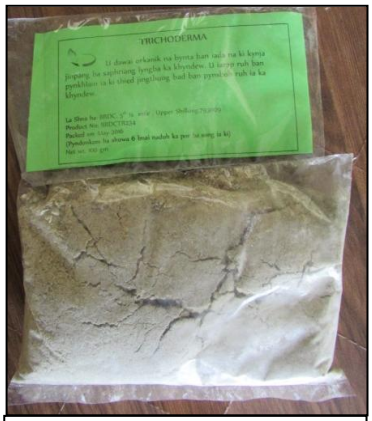


Fig 18: Packaged product of *Trichoderma viride*

Benefits of *Trichoderma*:

- **Disease control:** Trichoderma is a potent bio-control agent and used extensively for soil borne diseases. It has been used successfully against pathogenic fungi belonging to various genera viz. *Fusarium, Phytopthara, Scelerotia.*

- **Plant growth promoter:** *Trichoderma* strains solubilise phosphates and micronutrients. The application of trichoderma strains with plants increases the number of deep roots, thereby increasing the plant's ability to resist drought.
- **Primary benefits**
  - ✓ Improves soil fertility
  - ✓ It kills the soil pathogens
  - ✓ Improves roots and shoots growths
- **Secondary benefits**
  - ✓ No transplanting shock due to longer root
  - ✓ Improve the post harvest quality storage

Production of *Trichoderma*:

- The Centre has produced 80 kg of *Trichoderma viride* On-Lab, out of which 70 kg has been used for various field trials in different districts of Meghalaya
- Culturing and inoculation of Trichoderma is carried on in the laboratory for further multiplication

b) Bio-Fertilizers

Biofertilizers are low cost, renewable sources of plant nutrients which supplement chemical fertilizers. These are selected strains of beneficial soil microorganisms cultured in the laboratory and packed in a suitable carrier. They can be used either for seed treatment or soil application. The following types of biofertilizers are being produced in the laboratory:

a. Phosphate solubilising biofertilizers (PSB) eg. *Bacillus and Pseudomonas*

b. Plant growth promoting biofertilizers eg. *Pseudomonas fluorescens*

c. Nitrogen fixing biofertilizers eg. *Rhizobium, Azospirillum*

d. Phosphate mobilizing biofertilizer eg. *Mycorrhiza*

i. **Phosphate Solubilizing Bacteria (PSB)** are a group of beneficial bacteria capable of hydrolysing organic and inorganic phosphorus from insoluble compounds. There are various types of soil microbes which can solubilize the fixed form of P and make it available to plants. Such organisms are called Phosphate solubilizing bacteria (PSB). PSB strains could grow well at the temperature ranged from 28°C to 35°C. This bacteria in which Pseudomonas and Bacillus are the paramount species, can convert insoluble phosphate into soluble forms and usable by the plant. The use of phosphate solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and crop yield.

Benefits of Phosphate Solubilizing Bacteria are:

- rising rate of phosphorus absorption that their use in form of bio-fertilizers
- improve soil nutritional status
- secretion of plant growth regulators
- control of soil-borne diseases and

- better growth and yield in farming plants

ii. ***Pseudomonas*** **and** ***Bacillus*** are two important genera of soil bacteria with promising activity of phosphate solubilisation. Their role in increasing the soil nutrient value is of utmost importance. Their application to crop fields has resulted in an increased yield of several crops.

ii (a) Pseudomonas fluorescens is a common gram negative, rod-shaped bacterium, non-pathogenic saprophyte that colonises in soil, water and on plant surfaces. It produces a soluble greenish fluorescent pigment. *P. fluorescens* that suppress plant diseases by protecting the seeds and roots from fungal infections. *Pseudomonas fluorescens* belong to Plant Growth Promoting Rhizobacteria (PGPR), the important group of bacteria that play a major role in the plant growth promotion, induced systemic resistance, biological control of plant pathogens, *etc.*. P. *fluorescens* possess many traits that make them well suited as bio-control and growth-promoting agents. These include the ability to-

- ✓ Grow rapidly ***in-vitro*** and to be mass produced.
- ✓ Rapidly utilize seed and root exudates.
- ✓ Colonize and multiply in the rhizosphere and spermosphere environments and in the interior of the plants.
- ✓ Produce a wide spectrum of bioactive metabolites.
- ✓ Compete aggressively with other microorganisms.
- ✓ Adapt to environmental stresses and,
- ✓ Inexpensive

ii (b) Bacillus subtilis is a ubiquitous naturally occurring saprophytic bacterium that is commonly recovered from soil, water, air, and decomposing plant material. B. subtilis products are made for many uses. For plant disease control, these include foliar application and products applied to the root zone, compost, or seed. When applied directly to seeds, the bacteria colonize the developing root system, competing with disease organisms that attack root systems *B. subtilis* inhibits plant pathogen spore germination, disrupts germ tube growth, and interferes with the attachment of the pathogen to the plant. *B. subtilis* bacteria produce antibiotics, including some called iturins, which help the bacteria compete with other microorganisms either by killing them or reducing their growth rate. When applied directly to seeds, *B. subtilis* bacteria colonize the developing root system, competing with various disease organisms that attack root systems. When soil or seed-applied with *B. Subtilis,* feeds off plant root exudates, depriving disease pathogens of a food source.

Fig 19: Packaged product of PSB

Production of PSB

- The Centre has produced 50 kg of PSB (a consortium of *Pseudomonas* and *Bacillus*) on lab., out of which 45 kg has been used for various field trials in different districts of Meghalaya
- Culturing and production of PSB is carried on in the laboratory for further multiplication and field application

iii. Nitrogen Fixing Biofertilizers:

iii (a). *Azospirillum*: *Azospirillum* is a Gram-negative motile bacteria belonging to the order *Rhodospirillales*, associated with roots of monocots, including important crops, such as wheat, corn and rice. It is the associate symbiotic nitrogen fixer, aerobic free living making the atmospheric nitrogen available to various crops. This nitrogen-fixing bacterium when applied to the soil undergoes multiplication in billions and fixes atmospheric nitrogen in the soil.

Actually, *Azospirillum* is the primary commercial phytostimulator inoculant for cereals worldwide. In the context of sustainable agriculture, plant inoculation with *Azospirillum* is a good alternative to reduce chemical inputs. *Azospirillum* can establish an associative symbiosis with cereals but unlike mutualistic symbiosis (such as rhizobia with leguminous plants), the association is not accompanied by the formation of new organs.

Fig 20: Cultured plate of *Azospirillum*

***Azospirillum* benefits the plant directly:**

- by associative nitrogen fixation
- synthesis of phytohormones (notably indole-3-acetic acid, IAA)
- modulation of plant hormonal balance by deamination of the ethylene precursor 1-aminocyclopropane-1-carboxylate (ACC).
- enhanced root system branching and root elongation, which in turn favour the uptake of soil water and minerals.

Production of *Azospirillum*

- The Centre has produced 6.5 kg of *Azospirillum* on lab., and field trials in different districts of Meghalaya are yet to be carried out
- Culturing and inoculation of *Azospirillum* is carried on in the laboratory for further multiplication

iii (b) Rhizobium is a nitrogen fixing biofertilizer. *Rhizobium* sp. is the symbiotic nitrogen fixer which assimilates atmospheric nitrogen and fixes in the root nodule, formed in the roots of leguminous plants. These bacteria infect the roots of leguminous plants, leading to the formation of "lumps" or "nodules" where the nitrogen fixation takes place. The bacterium also produces enzymes (nitrogenase) that supply a constant source of reduced nitrogen to the host plant.

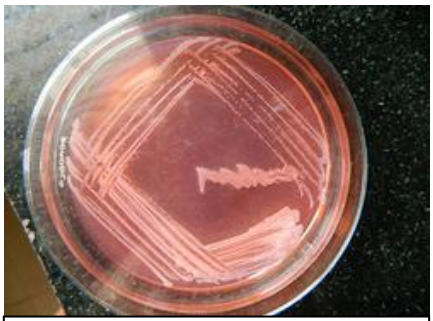


Fig 21: Cultured plate of *Rhizobium*

Benefits of *Rhizobium*:

- ✓ rhizobia are a major world source of protein and soil nitrogen
- ✓ they fix nitrogen gas (N_2) from the atmosphere turning it into a more readily useful form of nitrogen (N).
- ✓ increase crop yield

Production of *Rhizobium*

- The Centre has produced 7.5 kg of *Rhizobium* on lab., and field trials in different districts of Meghalaya are yet to be carried out
- Culturing and inoculation of *Azospirillum* is carried on in the laboratory for further multiplication

Overall production of Biopesticides and Biofertilizers produced from January to December, 2016

(*Details at Annexure II*)

Biofertilizer	Production (Kg)
PSB	100
Azospirillum	10
Rhizobium	10

iv. Mycorrhizal fungi as biofertilizer

The word mycorrhizae come from two Greek words, 'mycos', which means fungus, and 'rhiza', which means root; therefore, mycorrhizae literally means "fungus root." Mycorrhizal fungi are species of fungi that have a symbiotic association with plant roots. Plants which suffer from nutrient scarcity, especially phosphorus and nitrogen develop micorrhiza. The hyphae of the fungi spread through the soil and infect the roots of plants creating specialized structures for the exchange of nutrients. This relationship generally benefits both organisms by providing carbon to the fungi and increased nutrient uptake (primarily phosphorus) for the plant.

