TRAINING MODULES
FOR MASTER TRAINERS
ON GREEN TECHNOLOGIES

Green Technologies for Sustainable Agriculture

Bio-Resources Development Centre

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INTRODUCTION

Organic Farming/Sustainable Green Agriculture is a traditional practice being adopted by the farming community of the State for ages. But in due course of time when chemical fertilizers and pesticides came into supply for plant nutrients and control of diseases the noble practice slowly started fading and chemicals took over in certain crops over a period of time. Though there can be an increase in the crop yield with inorganic inputs, however, it adversely affect the sustainability of productivity due to declined soil health regime. It also reduces the scope and opportunity for cultivation of indigenous crops and biodiversity promotion due to toxicity.

Organic farming/ Sustainable Green Agriculture can be promoted to the farming communities by enhancing soil and plant health through the introduction of bio-inputs such as microbial inoculants, organic inputs and bio-control agents. Bio-inoculants can be expected to reduce the use of chemical fertilizers and pesticides and eventually replacing them. Through the use of bio-inputs, healthy plants can be generated and productivity will be enhanced, while promoting the sustainability and the health of the soil. Organic inputs production could be taken-up by the local entrepreneurs/farming communities after validation in the Farmer's Fields. Such Enterprise would be an add-up item for local economy growth and employment opportunities.

Hence, it is of prime necessity that the farming communities be empowered with knowledge on the beneficial aspects of green or natural inputs for sustainable agricultural practices. Knowledge on a wide range of green technologies is to be empowered, including their uses and production of green inputs. These inputs can be produced by the farming communities utilizing locally available resources and materials, thereby reducing the cultivation cost and significantly enhanced profit. Simultaneously, these technologies are to be validated on-farm and on-field (farmer's field) prior to propagating in large scale.

GOAL

Empowering Knowledge on the Use and Production of Affordable Green Technologies/ Inputs in Agriculture and Allied Activities

OBJECTIVES

- Promoting awareness on the beneficial aspect of sustainable agricultural practices
- Empowering hands-on knowledge of green technologies and production of input.
- Propagating sustainable agricultural practices to the farming communities for improved productivity.
- Promoting Social Enterprises in on-farm production of organic inputs.

SCHEDULE

	Time	Activities
Day I	9.30 am-10.00am	Registration
	10.00 am-11.00am	Introductory session on sustainable green technologies
	11.00am–11.15 am	Tea break
	11.15am-12.30pm	**Composting technologies:** Theory
	12.30pm-1.30pm	Hands on demonstration on composting
	1.30pm-2.00pm	Lunch break
	2.00pm-4.30pm	Hands on demonstration on composting
	4.30pm-5.00pm	Interaction / discussion session
Day II	9.30 am-10.30am	**Organic growth promoter:** Theory
	10.30 am-11.30am	Hands on demonstration on organic growth promoter (vegetable waste enzyme)
	11.30am-11.45am	Tea break
	11.45am-12.45pm	**Botanical pesticides/insecticides:** Theory
	12.45pm-2.00pm	Hands on demonstration on botanicals pesticides/insecticides (Broad spectrum Bio-pesticides & ginger garlic extract)
	2.00pm-2.30pm	Lunch break
	2.30pm-3.15pm	**Panchagavya:** Theory
	3.15pm-4.45pm	Hands on demonstration on Panchagavya
	4.45pm-5.00pm	Interaction / discussion session
Day III	9.30 am-10.30am	**Integrated Pest Management:**
	10.30 am-10.45am	Tea break
	10.45am-12.30am	Hands on demonstration on Integrated Pest Management (bait trap, yellow sticky trap, light trap, pheromone trap)
	12.30pm-1.30pm	**Bio-inoculants (Bio-fertilizers):** Theory
	1.30pm-2.00pm	Lunch break
	2.00pm-4.00pm	Hands on demonstration on the use of bio-fertilizers (Phosphate solubilising bacteria(PSB), Rhizobium, Azospirillum, Trichoderma, Azolla)
	4.00pm-5.00pm	Interaction / discussion session
Day IV	9.30 am-10.45am	**Energy Pillar Technology:** Theory
	10.45 am-11.00am	Tea break
	11.00am-2.00pm	Hands on demonstration on Energy Pillar Technology
	1.30-2.00pm-	Lunch break
	2.00pm-3.00pm	**Vertical farming Technology:** Theory
	3.00pm-4.30pm	Hands on demonstration on Vertical Farming
	4.30pm-5.00pm	Interaction / discussion session
Day V	9.30 am-10.45am	**Vermi-wash:** Theory
	10.45 am-11.00am	Tea break
	11.00am-1.30pm	Hands on demonstration on Vermi-wash
	1.30pm-2.00	Interaction / Discussion session
	2.00pm-2.30pm	Lunch break
	2.30pm-4.30pm	Evaluation & Assessment Session
	4.30pm-5.00pm	Valedictory Session

TRAINING MODULES: TRAINING OF TRAINERS ON SUSTAINABLE GREEN TECHNOLOGIES			
TIME (HRS)	ACTIVITIES	OBJECTIVE	CONTENT
MODULE-1: COMPOSTING & NUTRITIONAL SUPPLEMENTS			
6.50	Composting technologies	• Empowering knowledge on production of Composts and Nutritional Supplements for the crops utilising locally available resources	• Theory • Hands on demonstration; • Interaction & Discussion
2.50	Organic growth promoter		
3.50	Vermi-wash		
3.50	Panchagavya		
MODULE-2: INTEGRATED PEST MANAGEMENT			
3.00	Pest Management Tools & Techniques	Empowering knowledge on: • Iidentification of insect and pest • Production of various Insect Management tools (bait trap, yellow sticky trap, light trap, pheromone trap) • Production of various botanicals pesticides/ insecticides (Broad spectrum Bio-pesticides & ginger garlic extract)	• Theory • Hands on demonstration • Interaction & Discussion
2.50	Botanical pesti-cides/insecticides		
MODULE-3: MICROBIAL BIO-INOCULANTS			
4.00	*Microbial Bio-inoculants (Bio-fertilizers & Bio-pesticides)*	Empowering knowledge on: • Production of various microbial bio-inoculants (Phosphate solubilising bacteria(PSB), *Rhizobium, Azospirillum, Trichoderma, Azolla)* • Use of bio-inoculants and Field Trials	• Theory • Hands on demonstration • Interaction & Discussion
MODULE-4: TECHNOLOGIES FOR IMPROVED CROP PRODUCTION			
4.50	Energy Pillar Technology: Theory & Hands on demonstration on Energy Pillar Technology; Interaction & Discussion		• Theory • Hands on demonstration
3.50	Vertical farming Technology: Theory & Hands on demonstration on Vertical Farming; Interaction & Discussion		• Interaction & Discussion

MODULE-I: COMPOSTING & NUTRITIONAL SUPPLEMENTS

COMPOSTING:

Composting is the process in which organic matter is decomposed and recycled as a fertilizer and soil amendment. Compost is a key ingredient in organic farming. At the simplest level, the process of composting requires making a heap of moist organic matter known as green waste (leaves, food waste) and waiting for the materials to break down into humus after a period of weeks or months. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. Worms and fungi further break up the material. Bacteria requiring oxygen to function (aerobic bacteria) and fungi manage the chemical process by converting the inputs into heat, carbon dioxide and ammonium. The ammonium (NH_4) is the form of nitrogen used by plants. When available ammonium is not used by plants it is further converted by bacteria into nitrates (NO_3) through the process of nitrification.

Compost is rich in nutrients. It is used in gardens, landscaping, horticulture, and agriculture. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover (see compost uses). Organic ingredients intended for composting can alternatively be used to generate biogas through anaerobic digestion.

INGREDIENTS

Composting organisms require four equally important ingredients to work effectively:

- ***Carbon*** **—** for energy; the microbial oxidation of carbon produces the heat, if included at suggested levels. High carbon materials tend to be brown and dry.
- Nitrogen — to grow and reproduce more organisms to oxidize the carbon. High nitrogen materials tend to be green (or colorful, such as fruits and vegetables) and wet.
- ***Oxygen*** **—** for oxidizing the carbon, the decomposition process.
- ***Water*** **—** in the right amounts to maintain activity without causing anaerobic conditions.

Certain ratios of these materials will provide beneficial bacteria with the nutrients to work at a rate that will heat up the pile. In that process much water will be released as vapor (“steam”), and the oxygen will be quickly depleted, explaining the need to actively manage the pile. The hotter the pile gets, the more often added air and water is necessary; the air/water balance is critical to maintaining high temperatures (135°-160° Fahrenheit / 50° - 70° Celsius) until the materials are broken down. At the same time, too much air or water also slows the process, as does too much carbon (or too little nitrogen). Hot container composting focuses on retaining the heat to increase decomposition rate and produce compost quicker.

The most efficient composting occurs with an optimal carbon: nitrogen ratio of about 10:1 to 20:1. Rapid composting is favored by having a C/N ratio of ~30 or less. Theoretical analysis is confirmed by field tests that above 30 the substrate is nitrogen starved; below 15 it is likely to outgas a portion of nitrogen as ammonia. If nitrogen needs to be increased, it has been suggested to add 0.15 pounds of actual nitrogen per three bushels (3.75 cubic feet) of lower nitrogen material. [For those not familiar with these types of units: 0.64g/L or 640 grams of actual nitrogen per cubic meter.] Two to 3 pounds of organic nitrogen supplement (blood meal, manure, bone meal, alfalfa meal) per 100 pounds of low nitrogen materials (for example, straw or sawdust), supplies generally ample nitrogen and trace minerals in high carbon mixes.

Nearly all plant and animal materials have both carbon and nitrogen, but amounts vary widely, with characteristics noted above (dry/wet, brown/green). Fresh grass clippings have an average ratio of about 15:1 and dry autumn leaves about 50:1 depending on species. Mixing equal parts by volume approximates the ideal C:N range. Few individual situations will provide the ideal mix of materials at any point. Observation of amounts, and consideration of different materials as a pile is built over time, can quickly achieve a workable technique for the individual situation.

ANIMAL MANURE AND BEDDING

On many farms, the basic composting ingredients are animal manure generated on the farm and bedding. Straw and sawdust are common bedding materials. Non-traditional bedding materials are also used, including newspaper and chopped cardboard. The amount of manure composted on a livestock farm is often determined by cleaning schedules, land availability, and weather conditions. Each type of manure has its own physical, chemical, and biological characteristics. Cattle and horse manures, when mixed with bedding, possess good qualities for composting. Swine manure, which is very wet and usually not mixed with bedding material, must be mixed with straw or similar raw materials. Poultry manure also must be blended with carbonaceous materials - those low in nitrogen preferred, such as sawdust or straw.