The fungi also help the plants to increase water uptake mechanism. However the used of artificially produced inoculums of micorrrhizal fungi has increased its significance due to its multifarious role in plant growth and yield, and resistance against climatic and edaphic stresses, pathogen and pests.

There are three types of mycorrhiza: (a). **Endomycorrhizas:** "Endo" means inside hence these fungi grow inside the root of the plant. Plant species having this type of mycorrhiza are *Agrostis capillaries, Trifolium repen, Hespersostipa comata, Carex duriusula, Bouteloua gracilis, Duchesnea indica* etc. (b). **Ectomycorrhiza:** This type of mycorrhiza lives outside the roots of the plant. Plant species having ectomycorrhiza are eucalyptus, oak, pine rose, orchids etc. (c). **Ectendomycorrhiza:** This type of micorrhiza shares the features of both ecto and endomycorrhiza and it is found in both gymnosperms and angiosperms.

Benefits of mycorrhizas to plants:

- ✓ Arbuscular mycorrhizae (AM) are important factors of soil quality through their effects on host plant physiology, soil ecological interactions and their contributions to maintaining soil structure.
- ✓ AM fungi play an important role in plant health by improving nutrient (especially inorganic P) and water uptake by their host plant and providing protection against soil-borne pathogens
- ✓ AM fungi increase overall absorption capacity of roots due to morphological and physiological changes in the plant. There is increased absorption surface area, greater longevity of absorbing roots.
- ✓ Mycorrhizal fungi improve crop yields, especially in infertile soil as fungal partner is a potential contributor to plant nutrition and pathogen suppression in low input agricultural systems. Increased uptake of macronutrients other than P, including N, K and Mg has also been measured as well as increased uptake of some micronutrients maintaining soil aggregate stability.

- ✓ AM fungi are recognized as high potential agents in plant protection and pest management. AM fungi can decrease the severity of diseases caused by root pathogenic fungi, bacteria and nematodes.
- ✓ Mycorrhizal fungi can contribute to weed control also.
- ✓ soil and crop productivity

Production of mycorrhizas:

Production of mycorrhiza was carried out and result will be obtained during the last week of October, 2016.

c) Bio-Control Agents

Biological control is the use of natural enemies (called biological control agents) to reduce populations of pests such as insects and weeds. Biological control can also be defined as the use of living organisms to depress the population of pest.

Objectives

- To control pests through the use of natural predators instead of using chemical pesticides.
- To establish the economics and risk reduction potential of a bio-control/IPM (Integrated Pest Management).

The following are the two bio-control agents taken up for production by the centre:

a. Corcyra cephalonica

Corcyra cephalonica commonly called as rice meal moth or rice moth is a pest of stored foods, *viz.,* cereals, pulses, dried fruits and spices. Many of the natural enemies mass-bred in the laboratory for use in field against crop pests are dependent on either egg or larval stages of *Corcyra* due to the simple reason that it is easier and cheaper to produce natural enemies on different stages of *Corcyra* than on their original hosts. It has been proved to be one of the most efficient surrogate host for rearing a wide range of biological control agents. The important among them are egg parasitoids – *Trichogramma s*pp.

Fig 22: Trichogramma parasitizing the egg

The overall production involves initial infestation of the maize medium with *Corcyra* eggs in desired quantities. This is accomplished by sprinkling the freely flowing eggs on the surface of the medium in individual basins. Per basin 0.5 cc eggs of *Corcyra* is infested. The basins are then covered with clean *muslin* cloth and held tightly with rubber fasteners.

The larvae that hatch out in 3-4 days begin to feed the maize medium. At this stage, light webbings are noticed on the surface. As the larvae grow up they move down. During this period the larvae are allowed to grow undisturbed in the basin. The adults begin to emerge in 28-30 days after infestation of the eggs. The adults can be seen on the inner side of the *muslin* cloth. They are either aspirated with mechanical moth collector or collected with specimen tubes. The moths lay the eggs in large numbers loosely in an oviposition drums. The collections are cleaned by gently rolling the eggs on filter paper to another container. Then they are passed to sieves in series and finally clean eggs are collected.

The eggs are quantified in measuring cylinders and used for building up the stocks. About 100 pairs of adults produce 1.5 cc of eggs in 4 days laying period inside the oviposition drums. From each basin 18.00 – 20.00 cc of eggs can be obtained in 90 days.

At present, there are 60 basins use for Corcyra charging for further multiplication at BRDC. A total of 100 cc of eggs has been collected. 30 cc has been used for making *Trichogramma* cards.

b. *Trichogramma*

Trichogramma is one of 80 genera in the family Trichogrammatidae. *Trichogramma* are primary parasitoids eggs of Lepidoptera. It is important for plant protection because of its wide spread natural occurrence and its success as biological control agent by mass releasing. Since this parasitoid kills the pest in the egg stage itself before the pest could cause any damage to the crop and also that it is quite amenable to mass production in the laboratories, it has the distinction of being the highest produced and most utilized biological control agent in the world Trichogrammatidae includes the smallest of insects, ranging in size from 0.2 to 1.5 mm. *Trichogramma chilonis* and *Trichogramma japonicum* are the two species produced at our centre through Tricho cards to control pest (stem and fruit borer) found in paddy, maize, tomato, sugarcane and cotton. One Tricho card can target pests in an area of one hectare.

Tricho cards

- The parasitisation of *Trichogramma* spp., in laboratory condition on one cc (16000 – 18000 eggs).
- eggs of *Corcyra cephalonica*, which are uniformly spread and pasted on a card measuring 15 cm x 10 cm is called as Tricho card. The card has 12 demarcations (stamps). 0.5 cc of eggs is known to contain approximately About 12,000 *Trichogramma* adults emerge out from this card in 7-8 days after parasitisation.
- To delay the emergence of *Trichogramma*, these cards can be stored in refrigerator at 5-10°C for 10-15 days.
- On removing the cards to room temperature, the parasitoids emerge normally. Tricho cards have a shelf life of 2-3 days. However, these can be stored in a refrigerator for a period of 1 month without any spoilage.

Fig 23: Tricho- cards in the laboratory

II. On-field production of Trichoderma:

A one day training programme was conducted at Nonglwai village, Nongstoin Block, WKH district on 19th October, 2016. A total of 15 farmers attended the training programme.

Fig 24: Hands on demonstration on installation of Tricho-cards in paddy Field at Nonglwai

F. FIELD TRIALS AND EXPERIMENTS:

Conventional agriculture plays a significant role in meeting the food demands of a growing human population, which has also led to an increasing dependence on chemical Fertilizers and pesticides. Chemical fertilizers are industrially manipulated, substances composed of known quantities of nitrogen, phosphorus and potassium, and their exploitation causes air and ground water pollution by eutrophication of water bodies. In this regard, recent efforts have been channelized more towards the production of 'nutrient rich high quality food' in sustainable comportment to ensure bio-safety. The innovative view of farm production attracts the growing demand of biological based organic fertilizers exclusive of alternative to agro-chemicals. In agriculture, encourage alternate means of soil fertilization relies on organic inputs to improve nutrient supply and conserve the field management. Organic farming is one of such strategies that not only ensures food safety but also adds to the biodiversity of soil. The additional advantages of biofertilizers include longer shelf life causing no adverse effects to ecosystem

In order to improve the productivity of different crops in the State, various trials have been conducted in Experimental Farms and Farmers' Field on the effects of bio-inoculants such as Trichoderma and Phosphate solubilising bacteria and different organic composts on productivity of different crops like potato, pea, french bean, ginger, turmeric, maize, etc. Trials have been conducted in over 40 farmer's fields of 27 villages across the State.

The result on crops which were harvested is encouraging in term of improved productivity and soil health. More of such field trials need to be conducted with scientific documentation before finalizing recommendation, etc. Results of a few field crops trial conducted at farmers' field is given hereunder:

Field Trials and Experiments (Details at *Annexure-III*)

District	Block	No. Of Villages
EKH	Mylliem	1
	Pynursla	2
	Mawkynrew	3
	Mawsynram	4
WKH	Mawthadraishan	1
	Nongstoin	1
	Mairang	1
	Mawphlanlur	1
SWKH	Mawkyrwat	1
Ri-Bhoi	Jirang	1
	Umsning	3
	Umling	1
EJH	Khliehriat	2
WJH	Amlarem	2
	Laskein	4
EGH	Samanda	3
NGH	Resubelpara	3

a. Tomato crop

Local name: Sohso/ Sohsaw
Family: Solanaceae
Variety Meg 19
Village Larnai
District: West Jaintia Hills

Tomato is a warm season crop, it requires warm and cool climate. It is a day neutral crop, so wildly grown in any season.

Soil:

Well drained loamy soil, pH range of 6.0 - 7.5

Seed and sowing:

Tomato is generally cultivated by transplanting seedlings on ridges and furrows. A seed rate of 300 to 350g/ha is required.

Seeds are sown in July August for autumn winter crop. The spacing recommended for autumn winter crop is 70 X 60cm.

Seed treatment:

Seeds are treated with Trichoderma @ 10g/kg seeds to prevent seed borne diseases.

Manuring:

Application of well rotten Farmyard manure/compost @ 20-25 t/ha at the time of land preparation which is mixed well with the soil. Potash requirement is met with the application of wood ashes. It is required to apply ash after 20-30 days after planting.

Plant protection:

Cultural traps with French bean and Marigold flowers (long type) works well in controlling pest and diseases. Pheromone lures for *Helicoverpa* and aphids could monitor the pest upto 80%.

Yield: 30 – 40t/ha

Increase in yield with bio-inoculants: 10-15%

Fig.25(a): Bio-inoculants application 25 DAT

Fig. 25(b):Tomato flowering (35 DAT) and fruiting (48 DAT)

b) Frenchbean crop

Local name: Tohsaru, Presbin
Family : Fabaceae
Variety: Local
Village: Chamcham, Umdiker
District: East Jaintia Hills, Ri-Bhoi

Soil:

Well drained loamy soil, pH range of 5.5 - 6.0

Seed and sowing:

Seed rate- 50-55 kg/ha (pole type)

2 seeds per hill in line/beds at a spacing of 30 x 15 cm

Seed treatment:

Trichoderma @ 4g/kg of seed 24 hours before sowing to control fungal disease

Manuring:

Application of well rotten Farmyard manure/compost @ 25 t/ha at the time of land preparation which is mixed well with the soil.

Plant protection:

Aphids- 20 yellow sticky trap coated with castor oil to attract white flies.

Yield:

2-4 t/ha in 90 -120 days

Increase in yield with bio-inoculants: 10-15 %

Fig: 26: Seed treatment and harvest

d) <u>Carrot</u>

Local name : Kajor
Family : Umbelliferae
Variety : Local
Village :Nongjrong, Nonglwai
District : East Khasi Hills, west khasi hills

Carrot is a cool season crop and prefers 15 to 20^{0} c.

Soil:

Well drained deep loose loamy soil, pH range of 6.0-7.0

Seed and sowing:

Seed rate- 4 kg/ha

Spacing of 25 -30 cm

Thinning- Hills: spacing of 10 cm between plants

Seed treatment:

Trichoderma @ 4g/kg of seed 24 hours before sowing to control fungal disease

Manuring:

Farmyard manure/compost @ 30 t/ha

Intercultural operations:

Thinning and earthing up given on 30th day

Plant protection:

Not required as is not affected by pests

Yield:

20-25t/ha in 100 -120 days

Increase in yield with bio-inoculants: 36.5%

Fig. 27: Crop harvest

e) <u>Cabbage</u>

Local name : Kubi

Family : Brassicaceae

Variety : Local

Village : Larnai, Nonglwai

District :West Jaintia Hills, West Khasi Hills

Soil: Well drained loamy soil, pH range of 5.5- 6.5

Seed and sowing:

Seed rate- 650 g/ha

Spacing of 40 x 40 cm

Nursery- 100sq m for raising plants for 1 ha area (5 days after emergence Organic growth promoter (OGP) foliar application is required

Seed treatment:

Trichoderma @ 4g/kg of seed 24 hours before sowing to control fungal disease

Manuring:

Farmyard manure/compost @ 30 t/ha

Intercultural operations:

Earthing up on 30th day

Plant protection:

Aphids- 12 yellow sticky trap to monitor macropterous adult

Yield:

50-60t/ha in 150 days

Increase in yield with bio-inoculants: 32.5%

Fig.28: Cabbage crop

Coriander

Local name : Dhania
Family : Apiaceae
Variety : Local
Village :Nongjrong
District : East Khasi Hills
Soil:
Well drained silt orloamy soil, pH range of 6.0-8.0
Seed and sowing:
Seed rate- 20-25 kg/ha
Spacing of 20 x 15 cm
Seed treatment:
Trichoderma @ 50kg/ha of seed 12 hours before sowing to control wilt.
Manuring:
Farmyard manure/compost @ 10 t/ha
Intercultural operations:
Earthing up on 30th day
Plant protection:
Not required as is not affected by pests
Yield:
5-6 t/ha
Increase in yield with bio-inoculants: 33%

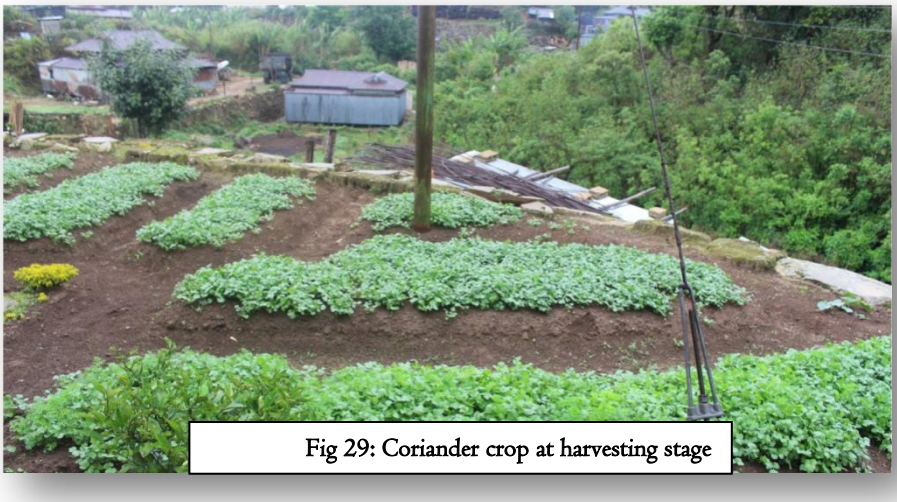


Fig 29: Coriander crop at harvesting stage

f) Potato

Local name : Phan
Family : Solanaceae
Variety : Local (Phaniingdieng)
Village :Mawphanlur, Nongkynrih
District : West khasi hills , East Khasi Hills
Soil:
Well drained loamy soil, pH range of 4.8 to 5.4
Seed and sowing:

Seed rate- 3000- 3500 kg/ha

Spacing of 45 cm

Seed treatment:

Trichoderma- 100 gm for 5kgtuber, PSB- 100 gm for 5kg tuber

Manuring:

Farmyard manure/compost @ 15 t/ha

Intercultural operations:

Earthing up on 30th day

Plant protection:

Crop rotation

Avoid late sowing

Yield:

10-15 t/ha

Increase in yield with bio-inoculants: 15 -20%

Fig 30: Potato; cultivation and harvest

FEEDBACK REPORT OF VARIOUS ACTIVITIES CONDUCTED AT VARIOUS VILLAGES

A. **Mawkohmoit, Mawthadrishan Block, WKH:** Bio-inoculant trial on paddy with Trichoderma and PSB by root dipping method.

Fig 31 (a): Paddy field at Mawkohmoit, WKH

Feedback from farmers: Mr. Gross Pariong, one of the progressive farmers of the village has acknowledged the performance of paddy in the area where seedling treatment with Trichoderma has been done. In his observation he noticed that the treated hill has higher tillering establishment and robust growth in both vegetative and reproductive perspective. He has also decided not to use any chemical input in the field instead to continue the usage of Trichoderma and PSB as well as other organic inputs in order to build up the natural soil fertility in the area. On observing the capacity of Trichoderma and PSB to improve the health and yield of the crop, the farmer himself has showed keen interest in receiving the training programme on low cost production of Trichoderma as well as other feasible bio-inputs for various SHG in the village.

Fig 31 (b): Mr. Gross Pariong

B. **Nonglwai, Nongstoin, WKH:** Trials of organic input *viz;* trichoderma, PSB, OGP, Vermi composting , NADEP Composting , Ginger chilli garlic extract, Broad spectrum biopesticide, Azotobacter, vermi wash, etc.

Feedback from farmers: Mrs Skentina Kharbani a farmer representative from Nonglwai has took up organic farming on her farm. She and her SHG (Nongrwe Iamonlang SHG) has started encouraging other farmers in the vicinity for taking up organic farming in a larger scale by using the bio inputs and other green technologies that were being demonstrated by the BRDC centre. She has also shared the effectiveness of trichoderma, PSB, Compost and other green technologies demonstrated to other farmers in the village. Furthermore, the SHG in the village has started taking up low cost production of Trichoderma for their needs as well as local distribution.

Fig 32(a): Application of Trichoderma, PSB, Compost and Bio pesticide on Cabbage

Fig 32(b): Application of Azotobacter (free living N-fixer), composting in the potato (var: Phan 5 minit)

Fig 33: application of Trichoderma, PSB, compost, OGP and Bio pesticide on various vegetables crops

Fig 34: Application of Azolla in rice field for supplementing nitrogen requirement of paddy

Fig 35: Trichogramma (an egg parasitoid) preliminary trial on rice for controlling of stem borer pest

Fig 36: Paddy cum fish culture in an advanced SRI method of paddy production

Fig 37: Crop diversification system of production has been followed to maintain soil fertility and manage pest infestation.