MICROORGANISMS

With the proper mixture of water, oxygen, carbon, and nitrogen, micro-organisms are allowed to break down organic matter to produce compost. The composting process is dependent on micro-organisms to break down organic matter into compost. There are many types of microorganisms found in active compost of which the most common are:

- Bacteria- The most numerous of all the microorganisms found in compost. Depending on the phase of composting, mesophilic or thermophilic bacteria may predominate.
- Actinobacteria- Necessary for breaking down paper products such as newspaper, bark, etc.
- Fungi- Molds and yeast help break down materials that bacteria cannot, especially lignin in woody material.
- Protozoa- Help consumes bacteria, fungi and micro organic particulates.
- Rotifers- Rotifers help control populations of bacteria and small protozoans.

In addition, earthworms not only ingest partly composted material, but also continually re-create aeration and drainage tunnels as they move through the compost.

A lack of a healthy micro-organism community is the main reason why composting processes are slow in landfills with environmental factors such as lack of oxygen, nutrients or water being the cause of the depleted biological community.

PHASES OF COMPOSTING

Under ideal conditions, composting proceeds through three major phases:

- An initial, mesophilic phase, in which the decomposition is carried out under moderate temperatures by mesophilic microorganisms.
- As the temperature rises, a second, thermophilic phase starts, in which the decomposition is carried out by various thermophilic bacteria under high temperatures.
- As the supply of high-energy compounds dwindles, the temperature starts to decrease, and the mesophiles once again predominate in the maturation phase.

USES

Compost is generally recommended as an additive to soil, or other matrices such as coir and peat, as a tilth improver, supplying humus and nutrients. It provides a rich growing medium, or a porous, absorbent material that holds moisture and soluble minerals, providing the support and nutrients in which plants can flourish, although it is rarely used alone, being primarily mixed with soil, sand, grit, bark chips, vermiculite, perlite, or clay granules to produce loam. Compost can be tilled directly into the soil or growing medium to boost the level of organic matter and the overall fertility of the soil. Compost that is ready to be used as an additive is dark brown or even black with an earthy smell.

Generally, direct seeding into compost is not recommended due to the speed with which it may dry and the possible presence of phytotoxins that may inhibit germination, and the possible tie up of nitrogen by incompletely decomposed lignin. It is very common to see blends of 20–30% compost used for transplanting seedlings at cotyledon stage or later.

Composting can destroy pathogens or unwanted seeds. Unwanted living plants (or weeds) can be discouraged by covering with mulch/compost. The "microbial pesticides" in compost may include thermophiles and mesophiles, however certain composting detritivores such as black soldier fly larvae and redworms, also reduce many pathogens. Thermophilic (high-temperature) composting is well known to destroy many seeds and nearly all types of pathogens (exceptions may include prions). The sanitizing qualities of (thermophilic) composting are desirable where there is a high likelihood of pathogens, such as with manure.

TYPES OF COMPOSTING

The following are some of composting methods:

A. Vermi-Composting

Vermi-composting essentially means the process of culturing and application of epigeic earthworms for decomposition of biodegradable wastes in combination with cowdung slurry. Apart from decomposing, the earthworms are also responsible for enhancing growth of beneficial micro organisms.

- **Materials required**

Sl.No.	Items	Quantity	Sl.No.	Items	Quantity
1.	Cowdung	100Kg	6	Dried Paddy Straw/ Biomass	1 tonne
2.	Water	200 L	7	Wooden Post	4 nos.
3.	Bamboos	20 nos.	8	Wooden planks	10 nos.
4.	Clay	100 Kg	9	Bucket (10 L)	1 no.
	Earthworms	2000 nos.		Drum with lid (100 L)	1 no.

- **Process:**

1. Collect locally available materials for construction of frame/ box/ tank and lining/ plastering.
2. Collect biomass like fresh livestock wastes, agricultural/ plant residue wastes
3. Dry the agricultural/ plant wastes and chop
4. Mix properly the chopped materials with fresh livestock (1:8 :: livestock waste: organic waste)
5. The height of the mixture wastes should not be more than 50 cms inside the tank
6. Keep the mixture wastes for about 2 Weeks or more for decomposition
7. Introduce the earthworms after the mixture is decomposed and cover with gunny bag or leaves of banana/ bamboo/ areca/ lamet, etc arranged and made in bamboo frame

- **After care:**

1. The unit must be checked many times in a week and sprinkle water as and when required
2. After 8 days, at least every 2 days observe on the decomposition of the mixture before introduction of earthworms
3. After 45 – 50 days, depending on climate condition, the compost is ready for harvesting

- **Precaution:**

1. Make a moat of standing water surrounding the tank to prevent ants, etc and cover with a metal 3 mm mesh which can be also used to separate cocoons from the vermi compost to prevent rats, etc
2. Make a roofing structure with locally available materials so as to protect the unit from rain and direct sunlight. The height of a roofing structure should not obstruct operational

- **Harvesting :**

1. Harvest and take the compost on the ground and make in a conical heap for few hours.The worms form-ball at the base which can be taken out and after counted, introduce in the next feed. This process shall run as a cycle
2. Dry the compost in shade not in direct sunlight and use the 30 mm sieve to separate young ones and cocoons from the compost. The young ones and cocoons are then introduced in the new feed mixture after counting. Keep the product safely in shade in containers like gunny bag, etc so as to maintain the moisture level, etc
3. A tank – size of 6 ftx3ftx4ft with a capacity of about 600 Kg of mixture wastes and with 2000 earthworms may yield about 700 Kg vermi compost in 45 – 50 days

B. NADEP Composting

NADEP composting is a natural process by which biomass wastes, soil wastes and animal wastes are biologically degraded and decomposed into an organic - compost

- **Materials Required**

1. Construction of a 6 ft x 3ft x 4ft aerated tank made of locally available materials like splitted bamboo or bamboo post or wooden post or plank
2. About 1500 Kg of agricultural wastes/ dried plant residues
3. About 100 Kg cowdung or slurry until harvesting
4. About 1700 Kg fine dry soil mass
5. About 1500 litres of water till harvesting

- **Process**

1. Collection of locally available materials for construction of aerated tank
2. Collection of biomass like cowdung, cowdung slurry, soil mass
3. Dry the plant residues, soil-mass
4. The 1st layer of 15 cms thickness is to be filled with biomass wastes and filled with cowdung slurry and followed with dried soil-mass. This sequence of layering is to be repeated till the tank is more than full
5. One sequence of three layers must be completed in one go
6. Repeat (4) above till the take is more than full on
7. The top layer is to be plastered with cowdung

- **After-Care**

Water should be regularly sprinkled (depending upon the season)

- **Precautions**

1. The area in which the tank is constructed should be compact
2. The ground of the tank is to be plastered with mud and dung to present leaching
3. As soon as cracks develop, filled up with dung slurry.
4. After completion of a sequence of 3 layers @ 15 cm per layer, the filling of the last sequence of remaining layers should be done after observation of the settlement of the 3 earlier layers
5. Make a roofing structure with locally available materials to protect from rain and direct sunlight

- **Harvesting**

1. Harvesting will be done after decomposition which may take 100 to 200 days without organic solution to hasten the decomposition
2. The compost is then ran through a sieve and store in a cool place in gunny bag or locally available material so as to prevent loss of moisture, etc
3. A tank size of (6 x 3 x 4) ft with a capacity of 1500 Kg agricultural wastes, 100 Kg cowdung, 1700 Kg fine dry soil-mass and 1500 litres water may yield 700 Kg NADEP compost in about 100 – 200 days

C. Non-Soil Composting

Non-soil composting is a natural process by which biomass, wastes, animal wastes are biologically degraded and decomposed into organic compost.

- **Materials Required:**

1. A frame/box/tank with 6x3x4 ft made out of locally available materials like bamboo or normal size planks or wooden post.
2. About 200 kg of fresh agricultural waste is needed in 1 m cum. frame size
3. About 400 kg of dried agricultural waste or residues is required in a size 1 m cum. frame
4. About 500 kg of fresh livestock waste (cow dung)
5. About 500 litres of water

- **Process**

1. Construct a tank of 6x3x4 ft in size with locally available materials.
2. Collect biomass like fresh agricultural waste, livestock waste (cow dung), plant residue wastes and chop into small pieces of 5”-6”.
3. Mix the fresh livestock waste with water in a 1 : 1 ratio to make it into a slurry
4. Introduce the chopped fresh agricultural waste in the frame/tank/box
5. Pour the slurry on top of the layer to cover it completely
6. Introduce the dry agricultural waste on top of the slurry
7. Keep repeating the steps to make a set of 3 – 4 layers to cover the height of 2 m of the frame/tank/box.
8. Cover the set up using locally found materials like banana leaves etc to ensure that the set up is covered

- **After Care:**

1. Check the unit as many times in a week and sprinkle water as and when required
2. After a week, at least once in a week thereafter, the set up needs to be observed to ensure proper decomposition
3. After 75 – 90 days, depending on climatic conditions, the compost is ready for harvesting

- **Precaution**

1. To ensure that sprinkling of water at regular intervals to maintain moisture content of the compost.
2. To ensure that the set up is covered so that during rainy seasons or hot climatic situations, the compost is not compromised of its quality/efficacy
3. The set up is made in such a way to ensure proper aeration in the whole set up

D. Berkely Hot Composting

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.

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

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

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

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 55-65oC.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.

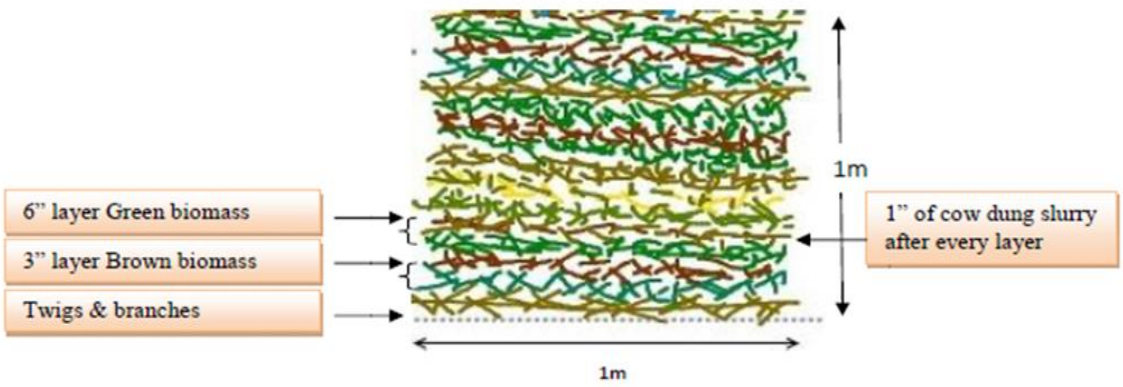


Fig: Diagram depicting Berkely hot compost

OBSERVATION AND RESULT:

The compost has been observed to produced a very foul smell at 5 Days after charging. This is dueto 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 cold composting method. 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.