Fig 38: Kong Skentina one of the progressive farmer from Nonglwai sharing her success stories with the local farmers

Mawphanlur, Mawthadrishan Block, WKH: Trials of organic input *viz;* trichoderma, PSB, OGP, Vermi composting , NADEP Composting , Ginger chilli garlic extract, Broad spectrum biopesticide, Vertical Farming, etc.

Fig 39(a): Vertical farming being practice by the farmers in the village

Fig 39(b): Marigold as trap crop for pest management in the nearby fields

G. GIVING BACK TO NATURE PROGRAMME:

Introduction:

Giving back to nature initiative is a programme undertaken for Promoting Ecosystem Conservation for generating livelihood through Eco-tourism Development. Ecosystem Conservation will include both the existing and the Introduced Resources.

The Centre has been micropropagating various indigenous Orchids as a result of the Project funded by the Deptt. Of Biotechnology, Govt. Of India in which about a lakh numbers of these Orchids, in different stages of growth are being maintained. Thus, the Centre aims to transfers these Orchids back to their natural environment with the objective of benefiting Rural Communities. Rural Communities that have Community Forests and having willingness to take charge with ownership will be selected for establishment of the Community Orchid Parks in such Forests. These Forests (Orchid Parks/Sanctuaries) will eventually hosts multi-livelihood activities of these Villages or adjoining Villages and ultimately develop into the marketing Hub for different produces (Agricultural & Horticultural) and products (Green inputs, Crafts, etc). In the event that these Community Forests developed into recreational destination, the Village Communities should have the resources to suffice the visitors. Therefore, village Communities should be able to produce different food items produced organically as well as safe drinking water with traditional packages. Mementoes/Souvenirs for the Visitors which are unique to the Village would have to be produced so as the visitors carries back these to commemorate their visits.

Goal:

Promoting Livelihood through Ecosystem Conservation for Promoting Heritage

Objectives:

- Establishment of Community Parks (Orchid, Medicinal & Aromatic Plants, Wildlife Parks, etc)
- Integration of Livelihood Activities into the Parks
- Marketing of Agricultural Produces/Products, Handicrafts, etc

Criteria for Selection of Village Communities:

- Demand-based
- Willingness of the Village Communities to own the responsibility for implementation.
- Availability of Village/Community Forest (minimum of a hectare) with water sources, non-pine vegetation cover, etc.

Strategy for Implementation: Once the demand is obtained from willing Village Communities having Community/Village Forest, the following preliminary activities are to be taken-up:

- Survey of the land/Forest including GPS mapping, etc.
- Identification of Floral (Orchids, Host trees, Medicinal plants, etc) and Faunal Resources within the Forest.
- Transfer of Orchids:
    a) Capacity building on propagation of orchids, production & application of green inputs, etc., including cost of production.
    b) Capacity building on Management Development and Skill sets enhancement for maintenance of the Park
    c) Orchids to be tied on suitable branches of host trees (preferably, one species on a single tree) for epiphytes and propagation of terrestrial species.
    d) Labelling the names and description of orchids (including existing species), host trees, etc.

- Analysis of the water quality within/around the Park which can be used for drinking and other purposes.
- Identification of Livelihood Activities (Agricultural, Non-farm, Innovations, etc) possible for dovetailing into the Park.
- Possibility of establishing Wellness Centres within the Park which should be managed by the Local Traditional Healers.

Activity:

About 10 villages have been selected as per demand for implementing the giving back to nature programme in the 1st phase. A total number of 150 orchids have been distributed to each of the villages. The following are the villages where the programme has been initiated:

1. **Nongsynrieh, Mawkyrwat block, South West Khasi Hills.**

Fig. 40(a): The Community Forest at Nongsynrieh, SWKH

Fig. 40(b): Distribution of Orchids

Fig. 40(c): Orchids introduced at the Community Forest

2. Phudjaud Rangthong, Mawkyrwat block, South West Khasi Hills.

Fig. 41(a): The Community Forest at Phudjaud Rangthong

Fig. 41(b) Interior view of the Community Forest

3. Lyngdoh Masi, Mairang Block, West Khasi hills

Fig. 42(a): The Community Forest at Lyngdoh Masi

Fig. 42(b): Introduction of Orchids by the Community

Fig. 42©: Introduced Orchids

4. Sangriang, Nongstoin Block, West Khasi hills

Fig. 43(a): The Community Forest at Sangriang, WKH

Fig. 43(b): Interior view of the Community Forest

Fig. 43(c): Orchids available in the Community Forest

5. Cham Cham, Khliehriat Block, East Jaintia hills

Fig. 44(a): The Community Forest at Chamcham, EJH

Fig. 44(b): Introduction of Orchids by the student

6. Jarain, Amlarem Block, West Jaintia hills

Fig. 45(a): Introduction of Orchids by the District Nodal Officer, BDU-WJH during the Programme

Fig. 45(b): Students introducing orchids in the Community Forest

7. Thangbuli, Amlarem Block, West Jaintia hills

Fig. 46: Raid Buam Forest at Thangbuli, WJH

8. Amwi- Shkenpyrsit, Amlarem Block, West Jaintia hills

Fig. 47: Introduction of Orchids at the Community Forest in Amwi-Shkenpyrsit, Amlarem, WJH

9. Iamkhon (28.07.2016), Umsning Block, Ri Bhoi

Fig. 48(a): The Community Forest at Village Iamkhon

Fig. 48(b): The Entrance to the Community Forest

Fig. 48(c): Bamboo Structure for resting inside the Community Forest

Fig. 48(d): Transfer of Orchids by Village Community

10. Mawlyngbna (16.07.2016), Mawsynram Block, East Khasi Hills

Fig. 49(a): The Community forest at Mawlyngbna, EKH

Fig. 49(b): Introduced Orchid in the Community forest

II. Pine Brook School, Umbang village, Ri-Bhoi District

Fig. 50: Introduction of Orchid in the Campus of Pine Brook School, Umbang, Umsning Block, Ri bhoi

LIST OF ORCHIDS DISSEMINATED DURING THE GIVING BACK TO NATURE					
Sl.No.	Name of Orchid	Sl.No.	Name of Orchid	Sl.No.	Name of Orchid
1.	*Aerides* spp.	8.	*Cymbidium elegans*	15.	*Dendrobium ochreatum*
2.	*Agrostophyllum* spp.	9.	*Cymbidium iridioides*	16.	*Epigeneum amplum*
3.	*Bulbophyllum* (4-5 species)	10.	*Cymbidium mastersii*	17.	*Eria* spp.
4.	*Coelogyne corymbosa*	11.	*Dendrobium chrysanthum*	18.	*Pholidota* spp.
5.	*Coelogyne* spp.	12.	*Dendrobium densiflorum*	19.	*Micropera spp.*
6.	*Cymbidium cyperifolium*	13.	*Dendrobium hookerianum*	20.	*Otochilus porrecta*
7.	*Cymbidium eburneum*	14.	*Dendrobium longicornu*	21.	*Otochilus* spp.

Sl. No.	District	Village	Status	Remarks
1	South West Khasi Hills	Phudjaud- Rangthong	Over 2000 plantlets have been transferred to the community forest across the State	More plantlets will be transferred as given back to nature programme for the development of orchid park.
		Nongsynrih		
2	East Jaintia Hills	Chamcham		
3	West Jaintia Hills	Jarain		
		Thangbuli		
		Amwi-Shkenpyrsit		
4	Ri-Bhoi	Iamkhon		
		Pine Brooke School		
5	East Khasi Hills	Mawlyngbna		
6	West Khasi Hills	Sangriang		
		Lyngdoh Masi		

H. DOCUMENTATION OF TRADITIONAL BEST PRACTICES:

Meghalaya is one of the state in India which is rich in traditional knowledge and best practices practiced by indigenous tribes in which many of them are of old age traditions. Many of these knowledge and practices were closely related to their livelihood. With modern technology especially in agriculture, such practices have gradually depleting from the community. Documentation of such traditional knowledge has attracted increasing attention in recent years from governments and cultural institutions as well as from indigenous peoples and local communities. In order to facilitate such knowledge and practices the Centre strongly play a part in preserving those treasures by documenting such practices from time to time and maintaining them in the form of pamphlets or in near future as an organized data set, such as paper files, digital databases and traditional knowledge digital library.

Table : List of Traditional knowledge and Practices documented By BRDC

Knowledge Documented	Commencement period	District	Block	Village	Status
Soap production from *Sapindus mucorossi* (Soap Nut)	September 2015	WJH	Laskein	Sahsniang	3 best practices such as Indigenous Air Layering Method for Khasi Mandarin, propagation of tree tomato and Indigenous Method of Banana Propagation have been published and the rest are yet to be published
Traditional Fermentation of Tungrymbai (Soyabean)				Pasyih	
Package and practices of Sticky Rice From Jaintia Hills			Thadlaskein	Sung Valley	
Smoked Fish Production			Amlarem	Umlatkur	
Package and practices of traditional tomato cultivation at Laitkynsew	July 2015	EKH	Shella-Bholaganj	Laitkynsew	
Documentation on the Package and practices of scented rice from Rongjeng		EGH	Rongjeng	Rongjeng	

(i) DOCUMENTATION ON SOAP NUT (*Sapindus mucorossi*)

A. Introduction:

Soap nut is a wild growing tree plant found in some parts of Meghalaya. It possesses many medicinal properties like anti-dandruff, tonsillitis, skin diseases, etc. It is locally known as 'Sohpairah' in Khasi and 'Sohpinrah' in Jaintia. According to the people of Sahsniang village, the plant was found to grow in this village and adjoining villages more than 150 years ago. The fruits (nuts) are extensively used as soap by the people of Meghalaya for more than centuries. It was believed that during the olden days, the Khasis and Jaintias used Soap nut as washing agent for washing their clothes, utensil, bathing and washing of jewellery. In Jaintia hills particularly, soap nut was traditionally used for cleansing the dead bodies and placed an integral parts in the community.

Fig. 51: Soapnut tree (*Sapindus mucorossi*)

B. Basic information about Soap nut from Jaintia Hills:

- **Distribution:-** Umsalait (WJH)/Laskein Block
  Myntang (WJH)/Laskein Block
  Pdein Lapatein (WJH)/Laskein Block
  Shnongrim/Sahsniang (WJH)/Laskein Block
  Jowai (WJH)/Laskein Block

The plant is scarcely distributed and less populated

- **Volume of the fruits/tree**: 100-150Kg/tree

In Sahsniang, a Self Help Group by the name of '**Chirooplang SHG**' founded in the year 2006 with ten female members have recently started manufacturing of soap from Sapindus. This group could produce a thousand soups per year where they market it at the rate of Rs. 20-25 per soup. The production is based on the demands generated by the customers from Mookyndeng (WJH) and Shillong. This group finds it difficult to market their products and sometime display their products during District level exhibitions.

The raw materials (soap nut) required for making soap were purchased from the various villages mentioned above at the rate of Rs. 30/Kg.

PHOTOGRAPHS OF THE SOAP NUT AND ITS PRODUCTS

Fig. 52(a): Dried Soapnut fruits

Fig. 52(b): Soap nut Extract

Fig. 52(c): Freshly prepared soaps

C. Method of soap production:

- Take 750gm of dried soapnut and remove the seeds from it
- Then it is soaked in water for one hour after which the excess water is squeezed off till the solution become clear
- Collect the solution and filter using a muslin cloth
- The filtrate is collected in a bucket
- Take 750ml of the filtrate in a bucket
- A solution containing 150ml of lime juice, 2kg of melted ghee and 320gm of caustic soda is prepared separately and added to the bucket containing soapnut solution.
- The solution is mixed properly till it reach a consistency stage
- Pour the solution in a square wooden tray lined with chart paper arranged in a levelled position so that the thickness is uniform
- Leave it for 2-3 hrs in a partial shade till the solution solidifies and cut it into standard pieces or blocks
- The blocks are dried in the sun for 15 days and packed for marketing

D. Challenges:

a. Product finishing/designing
b. No fragrance and aromatic properties of the soap
c. No packaging features
d. Market linkages

(ii) DOCUMENTATION ON STICKY RICE FROM JAINTIA HILLS

A. Introduction:

Sticky rice (Kho-Pnah in Jaintia) is one of the rice varieties which are used by the people of Meghalaya for making different types of food item particularly the slow food item which is taken along with tea. In Jaintia Hills, sticky rice was very close to the tribal living in different parts of the district as diverse types of food item can be produced out of it such as ***Ja-chulia, Tpu-pnah, Tpu-sein, Tpu-langdong, Tpu-nai, Tpu-sawe, Tpu-sla,*** etc. For making these different varieties of food product, sticky rice is mixed with other scented rice such as Manipur rice.

Fig. 53(a): Kho-pnah produced from Sung valley

Fig. 53(b): Mixed cropping between Soybean and sticky Rice

Sticky rice is a cultivated variety which is being grown in different parts of Jaintia Hills such as Saipung, Saitsama, Nangbah, Shiliang Myntang, Sung Valley, Sahsniang, Shangpung, Laskein, etc. On conversation with some of the people from Nangbah village (WJH), Moodymmai (WJH), and farmers from Sung Valley (WJH), they stated that sticky rice was cultivated in small quantity for self-consumption only and very few people cultivate it for marketing. Although it grows very well in this area, but the market demand is very low and it is usually sold at a rate of Rs 80 per kg.

B. Method of cultivation practiced in Sung valley:

I. Nursery raising techniques	
a. Seed bed preparation	▪ Wet bed method
b. Varieties	▪ Local variety (Kho Pnah)
c. Seed rate	▪ 3-4Kg/100 sq ft
d. Seed treatment	▪ No seed treatment
e. Sowing time	▪ 2nd week of June
f. Manuring	▪ No manuring
g. Irrigation	▪ The nursery area is submerge with water up to 3-4 inch depth
h. Days to transplanting	▪ 30 days after sowing (2nd week of July)
i. Transplanting techniques	▪ 2-3 seedlings/ hill

II. Cultivation practices	
a. Soil & Field preparation	▪ The soil is ploughed using power tiller one week before transplantation ▪ Azolla prevailing in the field were incorporated during field preparation and this method helps to retain the soil fertility
b. Time of transplanting	▪ 2nd week of July

c. Seedling Treatment	▪ No seedling treatment followed
d. Spacing	▪ 20 cm x 20 cm
e. Cropping system	▪ Border-cropping with soybean
f. Manuring	▪ No manuring
g. Weeding	▪ Weeding is done once throughout the season (Last week of August)
h. Irrigation	▪ The field is maintained with standing water throughout the season
i. Pest infestation	• Swarming caterpillar which were observed once in 30 years
j. Diseases infestation	• Bacterial leaf Blight (mild infestation)
k. Harvesting	▪ Harvesting is done during 1st week of November ▪ Harvesting is done at an appropriate time in order to avoid grain shattering. ▪ The paddy is harvested with a sickle and dries in the field for one week. ▪ The harvested paddies is thresh on a hard surface with a stick and the husk is separated from the grain by winnowing
l. Duration (sowing-harvesting)	▪ 5 months
m. Yield	• 5.3 tonnes/Hectare

III. Seed saving techniques:

Source of Seed	• Self seed saving (approx 60 years)
a. Seed saving techniques	• Selection of seed from healthy mother plant • Threshing and winnowing of the harvested paddy • Sun drying till optimum moisture content is achieved
b. Storing techniques	▪ The dried seeds are stored in storage chamber made of wood known as Tyllu in a moisture free environment
c. Viability of the seeds	▪ One year
d. Challenges in Seed storing	▪ No challenges faced as such

(iii) DOCUMENTATION ON THE PACKAGE AND PRACTICES OF TRADITIONAL TOMATO CULTIVATION AT LAITKYNSEW

A. History of the traditional 'Laitkynsew' tomato:

- The exact time of its introduction in the village was not known however it has been cultivated in the village for the last 200 years according to the village community.
- The tomato is grown in all the four localities of the village Laitkynsew whereas the main cultivation as well as production comes from the Lumwahkrem locality.
- The Laitkynsew tomato is also cultivated at Nongwar village however the skin of the fruit is thicker than the one cultivated at Laitkynsew.
- Trials of the same variety (under controlled conditions) have also been conducted in other places like Shillong, Ri-bhoi, Mairang, etc. however only a profuse vegetative growth (6-7ft height) was observed with less fruiting.
- Characteristics of the 'Laitkynsew Tomato':
  - ✓ Tomatoes are purely organic
  - ✓ The texture is very soft and juicy
  - ✓ The outer skin is very thin
  - ✓ The fruit has a beefsteak type of structure
  - ✓ Approximate height 3-4 feet

Fig. 54(a): Nursery of tomato in a hanging tub

Fig. 54(b): Traditional basket for Packaging and marketing of tomato

B. Cultivation Methods

I. Nursery raising techniques:	
a. Seed bed preparation	▪ Top soil is collected in a tray or basin and used for raising the nursery
b. Varieties	▪ Laitkynsew
c. Seed rate	▪ No exact seed rate ▪ The seeds are broadcasted uniformly in the basin/tray
d. Seed treatment	▪ No seed treatment
e. Sowing time	▪ Mid-August to September
f. Manuring	▪ No cow dung is added as this will promote damping-off of the seedlings ▪ The top soil is the only source of nutrition
g. Irrigation	▪ Watering is done daily
h. Days to Hardening	▪ Two weeks after transplanting

i. Hardening method	▪ The seedlings are hardened by transplanting into the nursery bed in the field when they have at least three leaves foliage ▪ The nursery soil is mixed with only a low amount of cow-dung ▪ The nursery beds are covered with polythene if rain occurs
j. Days to transplanting	▪ The seedlings are hardened for two weeks and transplanted into the main fields
k. Transplanting techniques	▪ The seedlings which are healthy with better foliage are selected for transplanting ▪ The seedling are transplanted along with the root soil intacted