COST OF PRODUCTION OF COMPOSTS:

A. Compost Shed

Size: 52 ft × 16 ft, containing 10 Compost units of size 8 ft × 4½ ft each

Item/Particular	Quantity/Mandays	Amount (₹)
Bamboo	300 pieces	-
Bully post	50 pieces	-
Nails	2",3", 4" & 5" 10 kg @ 80/-	800.00
Wire	5 kg @ 140/-	700.00
Bedding	2 ½" x ½"	1,000.00
Carrying charges	-	1000.00
Thatch	850 bundles (including carrying charges) @ 20/-	17,000.00
Labour charge	96 mandays @ 170/-	16,320.00
Total		36820.00

B. COMPOSTS

Item	Vermi	NADEP	Non–Soil	Catalyzed Non-Soil
Cost of Collection of materials and construction cost in making the compost units as may be prescribed	912.00	912.00	912.00	912.00
Cost of collection of biomass (Cow-dung, Maize Stalk, All Legumes Including Wild, Paddy Straw, Grasses, Garden Green Waste, Weeds, All Vegetable Waste, Water Hyacinth, Forest Tree Leaves, Wild Indigo, White Madar)+ Earth-worms for Vermi + OGP for Catalyzed Non–Soil	2304.00	1304.00	1304.00	1604.00
Operational Costs	326.00	326.00	163.00	163.00
Harvesting Cost till the final product	326.00	163.00	163.00	163.00
Total Unit Cost of production	3,868.00	2,705.00	2,542.00	2,842.00
Total	11,957.00			

C. Compost storage (Size – 30 ft x 18 ft)

For 6 units, each unit size – (6 x 5) ft

Item/Particular	Qunatity/Mandays	Amount (₹)
Bamboo	150 pieces	-
Nails	5 kg @ 80/-	400.00
Wire	6 kg @ 140	840.00
Bedding	-	1500.00
Carrying charges	-	1000.00
Thatch	400 bunddles @ 20/-	8,000.00
Labour charges	48 mandays @ 170/-	8,160.00
Total		19900.00

E. Organic Growth Promoter (OGP)

Organic Plant Growth Promoter is a liquid solution made from enzymes produced from vegetable waste and jaggery. It helps in improving the yield and better crop quality. It also helps in arresting fruit dropping and further prolongs shelf life of the crop.

Materials Required

- 3-4 Kg Organic Kitchen wastes like vegetables, etc.

Procedure

1. Crush, dilute 1Kg jaggery in 1 litre of water and pour into a container
2. Add 3-4 kg of chopped vegetables in the container.
3. Add about10 litre of water & mix thoroughly by stirring the mixture clock & anti-clock wise, twice a day for 15 days
4. Close the container every time after stirring.
5. After 15 days close the container tightly & leave it for about 40 days.
6. Yeast formation at the surface of the mixture will be seen after 40 days.
7. Filter the solution and store in a cool place for future usage. The container should be tightly closed.

Precaution

- Stir the mixture twice a day for 15 days continuously
- Close the container tightly
- Do not dilute the jaggery by boiling
- Fruits & skin of fruits can also be added along with vegetables but not lemon

Application

- Add 1 Litre of solution in 500 litres of water
- May be sprayed for all kinds of crops
- During the crop life cycle, the solution may be sprayed every 2 or 3 weeks

In case of rain after spray, the solution may be applied the next day.

COST OF PRODUCTION OF ORGANIC GROWTH PROMOTER (10 Litres)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	Jaggery	1 kg	-	60.00
2.	Collection of vegetable waste, chopping and preparation of solution	-	1	170.00
			Total	230.00

F. VERMI-WASH

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

G. Panchagavya

Panchagavya acts as a growth promoting and an immunity booster for plants. Panchagavya consists of a fermented mixture of five derived cow products (ghee, milk, curd, cow-dung and cow urine) and a few additional natural ingredients.

Ingredients for making Panchagavya

- Fresh cow dung - 5 kg
- Ghee - 1 kg
- Cow's urine - 3 liters
- Cow's milk - 2 liters
- Curd - 2 liters
- Tender coconut water - 3 liters
- Yellow banana (mashed) - 12 nos
- Jaggery solution - 1 kg dissolved in l liter water
- Honey - 50 ml or fermented coconut juice – 2 liters

Preparation method:

- Add all the ingredients together and stir the mixture thoroughly
- Cover with a mosquito net and let the mixture ferment for 3 weeks. Twice a day mix one minute with a stick.
- After 20 days, a good odour generates; this indicates that Panchagavya is ready.
- For spraying purposes, Panchagavya should be filtered before usage. For efficient spraying do a double filtration

Dosage: Panchagavya is used and sprayed at 3% concentration for both soil and foliar application.

Method of Usage:

1. Soil & Foliar application – By spraying

Spraying of Panchagavya :

- 1 time at soil or pit preparation
- 2 times during the crop vegetative growth
- 2 times during the crop flowering
- 1 times during crop maturation and fruiting
- Or, spray panchagavya every 2 or 3 weeks during one food plant life cycle. It is essential to spray panchagavya 4 to 6 times per crop for best results

Storage:

Panchagavya can be store up to 3 months in shade with daily stirring for 1 minute.

MODULE-2: BIO-RATIONALES FOR INTEGRATED PEST MANAGEMENT

INTEGRATED PEST MANAGEMENT:

Integrated pest management (IPM), also known as integrated pest control (IPC) is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations below the economic injury level (EIL). The UN's Food and Agriculture Organisation defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

Pest/insect control materials that are relatively non-toxic to people with few environmental side-effects are sometimes called 'biorational' pesticides/insecticides. These can be made out of waste materials and locally available resources.

A. Insect Traps

Insect traps are used to monitor or directly reduce populations of insects or other arthropods. They typically use food, visual lures, chemical attractants and pheromones as bait and are installed so that they do not injure other animals or humans or result in residues in foods or feeds. Visual lures use light, bright colors and shapes to attract pests. Chemical attractants or pheromones may attract only a specific sex. Insect traps are sometimes used in pest management programs instead of pesticides but are more often used to look at seasonal and distributional patterns of pest occurrence. This information may then be used in other pest management approaches.

The trap mechanism or bait can vary widely. Flies and wasps are attracted by proteins. Mosquitoes and many other insects are attracted by bright colors, carbon dioxide, lactic acid, floral or fruity fragrances, warmth, moisture and pheromones.

1. Bait Trap

Bait Traps are materials for entrapment of fruit flies responsible for infestation of fruits. These traps can be easily made by reusing water bottles. These traps are designed to catch flying or wind-blown insects. Flight interception traps or are net-like or transparent structures that impede flying insects and funnel them into collecting. Barrier traps consist of a simple vertical sheet or wall that channels insects down into collection containers. The Malaise trap, a more complex type, is a mesh tent-like trap that captures insects that tend to fly up rather than down when impeded.

Pan traps (also called water pan traps) are simple shallow dishes filled with soapy water or a preservative and killing agent such as antifreeze. Pan traps are used to monitor aphids and some other small insects.

Bucket traps and bottle traps, often supplemented with a funnel, are inexpensive versions that use a bait or attractant to lure insects into a bucket or bottle filled with soapy water or

antifreeze. Many types of moth traps are bucket-type traps. Bottle traps are widely used, often used to sample wasp or pest beetle populations.

Requirements:

1. Water - 500ml
2. Jaggery - 50 gm
3. Rotten fruits - 4-5 nos.

Method of making Bait Traps:

1. Dissolve 50 gms of jiggery in 500 ml of water.
2. Squeeze the juice of rotten fruits and mix with the above solution.
3. Create opening on the plastic bottles to enable entry of flies.
4. Pour about one-fourth of the above prepared solution into the bottles.

Method of using the Bait Traps:

1. Hang the traps on the branches of the trees about three feet above the ground.
2. The most appropriate period of using these traps is during the onset of fruiting.
3. One trap can be placed for every 400sq.m or 12 traps can be placed per acre.
   This also means one trap for every four trees which are of 20x20 m spacing.

II. Yellow Sticky Traps

Yellow sticky traps are non-toxic tools for controlling and monitoring of aphids, cucumber beetles, fruit flies, fungus gnats, leafhoppers, froghoppers, moths, whiteflies, flea beetles, leaf miners etc. The exposed portion of traps coated with an adhesive substance that does not dissolve in water so that traps can be left outside for several weeks or months. Pests become immobilized when they contact the sticky surface of the trap. Many herbivores insects attracted to Yellow.

The attraction to Yellow is considered to be a natural response to plant foliage. These traps are also used to monitor pest dispersal or migration.

III. Light Traps

Light trap is a device used at night in the field to collect moths and other flying insects such as:

- Armyworm.
- Bugs.
- Cutworm.
- Flies.
- Gnats.
- Heliotis/Helicoverpa.
- Leafhoppers.
- Planthoppers.

Light traps are widely used to survey nocturnal moths. Total species richness and abundance of trapped moths may be influenced by several factors such as night temperature, humidity and lamp type. Grasshoppers and some beetles are attracted to lights at a long range but are repelled by it at short range. Farrow's light trap has a large base so that it captures insects that may otherwise fly away from regular light traps. Light traps can attract flying and terrestrial insects, and lights may be combined with other methods described below.

Cost of Production:

A. Bait Traps (100 Nos.)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	Jaggery	5kg	-	300.00
2.	Plastic Bottles (500ml)	100		-
3.	Collection of fruit waste and preparation of solution	-	1	170.00
			Total	470.00

B. Yellow sticky traps (100 Nos.)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	Yellow chart paper	10nos		50.00
2.	Sugar	5kg		200.00
3.	Honey	1litre		300.00
4.	Thread	1 roll		10.00
5.	Manday for preparation and installation		1/2	90.00
			Total	650.00

C. Light traps (100 Nos.)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	Basin	100nos	-	4000.00
2.	Light trap Stand	100nos	-	500.00
3.	Kerosene oil	½ litre	-	20.00
4.	Candle	100	-	300.00
5.	Manday for preparation and installation		1	170.00
			Total	4990.00

B. Broad Spectrum Bio-Pesticides-cum- bio-insecticides

Broad spectrum bio-pesticides is an organic solution prepared from plants having bio-pesticidal properties.

Material required:

- ✓Stinging nettle (seinthap)- 5 Kg
- ✓Eupatorium spp (Bat Japan)- 5 Kg each
- ✓Lantana camara – 5 Kg
- ✓Tobacco (Duma mutia) – 1 Kg
- ✓Geranium sp (Tiew Jaiaw) – 5 Kg
- ✓Neem leaves – 5 Kg
- ✓Chilli- 1 Kg
- ✓Garlic- 1 Kg
- ✓Ginger- 1 Kg
- ✓Seeds and leaves of Xanthoxylum (Jaiur)- 3 Kg
- ✓Allium (Jalang)- 1 Kg
- ✓Cow urine- 10 Lits
- ✓Water- 90 Lits

Method of preparation

- ✓Chop all the above plant materials and keep them in a 200 lit drum.
- ✓Add 10 lit of cow urine and fill the drum with water to make 100 lit.
- ✓Seal the drum and allow it to ferment for 15 days.
- ✓Stir the solution every day.
- ✓After 15 days mix the contents properly
- ✓Dilute 250 ml of concentrated solution with 10 lit of water and mix it thoroughly.
- ✓Now use it as a foliar spray on the crop.
- ✓The solutions prepared here be mixed well with soap solution at the rate of 10 g/lit of extract before spraying.

Ideal spraying time: It is recommended that the application or spraying of the all the botanical pesticide should be carried out only in the late afternoon of the day.

Effective control: The compounds produced by the fermentation of the above extract are poisonous to many micro-organisms and insects. The extract prepared is very useful for the control of wide variety of pests such as thrips, leafhopper, leaf folder, mealy bugs, fruit, stem and bark borer, hairy caterpillar and aphids.

COST OF PRODUCTION:

B. Broad Spectrum Biopesticides (100 Litres)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	Collection of plants, chopping and preparation of solution	-	1	170.00
2.	Tobacco	1 kg	-	200.00
3.	Ginger	1 kg	-	-
4.	Garlic	1 kg	-	-
5.	Chilli	1 kg	-	-
6.	Allium (Jyllang)	1 Kg	-	-
7.	Xanthoxylum (Jaiur)	3 Kg	-	-
8.	Cow Urine	10 lits	-	-
			Total	370.00

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* spp.

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.

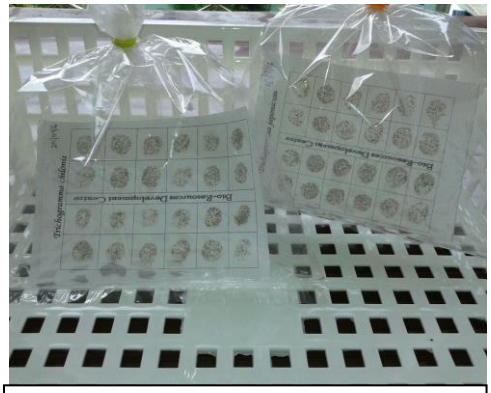


Fig 23: Tricho- cards in the laboratory

MODULE-3: MICROBIAL BIO-INOCULANTS

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

1. 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.

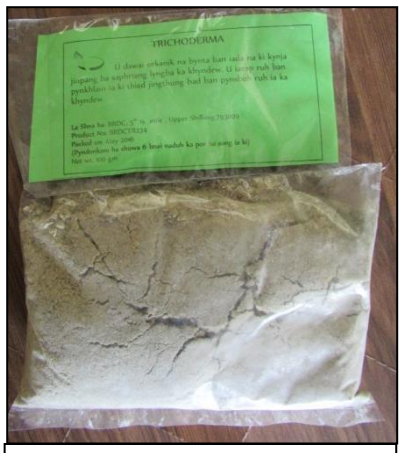


Fig 18: Packaged product of *Trichoderma viride*

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 28ºC to 35ºC. 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

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 (N2) 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

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

COST OF PRODUCTION:

A. LABORATORY (THATCH HOUSE) Size: (30 ft × 13 ft)

Item/Particular	Qunatity/Mandays	Amount (₹)
Bamboo	150 pieces	-
Nails	5 kg @ 80/-	400.00
Wire	6 kg @ 140/-	840.00
Bedding	-	1,000.00
Carrying charges	-	1000.00
Thatch	400 bundles (including carrying charges) @ 20/-	8,000.00
Labour charge	62 mandays @ 170/-	10,710.00
	Total	**21,950.00**

B. PRODUCTION OF TRICHODERMA

A. Particulars	Cost of production for Trichoderma (₹)
I) Consumables	
Maize	22.00
Polythene bag	6.00
Cotton	10.00
Talcum powder	10.00
Ethanol	10.00
Rubber band	2.00
Mother culture	30.00
II) Non-consumables	
Sterile spoon	5.00
Innoculation chamber	2000.00
Room heater	350.00
Pressure cooker	600.00
Grinder	50.00
Candle	5.00
Tray	20.00
B.Labour	
Culturing of Trichoderma (time required=2hrs) = 1/4 manday	40.00
Inoculation of Trichoderma in maize (2hr)= 1/4 manday	40.00
Mixing and shaking of the inoculated bags = 1/6 manday	27.00
Drying, grinding and formulation of trichoderma = 1/2 manday	80.00
Total cost of production for 1 kg Trichoderma on first batch	**3307.00**

C. COST OF PRODUCTION OF BACILLUS

Particulars	Amount (₹)
I. Consumables	
i. Jaggery	50.00
ii. Yeast	80.00
iii. Salt	15.00
iv. Bottles	10.00
v. Spoon	5.00
vi. Heater	350.00
vii. Pressure cooker	1500.00
viii. Wooden box	500.00
ix. Plastic trays	50.00
x. Candles	15.00
xi. Cotton	20.00
xii. Rubber band	10.00
xiii. Mother culture	30.00
Total cost of production for 1 kg Bacillus on first batch	**2635.00**

D. COST OF PRODUCTION OF *PSEUDOMONAS*

Particulars	Amount (₹)
FYM (100kg)	-
Labour charge	
Incorporation of Pseudomonas and FYM=1/4 manday	40.00
Water sprinkling and turning of the incorporated FYM =1/4 manday	40.00
Total cost of production for mass production of Pseudomonas in the field in 100kg FYM	80.00

MODULE-4: TECHNOLOGIES FOR IMPROVED CROP PRODUCTION

A. Energy Pillars Technology (EPT) for Improved Productivity of Fruit Trees

Energy Pillar Technology (EPT) is a technology in rejuvenation of economic potential trees by supplementing its nutritional requirements and promoting its growth through organic catalytic solutions for improving the productivity of the trees.

Materials Required:

1. About 200 Kgs. of plants biomass
2. 10 liters Container
3. Spade,
4. Organic catalyse decomposing solution and Organic Growth Promoter.

Procedure:

1) Chop the green plants timely and dip in a mixture of 10litres water and 5ml of organic catalyse decomposing solution.
2) Clear the surrounding canopy area
3) Dig 4-5 pits with 3ft. depth and 1 ft. diameter along canopy area
4) Add equal quantity of plant biomass in the pits and fill the pits with soil properly compacted.
5) Mix 5ml of Organic Growth Promoter in 5 Litres water and stir well. Spray the mixture on the whole tree.
6) Mulch the canopy area with plant biomass around leaving just ½ foot away from the trunk

Note:

❖ EPT is one of the measures growers should adopt the whole package of management practices required for fruit-trees.

COST OF PRODUCTION:

1. Organic Growth Promoter (10 Litres)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	Jaggery	1 kg	-	60.00
2.	Collection of vegetable waste, chopping and preparation of solution	-	1	170.00
			Total	**230.00**

II. Bordeaux paste (for 100 trees)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	CuSO4	1/2 kg	-	150.00
2.	Quick lime	1/2kg	-	10.00
3.	Brush	2	-	100.00
4.	Bucket	2	-	200.00
5.	Manday for preparation and installation		1/2	90.00
			Total	**550.00**

III. Bordeaux mixture (for 100 trees)

Sl. No	Items	Quantity	Total Mandays	Cost (₹)
1.	CuSO4	0.2 kg	-	60.00
2.	Quick lime	0.2 kg	-	4.00
3.	Sprayer	1	-	1500.00
4.	Bucket	2	-	200.00
5.	Manday for preparation and installation		1	170.00
			Total	**1934.00**

CITRUS REJUVENATION PROGRAMME

INTRODUCTION: Mandarin is a delicious tropical fruit crop widely grows in the state of Meghalaya of North-East Region of India. The aromatic, nutritive and medicinal value of mandarins is integrally associated with day to day lifestyle of peoples of Meghalaya through ages. The commonly available Citrus fruits in the state are sweet oranges, pumelos, rough lemon, mandarins, wild orange, citron and other citrus species. Frequently, people use to call the acid ones as champra or solom, if it is larger one. The rich germplasm of acidic Citrus group is under threat of loss as it is frequently removed from farmer's field or home gardens in exchange for crops of higher economic value. Citrus is valued for the fruit, which is either eaten alone as fresh fruit, processed into juice, pickles or added to dishes and beverages.

Orange is a major horticulture crop in Meghalaya with an estimated area of 8600 hectares under this crop reported in 2012-2013. The production is 40,600 MT giving an average of 4.7 MT/Ha – almost half of the national average. Khasi Mandarin (Citrus reticulata Blanco) is one of the most widely cultivated and important commercial fruit crop of Meghalaya. It is considered unique for its high sugar content and therefore well suited for further value addition including concentrates and packed ready-to-drink juice. It has been observed that mandarin orange orchards in Meghalaya start to decline in production after satisfactory performance for few years. The term "citrus decline" denotes a condition of ill health and decadence of citrus trees which may arise from a number of causes such as plantation on unsuitable land, intercropping, inadequate nutrition, incidence of insect-pest and diseases. The general symptoms associated with decline are: retarded growth of

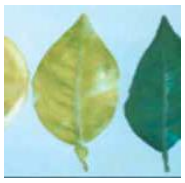
trees, appearance of chlorotic leaves, sparse foliage, die-back of twigs, delayed leaf flushes and blooming, deficiency symptoms (especially zinc), defoliation, off-season flowering, small fruit and fruit production declines during the entire decline development period. Declined trees do not usually die for several years but remain unproductive. Although citrus decline start to appear on bearing trees of aged 7-8 years, it generally become severe on trees above 15 years. The possible causes are due to the following:

- Poor and or improper orchard management
- Incidence of greening and other disease
- Incidence of insect-pests
- Low quality planting materials
- Unfavorable soil and climatic conditions

PROPAGATION OF CITRUS: Citrus is propagated by seeds and also vegetatively propagated by T-budding. Seedlings are mostly transplanted in the month of July-August after commencement of monsoon. Budding is preferably done in last week of January or first week of February following the T, or shield budding method.

MANURING AND FERTILIZATION: Like other crop plants, citrus also requires a number of mineral nutrients for growth, development and production and this includes nitrogen, phosphorus, potassium, calcium, magnesium, zinc, iron, copper, manganese, boron, and molybdenum. Micronutrients viz. zinc, copper, manganese, iron, boron and molybdenum are required in ample quantities and should be supplied through foliar spraying. Improper supply of nutrients may cause serious disorders which may lead to decline of the wole orchard. Following are the symptoms depicting the deficiency of nutrients:

- **Nitrogen deficiency:** General and uniform yellowing of leaves; limited twig and leaf growth; prolonged deficiency leads to die back of twigs; trees undersized; excessive flowering;; fruit size is reduced and yield get declined.