II. Seed saving techniques:	
a. Source of Seed	▪ Self seed saving (approx 200 years)
b. Seed saving techniques	▪ Wet extraction technique
c. Extraction techniques	▪ Selection of a good mother plant ▪ Scrapping of the seeds from the fruit ▪ These seeds are collected in a bowl/container and kept for 2-3 days in open space ▪ The seeds are then washed in water and filtered with the help of a muslin cloth ▪ The seeds are then dried in the sun
d. Storing techniques	▪ The dried seeds are stored in the muslin cloth itself in a moisture free environment
e. Viability of the seeds	▪ Two years
f. Challenges in Seed storing	▪ No challenges faced as such
l. Pest and diseases in Nursery	▪ Some of the common pest and diseases observed: Damping off, White grub and thrips like insect

III. Cultivation practices	
Soil & Field preparation	▪ The soil is ploughed thoroughly where in the borders of the field are used for planting of tomatoes ▪ Holes are dug at a spacing one feet along the border of the field
Time of transplanting	▪ Mid-September up to October
Seedling Treatment	▪ No seedling treatment followed
Spacing	▪ 1 feet from plant to plant ▪ Cultivated in a single row as a border crop
Cropping system	▪ Inter-cropping with cabbage, carrot, lettuce, mustard
Intercultural practices:	▪ Staking with bamboos during tomato fruiting
Manuring	*Process of Manuring in tomatoes*: ▪ All biomass available in the field are collected in a heap and burnt. The burnt biomass is then mixed with cow-dung. ▪ Around 1-2kg of this manure is then applied in each hole where the tomatoes are to be transplanted.
Weeding	▪ Weeding is done occasionally when required that is approximately 2 to 3 times per season
Irrigation	▪ Irrigation is carried out on daily basis during the dry season ▪ It is irrigated manually using water pipes
Pest infestation	*Observed pest infestation*: i). Fruit borer

	ii). Rat
Diseases infestation	*Observed disease infestation*: i). Blight ii). Wilting (4-5 years ago)
Duration	▪ 5 months
Harvesting	▪ Fruits are harvested once they turn yellowish in colour ▪ Harvest begins from the last week of December and extends up to the beginning of April (when rain is scanty)
Yield	▪ 3-5 kg/ Plant

IV. Post harvest management	
▪ Storage	▪ The fruits are spread on the floor and stored in an open room ▪ Stacking is not advice as this compromises fruit quality
b. Packaging	▪ Each fruit is wrapped in a newspaper and kept in locally made boxes and marketed
c. Shelf life	▪ 1 month
d. Post harvest loses	▪ 1\10 of the harvested fruits are damage during transportation
e. Post harvest pest and diseases	▪ Rat infestation is commonly observed when the fruits are not harvested on time from the fields
f. Constraints	▪ No proper storage facilities

V. Marketing Strategies:	
a. Quantity of production from village	▪ 20 tonnes
b. Market price in different months	▪ Initial Harvest (late December to January) : Rs 100-120/kg ▪ Final Harvest (March-April): 70- 80/kg
c. Target markets	▪ Sohra, Shillong(Iewduh)
d. Marketing system	▪ On farm marketing ▪ Individual marketing system
e. Marketing challenges	▪ Marketing of the harvested Tomatoes is linked through the middleman which leads to a decrease in selling price of the tomatoes ▪ The selling price quoted by the farmer decreases with time whereas the cost price of the tomatoes in the market remains the same (eg. Farmer's price- 120/Kg to 70/kg; Market price : 120/kg throughout)

(iv) DOCUMENTATON ON SMOKED FISH

A. Introduction:

Fish is one of the important food items amongst the tribes of Meghalaya. It is prepared in various recipes in which smoked fish is one of the unique products in the Jaintia hills District. It is popularly known as 'Da Kharang' in Jaintia hills and 'Doh Khasyang' in Khasi hills. Smoked fish in Jaintia hills is an old age practiced for preserving fishes from spoilage. This practise started in Borkhat, Muktapur around 120 years ago by the Jaintiapur. During those times the fishes were caught from the rivers and streams around the village vicinity and smoke dried along the river bank and marketed to the nearby markets. Later during the early 19th century, these people migrated to Umlatkur village under Amlarem block. Till date the people have been practising the same method of fish drying.

B. Raw materials used for drying:

- Firewood
- Bamboos
- Furnace stand
- Chopping block and daw
- Storing basket
- Fish: Presently, the common carp fish imported from Andhra Pradesh is used for drying due to the decline in local fish population in the Village Rivers and streams.

C. Products:

a. Kharang: A single fish inserted with a straight bamboo along the gut.
b. Khyrwong/Kha Pyndong: A double fish stand twisted in a circular manner by piercing a bamboo through the eyes and tails of both the fishes.

D. Methods of preparation:

- The fishes are washed properly after which a sharp bamboo is inserted through the mouth and degutted.
- The bamboo act as a stand in the furnace during the drying process.
- The fishes are smoked in the furnace for about five to six hours
- After drying, the smoked fish are kept in a bamboo basket and covered with locally available leaves (sla lamet) /muslin cloth/ newspaper to sustain the aromatic essence in them

E. Marketing:

- The smoked fish are marketed to Jowai and other nearby villages
- The smoke fish fetches a good market during the winter seasons. For instance, approximately 50-60 smoked fish are sold in a day per person whereas 20-25 smoked fish are sold during summer seasons.
- The volume of production from the village is approximately 1,87,800 fishes/year
- Due to the market potential of the smoked fish, the villagers started a self help group known as Seng borlang Women in the year 1995 for improving their socio-economic status.
- The women are the main sale person for marketing the products whereas the men take part in preparing the smoked fish.

F. Constraints/Challenges:

- Distant market linkages
- High transportation cost
- Non availability of local fishes

Fig. 55(a): Burning furnace

Fig. 55(b): Final Product ready for marketing

G. Cost of production per household:

Particulars	Mandays	Cost/year
A. Cost of raw materials/inputs:		
a. Firewood@16t/yr		22,000
b. Bamboo@1500bamboos/yr		7,000
c. Fish@12.5t/yr		15,02,400
B. Operational cost:		
a. Cost of labour in production@180/day	313	56,340
b. Cost of transportation@ 200/day		62,600
c. Cost of marketing labour@160/day	313	50,080
C. Final product cost:		
a. Cost of finish product@ Rs 150/fish(40 fishes/day)		18,78,000
D. Cost of production:		
a. Total cost of production		17,00,420
b. Unit cost of production per fish		136
c. Total Net profit		1,77,580

(V) DOCUMENTATION OF TRADITIONAL FERMENTATION OF TUNGRYMBAI (FERMENTED SOYABEAN)

A. Introduction

Tungrymbai is a fermented indigenous soybeans food common to the tribes of Meghalaya. It is not only the famous delicacy of the tribes of Meghalaya, but also a rich source of proteins.

Pasyih is one of the villages under Laskein Block in West Jaintia Hills District which is famous for its huge production and best quality of Tungrymbai. The village is located about 26 Kms from Jowai along the Jowai-Khliehriat Road. There are around 450 households in the village with a total population of 2300. The people of this village have been practicing fermentation of Tungrymbai for centuries. Out of the total household, around 50 households are taking fermentation of Tungrymbai as a source of livelihood. On having a dialogue with few of the villagers (Kong Des Siangshai, Ma Phlim Rymbai, Ma Win Dkhar), it was understood that fermentation and marketing are done by the same people.

B. **Raw materials:-** Soybean which is a local variety are bought from Iewduh in Shillong at a rate of Rs. 55/Kg. These soybeans are grown extensively at Umroi, Bhoirymbong area in Ri-Bhoi. The villagers said that they have tried cultivating soybean in the village, but could not thrive well in that particular area.

Fire wood are purchased at a rate of 7000/Truck. 2 trucks/ year are consumed through-out the whole process of fermentation by one family.

C. Method of fermentation:-

- 20 Kgs of Soybean are boiled in a pot for 8-10 hours till it become soft. Water should be added every now and then to ensure that it does not get dry.
- When the beans are soft, it is filtered using a muslin cloth. The filtered beans are kept in a basket having a base and lined with leaves grown locally and commonly known as '*Sla lamet*'. The filtrate is collected in a container and can be used to feed pigs and cows.
- The baskets are covered with a jute bag for the bean to rise and are kept over a fire place without disturbing for 3 days and 3 nights.
- After 3 days, the basket is open and checked whether the pungent smell has developed or not. If the smell has developed, it indicates that the soybean is ready for smashing.
- Smashing is done with the help of a wooden pestle and mortar.
- If the fermented soybean is too dry, cold water is added at this stage.
- The smashed soybeans are kept in a big container and are ready for used.
- Out of 1 Kg soybean seeds, 2 Kg of fermented soybean is produced.
- These fermented soybeans can be stored for 2-3 days during summer and 7-10 days during winter.