Corrective Measures: Application of 1500g Nitrogen (Non Soil compost) in three split doses- early March, May and late September

- **Phosphorus deficiency:** Defective formation of buds; discoloration of leaves; reduced number of lateral shoots with reduced growth; limited and delayed blossoming; poor fruit setting; premature fruit dropping; coarser fruits with thick rinds.

Corrective Measures: Application of 600g Phosphate/tree (NADEP compost) in single dose during late winter or early spring.

- **Potassium deficiency:** Foliage is spare, somewhat bronzed and lusterless; necrosis on one side of leaves; die back of twigs; Gum excludes from the trunk portion; fruits small but smooth with thin peel and decay rapidly and fruit acidity decreases. Irregular yellow blotching from potassium-deficiency is more common in late summer

Corrective Measures: Application of 600g Potash/tree (NADEP compost) in single dose during late winter or early spring.

- **Magnesium deficiency:** Yellow areas developed between the large veins and on both sides of the mid-rib; bronzed leaves; chlorosis in the old leaves; poor root growth; alternate bearing, poor fruit quality and reduced yields

Corrective Measures: Spraying of 0.25% Magnesium sulphate twice at 15 days interval on new flushes

- **Zinc deficiency:** Interveinal chlorosis; small leaf size; dieback from terminal twigs; twigs rosette-like appearance; fruits small, insipid and misshapen. Zinc deficiency is found in many mandrin orchard all over the country

Corrective Measures: Spraying of 0. 5% Zinc sulphate twice at 15 days interval on new flushes

- **Iron deficiency:** Chlorosis appears on young leaves while older leaves remain green; in acute cases fruits are small, hard, and coarse and light in color.

Corrective Measures: Spraying of 0. 1% Ferrous sulphate twice at 15 days interval on new flushes

- **Copper deficiency:** Gum exudation and dieback of twigs; dark green leaves on S-shaped twigs; fruit show gum pockets around the central pith

Corrective Measures: Spraying of 0. 1% Copper sulphate twice at 15 days interval on new flushes

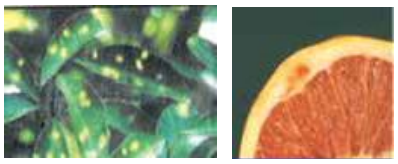
- **Manganese deficiency:** Similar to zinc deficiency except that the leaf size is not reduced; and symptoms are prominent in shady areas

Corrective Measures: Spraying of 0. 2% Manganese sulphate twice at 15 days interval on new flushes

- **Boron deficiency:** Enlargement, corking and splitting of leaf veins of matured leaves; and brown gum pockets formed around seeds and albedo of the fruit.

Corrective Measures: Spraying of 0. 1% Borax twice at 15 days interval on new flushes

- **Molybdenum deficiency:** Water soaked areas appeared on the leaves with the start of new growth in early spring. Subsequently these areas develop into larger interveinal yellow spots with gum on the lower side s. Fruits show marked break-down.



Corrective Measures: Maintain soil pH at 5.5 to 6.7

In citrus the nutrient availability is governed by the following factors:

i.) Soil reaction: Soil reaction is expressed in terms of soil pH and this is one of the most important factors influencing the nutrition of citrus. Citrus trees thrive well in the soil with a pH of 5.5-6.5. Therefore, where soils are having pH less than 4.5, lime should be added to the soil.

ii.) Nutrient element balance: Plant growth is a function of two variables of the nutrition, viz., intensity and balance. Here intensity refers to the actual total concentrations of all the functional elements in the leaf, while balance is the relative proportion among the essential elements. For eg. An increased supply of nitrogen will result in increased production when other elements are present in optimum balance and intensities.

Method of manures and fertilizers application: In general practices, there are two types of methods of manure and fertilizer application. They are: i). Soil application (root feeding) and ii). Foliar application (foliar feeding)

Soil application (root feeding):

- It is a common method of applying manures and fertilizers for all crops including citrus. Organic manures and chemical fertilizers supplying macronutrients are usually applied in the soil.
- This method is cheaper, easier, and the residual effect is longer. Tree basins are first prepared by light hoeing and then manures and fertilizers are broad casted. After broadcasting, they are mixed well into the soil by giving a second hoeing.
- Alternatively, a trench of 15-20cm wide and 15cm depth is dugout around and below the drip of the tree and then manures and fertilizers are applied in the trench. This is followed by covering with the dugout soil.
- The placement of fertilizer varies with the age of the plant. In case of young trees fertilizers should be applied in the tree basin only and as the trees grows the basin size should be enlarged. In case of bearing trees, a good rule is to cover an area twice the diameter of the tree canopy, because the feeding roots have spread beyond the drip of the canopy. In older groves entire field may be fertilized since the roots are found to spread the whole orchard area.
- While fertilizing the trees, care should be taken to keep the trunks of the trees free from the contact of fertilizers.
- Application of lime in alternate years is essential to maintain optimum soil reaction and to improve the soil structure.
- Localized concentration of fertilizers granules or crystals should be avoided.
- Deep placement of fertilizers should also be avoided. It is because 80-95% feeder roots are spread in the top 10 cm.
- Immediately after manuring and fertilization, trees should be irrigated. If no irrigation, apply fertilizers just after the rain or when there is sufficient moisture in the soil.

Foliar application (foliar feeding):

- Micronutrients with low biuret content (less than 0.25%) can be applied through foliar spray.
- Any fertilizers, that are to be applied through foliar spray, should be completely water soluble and neutral in reaction.
- Foliar application of elements should be done on young leaves or young flushes, when leaves attain half expansion in growth.
- It is better and safe to have repeated applications at low concentrations rather than a single heavy dose.

Time of manures and fertilizers application:

- Time of application of manures and fertilizers in citrus depends on types of manures and fertilizers, and phenological stages of the tree.
- Organic manures, which are slow to release mineral elements, should be applied well before

the initiation of new growth and flowering.

- 50% of the annual nitrogen requirements and all of the phosphorus and potassium requirements are generally applied in February-March (15-20 days before flowering).
- The remaining 50% of the nitrogen is applied after fruit set and during the fruit enlargement period (June-July).
- In case of non-bearing young trees, nitrogen fertilizers are applied in 3 split doses depending upon the soil conditions and plant growth.
- In this case the 3rd dose is applied just after the rainy season. Generally three split doses of nitrogen are recommended only when trees are in poor condition due to root rot.

IRRIGATION: Irrigation requirement of citrus is also closely related with soil, climate, and kind of crops, cultivation practices, variety, age and bearing capacity of the tree. Hence, it is rather difficult to make a general recommendation. However, Lemons require much larger quantities of water than mandarin and sweet oranges. Irrigation requirements of young trees are less than bearing trees. Closely spaced trees require more water than widely spaced trees. Similarly, orchards with inter-crops need more water than the orchards without inter-crops. Fine textured deep soil, soils rich in organic matter and land on a north slope generally need less water than their opposites. However, for Khasi Mandarin, irrigation is provided at an interval of 10-15 days during winter months whereas during summer months it is provided at an interval of 5-7 days. The water requirement varies from 900 to 1100 mm. per year depending upon the location.

MULCHING: Mulching around tree basins with organic material such as straw, saw dust, rice hulls, dry leaves, weed scrapings, plastic or compost. However, the mulch should not be in contact with the trunks of the trees, as this can provide a site for pests and diseases to attack the tree. The bark becomes soft and vulnerable to cold and to attack by pest and disease if it is covered by moist organic matter. Mulching has the following advantages:

- Assist in suppressing weeds by excluding light from the soil surface.
- Mulch will also help retain moisture in the topsoil by reducing surface evaporation, as well as moderating soil surface temperatures.
- It also helps in preventing soil erosion by reducing run-off water.
- Enhance the decomposition process of organic matter.
- NPK contents of the soil are increased.
- Help maintain the soil organic matter at desirable levels.
- Soil structure is improved.
- It also increases the content of available potassium, thus helping to overcome potassium deficiency.

TRAINING AND PRUNING: Trees are trained to single stem with 4-6 well-spaced branches for making the basic framework. The lowermost branches are not allowed to grow below the height of 50 cm. from the soil surface. Pruning is done during the initial years of planting. The bearing trees require little or no pruning. Main objective of pruning the bearing trees is to maintain the framework and to secure higher yields with better quality fruits. Pruning of bearing trees though differs with variety but chiefly consists of removal of dead, diseased, criss-crossed and weak branches. Removal of water sprouts and suckers of rootstocks is also highly essential. Pruning of non-bearing trees can be done at any time of the year, but for bearing trees the best time is after harvesting & during late winter or early spring when these are in somewhat dormant stage, Root pruning is also practiced in some parts of central and southern India to regulate flowering season.

SOIL pH: The soil pH (whether a soil is acidic or alkaline) is an important property. It affects the availability of nutrients and also the activity of microbes and other tiny creatures in the soil. In general, the best soil pH for citrus trees is between 5.5 and 6.5. If the pH falls below 5.0, aluminum toxicity and manganese toxicity often occur in citrus roots. A low pH also causes a deficiency of nutrients such as calcium, magnesium and phosphorus (which are easily fixed by soil particles) and molybdenum. Liming with limestone or dolomite is the usual action taken to correct soil pH. Growers should also avoid applying too much ammonium, in the form of nitrogen fertilizers such as urea or ammonium sulphate. This is because there is a danger of making the soil more acidic.

Application of liming materials:

- In orchards where the soil pH is found to be below 5.0, liming materials should be applied after the fruit is harvested. They should be incorporated into the soil at a depth of at least 15 - 30 cm, since lime has poor mobility in the soil.
- Mixing manure or compost with the lime materials is recommended. This helps to keep the soil aerated, and avoids compaction. (Chemical fertilizers should not be applied at the same time as lime, since this would reduce the fertilizer efficiency of the nitrogen). Inorganic fertilizers may also be applied separately, one month after applying the lime materials.
- Routine soil monitoring of soil pH is needed to determine whether there is a need for lime materials. Growers should not apply lime unless it is needed. Not only is it wasteful, but micronutrient deficiencies may occur if growers apply too much lime. For this reason, annual lime applications should be discontinued when the soil pH has been modified to more than 6.0.

WEEDING: Weeds are a serious problem in mandarin orchards particularly, young plantations. It is because citrus trees have a shallow fibrous root system compared with some other tree crops. Consequently citrus is susceptible to weed competition. Hence, citrus trees, particularly young ones, respond well to a weed-free growing environment. Tree basins up to the canopy spread should be kept free of weeds all the time of the year. Otherwise they compete with fruit trees for moisture and nutrients; and provide shelter for pests and diseases.