D. Production:-

- The production is more in winter (November-March) than in summer because in summer there is a high risk of spoilage and the taste is also much better during winter.
- Per household, 2.5 quintal Tungrymbai is produced in a month during winter and 1 quintal during summer.
- Total production from the village is approximately 105 tonnes/year

E. Market value:-

- The fermented soybean is mainly sold in Jowai market and other nearby market such as Shangpung, khliehriat at the rate of Rs.80/Kg.

F. Cost of Production per household

Particulars	Mandays	Amount/year
i. Cost of raw materials/inputs:		
a. Soybean seeds @ 1tonne/year		55,000
b. Firewood @ 2 truck/yr (Rs7000/truck)		14,000
ii. Operational cost:		
c. Total mandays for production @ Rs180/day	104	18,720
d. Total cost of Marketing @ Rs160/day	104	16,640
e. Total mandays for transportation of products @ Rs 1100/month		13,200
iii. Final product cost:		
a. Total cost of final products/year		1,60,000
iv. Total cost of production:		
a. Total cost of production/year		1,17,560
b. Unit cost of production per kg of tungrymbai		58.76
c. Total Net profit		42,440

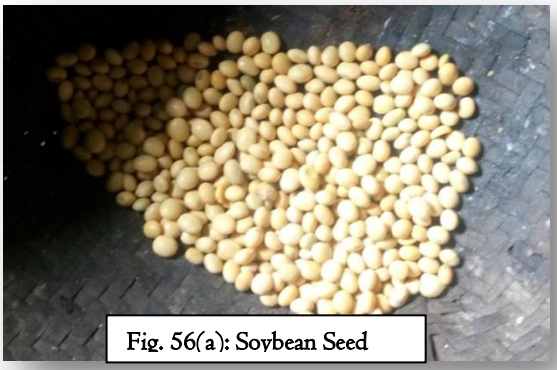


Fig. 56(a): Soybean Seed

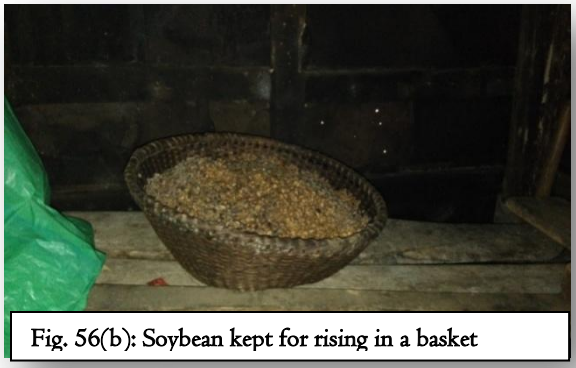


Fig. 56(b): Soybean kept for rising in a basket

Fig. 56(c): Utensils used in boiling of Soybean

Fig. 56(d): Mortar for grinding Soybean

Fig. 56(e): Furnace place for cooking soybean

Fig. 56(f): A product of soybean locally known as 'Tungrymbai'

Fig. 56(g): Packaging of 'tungrymbai' with sla lamet

Fig. 56(h): A product 'Tungrymbai' added with black sesame

(VI). DOCUMENTATION ON SCENTED RICE OF GABIL DANINGKA, RONGJENG BLOCK, WEST GARO HILLS

History of Jaha rice cultivation in Gabil Daningka village under Rongjeng dev. Block:

Jaha or Joha rice is one of the species of aromatic rice traditionally grown in Gabil Daningka village under Rongjeng Development Block of East Garo Hills since ages (year not exactly known). It is mostly grown in lowlands in small pockets.The rice is used in making traditional curries known as pura or for medicinal purpose for curing a disease known as mibang napa. It is a disease where a man or woman suddenly collapses due to weakness. The uncooked rice is to be swallowed along with water. It is known to be a source of energy which gives them strength to carry out their cultivating activities. After harvesting the farmer organises a small feast as a thanksgiving for the good harvest.

Description and Characteristics:

The farmers of Gabil Daningka mostly cultivate three different sub variety of local Jaha or Joha rice, namely Jaha gipok, Jaha gitchak and Jaha gisim, which are named based on the colour of the grain.

- **Jaha gipok**: Plant height is medium. Maturity period is approximately 4(four) months. Whitish or yellowish grain colour. Rice grain is smallerand finer. The grain are generally slightly sticky. It is used as both regular meal and special recipes in festivals like christmas and new year. Yield goes upto 8 mon per bigha. (1 mon=45kg).

  There are again two types of Jaha gipok, smaller and bigger sized grains. The aroma of smaller grain Jaha gipok is stronger than the bigger sized grain Jaha Gipok.
- **Jaha gitchak**: Grows in lowland. Plant height is medium. The grain type is slim and red in colour. Mainly cooked during festivals or special occasions. Average yield is 5-6 mon per bigha.
- **Jaha gisim**: Compared to other Jaha varieties it has the strongest aroma. It grows well on medium lowland. Plant hieght is medium. Grain type is slim and black in colour. Rice cooks slowly. The rice gives a full feeling for a long time. It is possible to store for a long period without spoiling. Average yield is around 7-8 mon per bigha.

Cultivation practices:

Sowing : May

Transplanting : Last week of June or July

Raising of seedlings:

a) **Preparation of seed bed**: Land is thoroughly puddle. Lenght and breadth of the seed bed may vary according to the convenience.
b) **Manure:** In seed bed cowdung is applied and mix well with the soil.
c) **Water management**: Irrigation water is properly applied to the surface soil of the nursery bed. Channels are made and water is let in into the beds from the water source.
d) **Preparation of seed**: Seeds are kept immersed in water for one or two night in a jute bag. Seed bags are taken out of water and kept open air for sufficient period till the shoots sprout upto a length of 1-2 mm.
e) **Sowing of sprouted seeds in the nursery**: Sprouted seeds are uniformly sown in the bed at the rate of about 1 kg/sq.m. Beds are watered after sowing.
f) **Uprooting of seedlings**: Seedlings become ready for transplanting when its height becomes 15-20 cm with 3 to 4 leaves.

Intercultural operations: Weeding is done once or twice during growing season.

Diseases and pest: Gundhi bug, leaf cutter and stem borer.

Indigenous technical knowledge: To get rid of general pests confronted in rice field, farmers follow the following practices:

- To reduce the initial inoculums of general pests and disease, farmers burn the straw and stubbles in the field before ploughing or field operations.
- Bamboo perches are used in the rice field which allow the predatory birds to rest on it and thereby able to prey the insect pest comfortably.
- Dead crab shell or fish etc, are used as cure to attract the rice bug and later on they are killed mechanically.
- When the grains are filled any shinning strips of ribbons are tied across the field in bamboo poles to prevent the birds from eating the grains.

Harvesting

It is harvested during the second or last week of november or first week of december. The rice is harvested and grinded in traditional mortar and pastle to remove the straw and grains and stored in bamboo structures or earthern pots.

Market

- As it is grown only in small areas, most of the farmers cultivate Jaha rice only for family consumption.
- If abundant they sell it in local market at Rongjeng or in weekly market at Rongmil.
- During festive seasons Jaha rice are ordered from the farmers directly by some people.
- It is sold @Rs. 50 per kg in local markets.

Source: Binu. G. Momin
Village: Gabil Daningka
Block: Rongjeng Development Block
District: East Garo Hills

I. ESTABLISHMENT OF MICRO-BIOTECH PARKS IN EXPERIMENTAL FARMS:

The Centre is setting up and maintaining Experimental Farms for conducting action research, demonstrations of various green technologies, field experiments and trials. Besides the Central Experimental farms located at Laitmynsaw, there are three other experimental farms at Horticulture Farm, Upper Shillong; Sangsanggre, WGH and Zikzak, SWGH. These experimental farms also serve as Knowledge Centres (Micro-biotech Parks) in propagating knowledge on production of affordable green technologies to the farming communities.

Fig 57: The Composting Unit at Laitmynsaw Farm

I. The Central Experimental Farm:

The Central Experimental Farm measuring a little over a hectare (3.04 acres) is located at Laitmynsaw Village, Upper Shillong, East Khasi Hills District. The following are the activities undertaken and managed in the farm:

I. Demonstration of Affordable Green Technologies:

a) ***Compost Production:*** Different types of composts are being produced for field applications during trials and action researches within the farm and in farmers' fields. These units also serve as demonstration tools for dissemination of knowledge on these technologies. The following are the different types of composts produced in this farm-

- Vermi-compost
- NADEP compost (Catalysed and Non-catalysed)
- Non-soil compost (Catalysed and Non-catalysed)
- Berkely Hot compost, and
- Vermi-wash

Fig 58: Composting Unit at Laitmynsaw Experimental Farm

Fig 59: The tanks for production of different composts

Fig 60: Composts making

Fig 61: Composts harvesting and sorting

b) ***Production of Bio-rationales & Nutritional Supplements:*** Bio-rationales (Plant based biopesticides-cum-bioinsecticides, insect traps, etc) made out of locally available resources are being produced and used in the farm.