INSECT / PESTS AND MANAGEMENT: On account of the attack of the different insect pests viz. citrus black fly, citrus psylla, citrus leaf miner, bark eating caterpillar, mealy bugs, citrus aphids, citrus thrips, fruit fly, mites etc. results in poor performance by the tree in terms of quality fruit production. In Meghalaya, information gathered from farmers indicates that every 2 to 3 years, the farmer loses 1 to 3% of their trees to diseases and pests such as stem borer. However, spraying with insecticides viz. monocrotophos, phosalone, dimethoate, phosphamidon, quinalphos etc. depending upon the type of pest infestation has been found to be effective in most cases as reported earlier. Major pests found are illustrated here under:

Insects/Pests	Damage	Management
Citrus Psylla, (Diaphorina Citri)	• Citrus psylla sucks sap from the foliage and excretes sugary liquid that covers leaves with honey dew. It attributes to the heavy development of sooty mold on honeydew-covered leaves and whole tree. • Most important role of citrus psylla is transmission of bacteria that causes Huanglongbing (greening) disease.	• Uproot and burn wild host plants • Use effective biological control agents against nymphs and adults of psyllids. • Predators like syrphids, chrysopids and lady beetles, and parasitoid like Tamarixia radiata are effective against them.

Citrus Leaf Miner, (Phyllocnistis citrella)	• Larval feeding causes serpentine silvery mines on young leaf leading it to wrinkling and curving up. Such leaves when developed are mottled and curved due to the unbalanced growth of leaves between infested and non-infested parts of leaves.	• Prune growth flushes • Mechanical control of mining larvae. • Fertilize in late winter to promote strong spring growth. • Do not over-water in autumn. • Do not fertilize during summer • Treat plants with insecticides at weekly intervals on new flush as soon as infestation in noticed. • Planting goat weed, Ageratum conyzoides, as ground cover under citrus plant.
Citrus Thrips, (Scirtothrips dosalis)	• Attacked leaves become cup shape, leathery, crinkled and mottled and have whitish two parallel lines on either side of mid rib. Infested fruits have silvery ring around the neck	• Foliar spray either with 0.05% Dimethoate or 0.02% Chlorpyrifos at bud burst stage and berry size fruits.
Brown Citrus Aphid, (Toxoptera citricida)	• Withdrawal of large quantities of sap from the foliage. • Heavy development of sooty mold on honeydew-covered leaves. • Transmission of Citrus Tristeza Virus (CTV), a phloem-limited closterovirus	• If only few plants in an orchard are infested, monitor these plants and spray only selected plants with insecticides like Quinalphos (0.5%) or Phosalone (0.5%) at 10 days interval.
Green Stink Bug, (Acrosternum hilare)	• Discolouration or deformation of immature fruits • Fruits with black dots surrounded by chlorotic field. • Premature fruit drop. Secondary fungal and bacterial infections in fruits.	• Collection and destruction of eggs on leaves. • Sweep net collection and destruction of adults. Collection and destruction of gregariously feeding nymphs on immature fruits. • Biological control of eggs
Citrus Trunk Borer, (Chelidonium cinctum)	• It occurs in neglected orchards and high rainfall area of hilly region. Grub bores the trunk at ground level horizontally up to the pith and then tunnels vertically and again horizontally for exit. • Attacked trees gradually dry up	• Injecting petrol in the borer holes and plugging with wet mud reduces damage.
Citrus Purple Scale, (Lepidosaphes beckii)	• Yellowish halos develop on leaves. • Young fruit the feeding sites remain green • Defoliation and twig dieback in limited patches on the lower north side of trees.	• Spread of infected material can be reduced by pruning and allowing adequate spacing between plants throughout cultivation. Mechanical control can be achieved by scraping and scrubbing to remove scales. • Burn the dropped infested leaves and fruits • Prune the infested and dead twigs. • Brushing or high pressure washing of twigs and trunks is recommended
Cottony Cushion Scale, (Icerya purchase)	• The insect sucks plant sap. When they occur in large numbers the infested leaves turn yellow and fall prematurely. Young shoots may die. The insect excretes a lot of honeydew upon which sooty mould develops.	• Vedalia lady beetle (Rodolia cardinalis) and parasitic fly (Cryptochactum iceryae) are used to control cottony cushion scale population
Oriental fruit fly, (Bactrocera dorsalis)	• These fruit flies are reported economically impairing the citrus crops in the eastern middle mountains.	• Install simple physical barrier to oviposition but it has to be applied well before the fruit is attacked • Regular collection of dropped infested citrus fruits and feed them to domestic animals. Never put into manure pit. • Frequently shallow ploughing of soil under the canopy of tree in an orchard • Regular collection and destruction of fruit flies trapped in methyl eugenol trap installed with a minimum density of one trap/hectare. • Neem seed kernel extract can also be used

DISEASES OF CITRUS AND THEIR MANAGEMENT: The major diseases of citrus in the state were identified as: Fungal diseases viz., foot and root rot, crown rot and gummosis (Phytophthora spp.); twig blight (Botryodiplodia theobromae, Colletotrichum gloeosporioides); citrus scab (Elsinoe fawcettii); powdery mildew (Acrosporium tingitaninum); pink disease (Corticium salmonicolor); felt disease (Septobasidium spp.); sooty mould (Capnodium citri) and bacterial diseases viz., Citrus canker (Xanthomonas axonopodis pv. citri) and citrus greening (Candidatus liberibacter asiaticus). Even though it is one of the main causes for poor productivity and loss of trees, the awareness of diseases amongst the farmers is surprisingly low. Afflicted trees are considered to be a result of only poor soil quality and inadequate management practices. In most cases the farmers manually exterminate the diseased trees from uprooting and destroying them to prevent its spread. Despite these measures it is common experience that, between the pests and pathogens, the trees suffer production loss in the form of poor fruit setting, early fruit drop at the bearing and maturity stage. The table below is the list of few diseases affecting the major citrus varieties including Khasi Mandarin production in Meghalaya. Their symptoms and management were also discussed below:

Diseases	Symptoms	Management
Huanglongbing (Greening disease)	• At the beginning yellowing of single or few branches is observed in some trees of the orchard which gradually spreads out to other branches. • Slightly infected tree becomes severely affected with symptoms like open growth, stunting, twig die back, sparse foliage and severe leaf and fruit drop. • The whole orchard declines within 2-3 years • The veins are often prominent and yellow. • Excessive leaf drop and unseasonal flushing with very small but erect type of leaves are developed. • Most of them remain green or poorly colored even after maturity especially at the rind part. • Fruits have aborted seeds	• Strict maintenance of internal and external quarantine • Removal of infected trees and their replacement by disease free planting material. • Removal and destruction of alternate host plants of psylla vector - Murraya paniculata (Kamini) and Murraya exotica (Kadipatti or Asare or Boke jamun or Ban Bakaino). • Soil application of Zinc Sulphate, Iron Sulphate and Manganese Sulphate
Phytophthora induced citrus diseases	• Damping off of seedlings in seed bed • Root rot of grown up seedlings in nursery bed or in grown up citrus trees especially when the roots are injured during the cultivation of inter-crops. • Foot rot, collar rot, gummosis (gum oozing from bark lesion on the trunk). • Leaf blight and leaf fall. • Brown rot of fruits.	• Produce citrus saplings inside screen house using either solarized and / or fumigated soil media. • Use containerized nursery with sterile media. • While budding, care should be taken to keep bud union at least 25-30 cm above ground level. • Field nursery/ seed bed should be well drained. • Plants from field nurseries should not be taken directly to planting site
Citrus Tristeza Disease	• Sudden and quick decline of trees • Leaves develop various deficiency symptoms • Leaf falling, root decay and twig die back andultimate death of the tree are also conspicuous	• The disease can be kept under control by use of tolerant rootstocks, such as rough lemon, trifoliate orange etc.
Citrus Canker	• Conspicuous raised necrotic lesions develop on leaves, twigs and fruits	• Pruning and destruction of infected twigs before monsoon.
Powdery Mildew	• The disease damages plants in orchards as well as in nursery • It not only damages the new flushes causing defoliation but also causes die back and fruit drop.	• Avoid dense planting. • Maintain the recommended planting distance. • Remove unnecessary branches from tree by pruning to allow air and light to pass. • This disease is prevalent in new flushes therefore remove false branches and water shoots from the base and stem of the tree. • Prepare spray solution by mixing 1 part cow urine and 2 part water and spray tree at 5 days interval at the time of new flushes. However, the quantity of spray solution varies (two to three liters/tree) with the stage of the tree.

REJUVENETION PROGRAMME BY BIO-RESOURCES DEVELOPMENT CENTRE (BRDC) THROUGH ENERGY PILLAR TECHNOLOGY (EPT)

As stated above, 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. The decline of trees starts with sparse appearance, yellowing and different type foliage symptoms, undergrowth and sickly appearance, dried-up top growth with small and less number of fruits. The branches of trees start to die from the top downwards, ultimately resulted poor quality fruits (rough surface, thick skin and less juice). Such type of decline may be seen in whole orchards, on in a single tree or patches. It is a rare site to get any plantation free of this malady even intensity varies from plant to plant and from month to month in the same plant. The growers do not adopt the proper management practices in terms of plant protection; manuring, irrigation; mulching, pruning etc. and the orchards become sick. In general, canopy of fruit crops has irregular shape. Trees of irregular shape and size are difficult to deal with and even culminate into poor yield in the subsequent years as the lower branches of canopy gradually turns inert and infertile as well. Following are the strategies adopted by Bio-Resources Development Centre in providing improved technologies with particular focus on combating citrus decline:

- Providing technical know-how including plant health coverage and nutritional management programme.
- Complete technological information on management of decline orchard may be packaged and same may be disseminated in farmer's field.
- 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 of the state of Meghalaya (Training is an important component, which improves overall efficiency of the knowledge and skill of field functionaries). The technology involves various steps as stated below:

a. Collection of soil in and around the tree canopy for analysing the pH and soil nutrients
b. Clearing of the area around the trunk
c. Digging of holes around the canopy
d. Filling the holes with biomass mixed with Organic Decomposer solution
e. Mulching around the tree canopy
f. Spraying with organic growth promoter
g. Prune and clean the tree trunk for pasting with organic fungicide and 1% Bordeaux mixture

Preparation of Bordeaux mixture: Dissolve one kilogram of good quality Copper Sulphate (Powdered) in five litres water overnight. Similarly in a separate vessel dissolve one kilogram good quality Slaked Lime in five litres of water overnight. When both the solutions are ready, pour them together slowly into the third bigger bucket with proper mixing while pouring and continue steering the mixture. The reaction of the mixture must be neutral.

❖ To check the quality of mixture whether it is neutral or not, take clean iron tool/ nail and dip in the mixture for one minute. Take it out and check the colour of the surface you dipped after removing the mixture. If it is unchanged, the mixture is of good quality you can spray it. If the surface has changed the colour as rusting then it is acidic and cannot be sprayed on plants. In such case add some lime solution in the mixture and mix it thoroughly and check its reaction as above until it becomes neutral. This solution can be used for Pasting/Painting.

- To make 1% Bordeaux mixture solution, add 90 litres of water to this to make a total volume of 100 litres. This mixture is ready for spraying.
- The Bordeaux mixture should be sprayed fresh within six hours of preparation.
- Application of Bordeaux paste on the tree trunk twice a year before monsoon and after monsoon.

TECHNOLOGIES DEVELOPED BY THE CENTRE IN CONTROLLING CITRUS INSECTS/PEST

1. Measures adopted for Aphids pest on orange trees:

a. Mixed 1kg of tobacco leaves and 1/4th of chillies in 10 litres of water.
b. Soak for 2 weeks.
c. Filter the water and spray it in affected trees. This technology has been useful in reducing the aphids infecting the fruit trees (particularly in orange tree at Nongrmai, Mairang Block, WKH)
d. Promising result was obtained after two days of spraying.

2. Measures adopted for fruit flies (low cost Fruit Fly Trap or Bait Trap):

a. Make small holes (approx. 5-6) on the sides of a plastic water bottle
b. Add the mixture (bait) inside the bottle
Bait: take 1 cup of vinegar or fermented/rotten fruits, 2 cups of water, 1 table spoon of honey or jiggery and shake well. Fill the trap to just below the bottle with this mixture and hang the bottle about 3-5 feet high.
c. The fragrance of the mixture inside the bottle attracted the flies and once the flies enter inside the bottle they will get immersed inside the mixture and are not able to escape, hence the technology has reduced the number of flies infesting the fruits durin the fruiting season.
d. Approximately, 4 traps can be placed in one tree. These traps should be baited 6-8 weeks before the fruit ripens.

MONITORING CHART FOR ENERGY PILLAR TECHNOLOGY (EPT)

Village		Block		District	
Farmer's name		Date of Action Research			
Latitude		Longitude		Altitude	
Field details					
Status of soil	Soil pH				
	Soil nutrients	Macro nutrients		Micro nutrients	
Name of diseases encountered			Treatment adopted		
List of insects/pest encountered			Treatment adopted		
Yield before productivity declined					
Name of the citrus tree (s)					
Age of the tree (s)					
Average size of fruit per tree					
Year from when the diseases occurred					
Year from when Insects/pest occurred					
Details of land preparation					

OBSERVATIONS ON POST ACTION RESEARCH		
Indicators	**Observations**	**Remarks**
Tree age		
Colour		
Emergence of flowers		
No. of days for flowering		
No. of days for fruiting compared to earlier year		
Length of time taken from fruiting to ripening of fruits		
Average size of fruit per tree compared to previous years		
Diseases or Insects/pest incidence		
Management taken		
Performance yield per plant		
Status of soil pH and nutrients		

CALENDAR OF ACTIVITIES FOR ENERGY PILLAR TECHNOLOGY (EPT)

December –January

- ✓ Marking of trees and their undesired branches for pruning.
- ✓ Pruning of marked branches in December.
- ✓ Pruning to be followed in alternate row.
- ✓ Pruning to be initiated from lower surface of the branch and alter from upper surface to avoid cracking of branch and bark splitting.
- ✓ Application of Bordeaux mixture on the trunk, branches as well as cut surfaces to check microbial infection.
- ✓ Ploughing and weeding in orchards in January.
- ✓ Analysing soil from in and around the tree canopy to determine the soil pH and availability of soil nutrients.

February - March

- Clearing of the area around the trunk
- Digging of holes around the canopy and filling up the holes with biomass mixed with Organic Decomposer solution
- Foliar spray with organic growth promoter
- Mulching in basins around trees.
- Careful observation for infestation of stem borer insect pest in pruned trees. Upon identification of infestation, placing cotton wick soaked with kerosene oil or petrol
- Irrigation as per requirement during March.

April – May

- Irrigation as per requirement
- Hoeing and weeding in basins.
- Care for new emerging shoots.
- Observation for incidence of stem-borer and its management.

- Analysing soil from in and around the tree canopy to determine the soil pH and availability of soil nutrients

June – July

- Thinning out undesired shoots while retaining about 8-10 healthy shoots with outwardly growth per pruned branch during June followed by spraying with organic growth promoter
- Irrigation at an interval of 10-15 days.
- Application of FYM in basins during July.
- Management of stem borer as described before

August - September

- Thinning out undesired shoots.
- Application of Bordeaux mixture on the trunk, branches as well as cut surfaces to check microbial infection.
- Observation of incidence of stem-borer insect pest and other diseases and their management.

October-November

- Cultural operations of ploughing, hoeing, weeding etc.
- Removal of dried and diseased twigs.
- Management of insect pests and diseases.
- Foliar spray of organic growth promoter during October for healthy vegetative growth.
- Marking of tress for pruning.

B. VERTICAL FARMING

Agriculture is one of the activities that play the main role in supporting a human in the world. According to the United Nations Population Division (2009), the percentage of urban population will likewise increase from 50.46% in 2010 to 68.70% in 2050. It is expected that world population will continue to increase. Currently, the rate of growth per year is about 80 million. This is a major concern because the land area of the Earth is limited only to about 13 billion hectares. Moreover, overpopulation of cities needs new agricultural methods so as to bring conventional farming inside cities. With growing number of people staying in cities, more agricultural land will be sacrificed to accommodate urbanisation.

A single technological strategy cannot be a panacea to the ever-growing food production system. Instead, there is a need for a mixture of multiple techniques to guide us towards the 21st century green revolution. Vertical farming (VF) is one of the greatest interesting examples of somewhat new that may contribute to these answers.

Vertical farming is the practices of growing vegetables in vertically stacked layers or in shelves like pattern where more crops are grown on a smaller land area. It normally means that, instead of having a single layer of crops over a large land area, stacks of crops can be grown upwards. It is also associated with city farming and urban farming. VF attempts to grow different types of vegetables in challenging environments where agricultural lands are rare or unavailable. VF technology is developed to increase crop yield without increasing the land area for crops. Due to the limited access to land for farming, there is a need for sustaining farming tasks so as to pave the way for adding to food needs.

Vertical farming is farming in shelves like pattern. It does not require a large area for practice. It is very effective in usage of water and other requisite minerals. About 6 – 7 different vegetables can be grown at the same time with minimum management practices.

VERTICAL FARMING DEVELOPED BY BIO- RESOURCES DEVELOPMENT CENTRE

A simple low cost Vertical Farming technology was developed by the Bio-Resources Development Centre (BRDC) to enhance, encourage and 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 entire vertical structure was made from locally available materials such as gunny bag, bamboo, etc. and is very much feasible even in schools and colleges.

REQUIREMENTS:

1. Pipe made from bamboo
2. Top soil
3. Seeds/Seedlings
4. Sacks/Gunny bag
5. Bamboo cone/basket (big size)
6. Sharp object for perforations

PROCEDURES:

1. Perforate the pipe which will be used for the supply of water to the entire set up by using the perforator.
2. A sack/gunny bag is taken and the vertical structure is made according to the size of the bag in an upright position with locally and easily available materials.
3. Place the perforated pipe (made in step1) in the middle of the structure which will act as an irrigation pipe for the supply of water to all sides of the structure.
4. Fill the vertical structure with top soil (the top soil is first mix with compost/cow dung in the ratio of 2:1) until it is almost full but not completely full.
5. Using the perforator, made small holes on the different sides of the vertical structure (the size of the holes should be just to be able to insert the roots of the seedlings inside the structure)
6. Insert the seedlings into the holes made on the different sides of the vertical structure and sow the seeds on the top of the structure
7. Irrigate the set up by pouring water into the pipe placed in the middle of the vertical structure
8. Observe the growth, development on a weekly basis with proper management practices

PRECAUTIONS:

1. The structure should not be filled completely with soil as it may cause soil and water loss along with seeds/seedlings during rainy seasons or during irrigation
2. The vertical farming structure should not be mixed with any chemical inputs

ADVANTAGES OF VERTICAL FARMING:

1. VF can grow a large number of vegetables in a *relatively small space* (45-50 numbers of vegetables in one square feet area).
2. VF uses no *pesticides and no fungicides* so the food is healthier and safer.
3. VF also reduces *water consumption* because VF uses 90% less water.
4. VF can also control plant *fertilizing nutrients* so the food that is grown is *highly nutritious.*
5. VF technology can ensure crop production all year round.
6. Weeding is not require

COST OF PRODUCTION:

VERTICAL FARMING (Size – 1 ft ×1 ft × 3 ft)

Item/Particular	Quantity/Mandays	Amount (₹)
Bamboo	1 piece	-
Wire	250 gms @ 80/kg	20.00
Gunny bag	I piece @ 20/-	20.00
Labour charge	1 manday @ 170/0	170.00
	Total	210.00

Figures: Process of constructing Vertical Farming Units

Figures: Vegetable cultivation through Vertical Farming Technology

MONTORING CHART FOR VERTICAL FARMING

1. PLANTING DATA			
Location		Farmer	
Trial		Planting date	
Type of trial		Design	
Length of rows		Distance between plants	
No. seeds per hole:		Size (Area) of trial	
Crop (Variety)		Source of seed	

Fertilization of plot (including that of the farmer) _____
Weed control_____
Insect control_____
Other operations at planting_____
Soil moisture_____

2. FIELD PLAN					
Location		Farmer		Trial	

3. CHARACTERISTICS OF THE PLOT

Location_____ Farmer_____ Trial_____

CROPPING HISTORY		
Year	Crop(s)	Fertilisation

PREPARATION OF THE PLOT	
Activitv	**Method**
Plow 1	
2	
Harrow 1	
2	
Furrow	
Slope	
Irrigation. If yes, Frequency?	
Soil Type	
Soil Analysis	
Altitude	
Details of Bio- inoculants treatment	
Treated Seeds + Trichoderma + PSB Control Seeds	
Source of inputs 1. Seeds - 2. Bio-inoculants -	

4. MANAGEMENT OF THE TRIAL

Location_____ Farmer_____ Trial_____

ACTIVITY	DATE	METHOD
Replanting		
Weed control 1		
2		
3		
4		
5		
Fertilization 1		
2		
Other 1		
2		
3		
4		
Irrigation 1		
2		
3		
4		
5		
6		