On the other hand, nutritional supplements such as organic growth promoter (OGP), Panchgavya, etc are being produced and used to improve quality of crops.

Fig 62: Preparation of Panchgavya

c) ***Vertical Farming:*** This technology is being carried out in the farm to demonstrate enhanced production of green leafy & other vegetables from very limited cultivable area. Vegetables which was effectively produced through this technique are mustard, coriander, menthe, carrot, lettuce,etc.

II. Action Researches and Trials:

a) Medicinal and Aromatic plants- As an effort to promote the traditional system of medicine through engagement with local health practitioners, the Centre realised the need to conserve indigenous medicinal and aromatic plants for the purpose of providing knowledge on these resources including their *ex-situ* propagation.

Fig 63: Ex-situ propagation of indigenous medicinal & aromatic plants

Simultaneously, action research and trials on propagation of high value medicinal & aromatic plants such as *Mentha piperita*, *Artemisia annua*, *Pelargonium graveolens*, *Citonella*, *Cymbopogon flexuosus*, Vetiver, is being conducted so as to develop agro-technologies

b) Trials of bio-inoculants on different crops- On farm trial of bio-inoculants on different crops are being conducted in order to establish the dosage & effectiveness of these inputs. Crops such as potato, maize, ginger, mustard, chilly, garden peas, beans, etc have been successfully tried.

Fig 64: Nursery of *Artemisia*

Fig 65: Trial of bio-inoculants on different crops

Fig 66: Trial on potato (Local variety- Phan ingding)

c) On farm production of Azolla: Azolla production is being carried out for mainly for generation of materials for conducting field trials on improved productivity of paddy.

Fig 67:. On farm production of Azolla

d) Production of Mushroom- Trial on production of Oyster mushroom is also being conducted as an initiative to promote mushroom cultivation by interested farmers.

Fig 68: Action research on production of Mushroom (Oyster)

2. The Upper Shillong Experimental Farm:

The Upper Shillong Experimental Farm measuring about 1 Ha is located at the Horticulture Farm, Upper Shillong, East Khasi Hills District. The major activity undertaken and managed in the farm is the action research and trials on propagation of high value aromatic plant *Mentha piperita* and establishment of demonstration unit for propagation of *Citonella, Cymbopogon flexuosus, Pelargonium graveolens, Vetiver*, Palmarosa, etc.

The land is highly suitable for propagation of Mentha piperita, in which over 4,00,000 stolons have been generated.

Fig 69: Propagation of *Mentha piperita* at Upper Shillong Farm

3. Sangsanggre Experimental Farm:

The Sangsanggre Experimental Farm (About I Ha area) is located at Horticulture Farm, Sangsanggre, Tura, West Garo Hills District. The following activities are being undertaken and managed in the farm:

Fig 70: Sangsanggre Experimental Farm

Fig 71 Composting Units

I. Demonstration of Green Technologies:

a) ***Compost Production:*** The following are the different types of composts produced in this farm-

- Vermi-compost
- NADEP compost (Catalysed and Non-catalysed)
- Non-soil compost (Catalysed and Non-catalysed)

Fig 72: Compost production and storage

b) ***Vertical Farming:*** This technology is being carried out for enhanced production of vegetables such as tomato, lettuce, mustard, chillies, etc.

Fig 73: Vertical farming Units

II. Action Research and Trials:

On farm trial of bio-inoculants and inputs (composts, OGP, etc) on different crops are being conducted to establish the dosage & effectiveness of these inputs. These trials are being done simultaneously in farmer's fields. Crops such as maize, tomato, mustard, chilly, tapioca, etc have been successfully tried.

4. Zikzak Experimental Farm:

The Zikzak Experimental Farm (About I Ha area) is located at Horticulture Farm, Zikzak, Ampati, South West Garo Hills District. The following activities are being undertaken and managed in the farm:

Fig 74: Zikzak Experimental Farm

I. Demonstration of Green Technologies:

a) ***Compost Production:*** The following are the different types of composts produced in this farm-

- Vermi-compost
- NADEP compost (Catalysed and Non-catalysed)
- Non-soil compost (Catalysed and Non-catalysed)

Vertical Farming: This technology is being carried out for enhanced production of vegetables such as tomato, lettuce, mustard, chillies, etc.

Fig 75: Composting Units at Zikzak Farm

Fig 76: Vertical farming Units at Zikzak Farm

III. Action Research and Trials:

On farm trial of bio-inoculants and inputs (composts, OGP, etc) on different crops are being conducted to establish the dosage & effectiveness of these inputs. These trials are being done simultaneously in farmer's fields. Crops such as maize, tomato, mustard, chilly, tapioca, etc have been successfully tried.

Fig 77: Field trials of bio-inoculants at Zikzak Farm

J. PROMOTION OF THE INDIGENOUS SYSTEM OF MEDICINE:

Introductory Note

Meghalaya is endowed with abundant natural resources. One of the components of plant diversity constitutes plants with medicinal and aromatic values. In the State, such plants have a long history rooted in its culture and tradition on account of wide range of use and application. There is a huge reservoir of persons with knowledge on the use of herbs plants for preventing and treating various human diseases and ailments including livestock. Presently, there is growing need and demand of medicinal and aromatic plants by Local Herbal Practitioners (LHPs), etc

On the other hand, there has been largely a bypass in the judicious use of natural resources and biodiversity in the State. The adverse impact is explicit as there are ascending challenges for people to access to basic and livelihood needs. It is utmost important to ensure sustainable use of natural resources while also promoting medicinal and aromatic plants. To ensure people's access to basic and livelihood needs, sustainability of development would not be possible with unsustainable utilization of natural resource – base

Goal – Setting

Promoting Traditional System of Medicine and Cultural Heritage

Objective – Setting

Promoting Bio Resources and Sustainable Development for Livelihood and Self Employment Creation

Process Mapping

a. Engagement with LHPs in understanding the plants used by them as also assessment of critical gaps linked to value chain

b. Mapping of geographical location and distribution of medicinal plants across the State and to understand their status

c. Preparing the Directory of LHPs

d. Documenting the Knowledge and Practice of LHPs and developing Digital Library on Traditional Knowledge and Practice

e. Promoting Community Nursery for propagation of plants with medicinal and aromatic values including micro – propagation, if required for creation of Herbal Garden/ Park including biodiversity promotion which would be opportunities for promoting rural tourism

f. Value Chain Study of Potential Marketable Medicinal and Aromatic Plants

g. Bio-prospection of the properties of plants commonly used by LHPs for dose – standardization, etc and Phytochemical analysis of potential marketable Medicinal and Aromatic Plants

h. Awareness promotion, institutional building and empowerment of knowledge and skill – sets of village communities/ CBOs who are interested in taking up nursery including plantation as also production of organic inputs by village communities for promoting herbal garden/ park for livelihood/ self employment creation and sustainable development

i. Empowering Entrepreneurs with the required knowledge and skill – sets by LHPs and Science in manufacturing herbal products like medicine/ herbal drinks/ candies/ ointments/ balm/ cosmetics as one of the possibilities to boost tourism industry.

j. Promoting Wellness Centres in Cluster/ Block/ District Level by LHPs

k. Facilitating GI Certification, Intellectual Property Rights and Government Certification of LHPs and their practice.

Progress:

i. A 3-day Block level Workshop for Traditional Healers of Amlarem Block have been conducted from 28th -30th March, 2016 in collaboration with the Basin Development Unit-West Jaintia Hills and the Block Development Officer, Amlarem. The objective of the workshop is to performed detailed documentation of the Traditional Healers and their practices including the types of plants used, sources of raw materials- their collection and propagation, assessment of critical gaps, etc. (**Report: Attached as *Annexure-IV***)

ii. In collaboration with Santhigiri Ashram and Research Foundation, Kerala and NRM Team, Meghalaya Basin Development Authority (MBDA), the Centre conducted a 1-Day programme - the "Meghalaya Traditional Practitioners Meet "on the 12th August, 2016. The theme of the workshop is *"Integrated Traditional Health Care Services as an Organised Sector".* The aim of the Workshop is to deliberate on issues pertaining to manufacturing, processing of the Herbal formulations especially relating to enhancement of the shelf life of these herbal formulations. It is also aims to promote the Indigenous system of medicine of the State to be at par with other forms of the Indian System of Medicine. Its promotion as health tourism will not only provide identity to the Traditional Healers but will address livelihood opportunities and employability (**Summary of the Event: Attached at *Annexure-V***).

iii. The Directory of Traditional Healers from across the State is being prepared in which the list of Traditional healers have been obtained through a series of District level Workshops, in collaboration with Martin Luther Christian University, Shillong and Traditional Healers. Further, mapping of these traditional healers have to be performed for integrating into GIS format. This Directory will provide basic information on the strength of this traditional practice and also as the baseline information on the Traditional Healers for which detailed documentation will be conducted (**Annexure-VI*)*.