INDICATORS FOR OBSERVATION			
Observation	Control	Treated	Remarks
Days to emergence / sprouting (DAS)			
Mortality Rate (%)			
Rate of germination (%)			
Plant height at peak vegetative stage (Cms)			
No. of leaves/plant at peak vegetative stage			
Weeding			
No of days for maturity			
Crop incidence (insect or pest) and treatment			
Performance yield on area basis (Kg)			
Increase Yield percentage			
Total yield/ha (Tonnes)			
P-value (student t test)			

Other observations _____

5. OBSERVATIONS ON THE FARMER'S CROP

Location_____ Farmer_____ Trial_____

Crop _____ Location of the field under observation_____

Slope _____ Soil type _____

CROPPING HISTORY		
Year	**Crop(s)**	**Fertilisation**

PLANTING DENSITY				
Crop	**Variety**	**No. Of seeds per hole**	**Distance between**	
			Plants	**Rows**

MANAGEMENT		
Activity	**Date**	**Method**
Weed control 1		
2		
3		
4		
Fertilization 1		
2		
Other 1		
2		

Irri gation during year _____

What are the principal insect problems in the field? _____

What are the principal disease problems in the crop? _____

What are the most common weeds?_____

Source of seed used in the field:_____

6. CHARACTERISTICS OF THE FARMER

Number of hectares worked this year:

Own _____Rented _____Share cropped _____

Principal crops: 1) _____ 2) _____

3) _____4) _____

For which crops does he hire labour? _____

For which crops does he use fertilizer? _____

Use of other agro-chemicals _____

Which crops are sold? 1) _____2) _____

3) _____4) _____

Off-farm employment or activities: _____

Problems in storage of crops: _____

Other observations:

7. AGRONOMIC DATA

Location_____ Farmer_____ Trial_____ Crop_____

Block	No.	% Garmination	Days to Flowering	Diseases				Damage				Other Observations			
				Date	Classification	Date	Classification	Date	%	Date	%	Date	%	Date	%

8. HARVEST DATA

Location______________________ Farmer______________________ Trial________________________ Crop___________________________

Each treatment harvested is _______________________________ rows of ___________________ meters.

Block	No.	No. Of plants	No. Of ears			Weight			% Humidity	% Shelling	Dry Weight	Beans			
			Good	Rotten	Total	Good	Rotten	Total				No. Of Plants	Weight	% Humidity	Dry weight

9. OBSERVATIONS OF THE TRIAL

(To be filled in on each visit to the trial)

Location_____ Farmer_____ Trial _____
Date _____ Technician _____
Was farmer present? Yes / No
Work on the plot since last visit:_____

INDICATORS FOR OBSERVATION			
Observation	**Control**	**Treated**	**Remarks**
Days to emergence / sprouting (DAS)			
Mortality Rate (%)			
Rate of germination (%)			
Plant height at peak vegetative stage (Cms)			
No. of leaves/plant at peak vegetative stage			
Weeding			
No of days for maturity			
Crop incidence (insect or pest) and treatment			
Performance yield on area basis (Kg)			
Increase Yield percentage			
Total yield/ha (Tonnes)			
P-value (student t test)			

Weather conditions_____

_____

Other observations:

Farmer's perception on the

Trials:_____

QUESTIONNAIRE FOR COLLECTING AGRICULTURAL INFORMATION

GENERAL INFORMATION:

Date: _____

Location: _____

Country: _____

Crop: _____

Type of coverage: _____

Other information: _____

PRODUCTION

1. What variety of _____ (Name of crop) is the most common in the area?
2. What is the average farm size for the crop?
3. What is the typical planting period for _____(Name of crop) (month/ week)?
4. What is the earliest date that can be planted?
5. What is the last date when maize can be success¬fully planted (month/week)?
6. Can you provide more details on the crop calendar, highlighting the main plant growth phases?

PHYSIOLOGICAL OR PHENOLOGICAL PHASES	WRSI PHASES	PERIOD (APPROX. DATE OF PHASE BEGINNING)	LENGTH OF PERIOD (DAYS)
Germination	Planting and Establishment		
Leaf Development			
Stem elongation	Vegetative		
Inflorescence emerging, heading	Flowering		
Flowering, Anthesis			
Development of Fruit	Maturation		
Ripening			

***WRSI- Water Requirement Satisfaction Index**

7. Is _____ (Name of crop) production in this area rain-fed or irrigated? (If both, indicate relative proportion.)
8. What is the average cost of production in the area (in total costs of inputs per hectare or other area unit—if different, specify)? Specify if it includes labor costs and/or land rent.
9. State the types of fertilizers or inputs used by growers. When are they applied during the season? What are the specific costs of these inputs per hectare?

ITEMS	TYPE	AMOUNT (LTS, KG/ HECTARE)	VALUE (INR)	MONTH INPUTS APPLIED
Seed				
Fertilizer				
Chemicals (specify)				
Other				

10. What is the optimal yield in the area?
11. What is the average yield in the area?
12. In which of the last 10 to 20 years do you recall hav¬ing the best yields?

YEAR	SIZE OF LAND	YIELD	NOTES

13. In which of the last 10 to 20 years do you recall hav¬ing the worst yield?

YEAR	SIZE OF LAND	YIELD	NOTES

INCOME

1. Do farmers in the area have alternative sources of income? What percentage of farmers relies only on farm income?
2. How relevant is this activity's revenues for households' incomes in the area?
3. Are/Is _____ produced for commercial purposes or for self-consumption?
4. What are the main sales markets for the crop/crops?
5. On average what are the prices for each crop? Give recent years' high versus low.
6. Is there any forward contracting for these crops?
7. During which month do most farmers normally sell their production?

RISK

1. What are the main risks for farmers' income?
2. What are the primary production risks?

a. Pests	
b. Diseases	
c. Weather	
d. Lack of access to inputs	
e. Other	

3. If farmers are exposed to weather risks, how do they currently manage them?
4. In how many years out of 10 are yields reduced because of weather?
5. In which of the last 10 years do you recall having the most favourable weather for production?

YEAR	SIZE OF LAND	YIELD

6. In which of the last 10 years do you recall having the worst weather for production?

YEAR	SIZE OF LAND	YIELD

RAINFALL CONTRACT PARAMETERS (IF DROUGHT /EXCESSIVE RAIN RISKS APPLY)

1. Do farmers in the area practice dry planting or do they wait for onset of rainfall?
2. How do farmers judge when rain is sufficient for planting?
3. What do they do if rains are insufficient for planting? Plant a different crop or plant anyway? Do they ever not plant if rainfall is not good?
4. a. Which periods in the growing season are the most critical to have rainfall for a successful harvest?

PLANTING	ESTABLISHMENT (GERMINATION &LEAF DEVP.)	VEGETATIVE (STEM ELONGATION	FLOWERING	MATURATION

b. Are there periods during the growing season when too much rain has destroyed or damaged the harvest?

PLANTING	ESTABLISHMENT (GERMINATION &LEAF DEVP.)	VEGETATIVE (STEM ELONGATION	FLOWERING	MATURATION

5. a. In the drought years, at which growth stage(s) was the crop most affected?
b. In the excess rainfall years, at which growth stage(s) was the crop most affected?

WRSI PHASES	YEAR	YEAR	YEAR	YEAR

6. Does rainfall at the reference station reflect the rainfall pattern of the area? Do parts of the area have different rainfall patterns?

ACCESS TO FINANCE

1. How do farmers normally finance input costs?

DO NOT BUY INPUTS	OWN FINANCES	LOAN FROM BANKS	MONEY LENDERS	OTHER SOURCES	INTERESTED IN INANCING BUT NO ACCESS

2. What type of financing? What are the terms?
3. What time of year is the financing received? What time of year is financing needed?
4. What types of collateral do they normally provide?
5. What months are they expected to pay back loans?
6. Would having access to some form of insurance improve farmers' access to credit?
7. Have there been experiences with rescheduling or default? If so, when and why?

TRAINING EVALUATION SHEET

(Training of Trainers on Sustainable Green Technologies at Bio-Resources Development Centre, Shillong)

Name of Trainee: _____

Village/Block: _____

Date: _____

Please indicate your response to the questions below by selecting the appropriate number, with 1 = POOR, 2 = FAIR, 3 = GOOD, 4 = EXCELLENT and 5 = HIGHLY SATISFACTORY:						
1.	Rate the overall quality of this training	1	2	3	4	5
2.	The objectives of the training were clearly defined	1	2	3	4	5
3.	How well did this program accommodate your background and interest	1	2	3	4	5
4.	Participation and interaction were encouraged.	1	2	3	4	5
5.	Satisfied with Instructor's questions and answers	1	2	3	4	5
6.	The topics covered were relevant to me.	1	2	3	4	5
7.	How the trainer is able to keep the session alive and interesting	1	2	3	4	5
8.	Which level of understanding and interest do you now have on the following Topics :					
A.	Composting	1	2	3	4	5
B.	Organic Growth Promoters	1	2	3	4	5
C.	Botanical pesticides	1	2	3	4	5
D.	Panchagavya	1	2	3	4	5
E.	Integrated Pest Management	1	2	3	4	5
F.	Energy Pillars Technology	1	2	3	4	5
G.	Field Experiments and Trials	1	2	3	4	5
H.	Production of Bio-inoculants	1	2	3	4	5
9.	The content was organized and easy to follow.	1	2	3	4	5
10.	The materials used/distributed were helpful	1	2	3	4	5
11.	This training experience will be useful in my work.	1	2	3	4	5
12.	The trainer was knowledgeable about the training topics.	1	2	3	4	5
13.	The trainer was well prepared.	1	2	3	4	5
14.	The training objectives were met.	1	2	3	4	5
15.	The time allotted for the training was sufficient	1	2	3	4	5
16.	Convenience and suitability of the location	1	2	3	4	5
17.	Relevance of the Training for the Community	1	2	3	4	5

B. Evaluation of Trainees

Please indicate briefly your response to the questions below:	
1. What were the most interesting topic/topics of this Programme?	
2. Was the length of each demonstration sufficient for the topic?	
3. Are the materials and tools used, sufficient for each topic? If	
4. What would have made the session more effective?	
5. What other training sessions would you like to be included?	
6. What changes/improvement would you recommend for the Training?	
7. Now that you have completed this course, what additional training (if any) would be helpful?	

8. Have you been trained on these technologies before? YES NO
If YES, state which of these technologies you have been trained.

9. Has this Training Programme further enhanced/improved your knowledge of such technologies? YES NO

10. Do you think that the knowledge and skills you gained from this program will be useful for you?
If YES, then list the technology (ies) that you are going to adopt.

11. Are you willing to share this knowledge to others? YES NO

12. Are the raw materials required for the training, easily available in your locality? YES NO
If otherwise, state which technology (ies) is/are having constraints of raw materials.

13. Any comments, observations, suggestions/recommendations:

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