RAMAKRISHNA MISSION VIVEKANANDA EDUCATIONAL AND RESEARCH INSTITUTE

FACULTY OF AGRICULTURAL, RURAL AND TRIBAL DEVELOPMENT

MULTIDISCIPLINARY CERTIFICATE COURSE (0+3)

COURSE MATERIAL

RURAL BIOTECHNOLOGY

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CONTENT

CHAPTER 1

ORGANIC MANURES

Manures are the organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms. Naturally occurring or synthetic chemicals containing plant nutrients are called fertilizers. Manures with low nutrient, content per unit quantity have longer residual effect besides improving soil physical properties compared to fertilizer with high nutrient content.

Major sources of manures are:

- Cattle shed wastes-dung, urine and slurry from biogas plants
- Poultry litter, droppings of sheep and goat
- Slaughterhouse wastes-bone meal, meat meal, blood meal, horn and hoof meal, Fish wastes
- Byproducts of agro industries-oil cakes, bagasse and press mud, fruit and vegetable processing wastes etc
- Crop wastes-sugarcane trash, stubbles and other related material
- Water hyacinth, weeds and tank silt, and
- Green manure crops and green leaf manuring material

Manures can also be grouped, into two based on concentration of the nutrients

1. Concentrated organic manures
2. Bulky organic manures

1. Concentrated Organic Manures

Concentrated organic manures have higher nutrient content than bulky organic manure. The important concentrated organic manures are oil cakes.

Oil cakes

After oil is extracted from oilseeds, the remaining solid portion is dried as cake which can, be used as manure. Oil cakes are of two types:

1. Edible oil cakes which can be safely fed to livestock; e.g.: Groundnut cake, mustard cake, Coconut cake etc.,
2. Non edible oil cakes which are not fit for feeding livestock; e.g.: **Jatropha oil cakes Pongamia oil cakes Cotton seed oil cakes** etc.,

Both edible and non-edible oil cakes can be used as manures. However, edible oil cakes are fed to cattle and non-edible oil cakes are used as manures especially for

horticultural crops. Nutrients present in oil cakes, after mineralization, are made available to crops 7 to 10 days after application. Oilcakes need to be well powdered before application for quicker decomposition.

Other Concentrated Organic Manures

Bone meal when dried and powdered can be used as manure. The meat of dead animals is dried and converted into meat meal which is a good source of nitrogen.

2. Bulky Organic Manures

Bulky organic manures contain small percentage of nutrients and they are applied in large quantities. Farmyard manure (FYM), animal manure (sheep, goat and poultry), green-manure, compost and verimicompost are the most important and widely used bulky organic manures.

Farmyard manure

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P_2O_5 and 0.5 per cent K_2O.

Sheep and Goat Manure

The droppings of sheep and goats contain higher nutrients than farmyard manure and compost. On an average, the manure contains 3 per cent N, 1 per cent P_2O_5 and 2 per cent K_2O.

Poultry Manure

The excreta of poultry birds ferment very quickly. Poultry manure contains higher nitrogen and phosphorus compared to other bulky organic manures. The average nutrient content is 3.03 per cent N; 2.63 per cent P_2O_5 and 1.4 per cent K_2O.

Green manure

Green undecomposed material used as manure is called green manure. It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest. Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops. The most important green manure crops are sunnhemp, dhaincha, pillipesara,clusterbeans and Sesbania rostrata.

Compost and vermicompost

Compost mainly refers to the end products formed by the biodegradation of organic matter by micro organisms. Vermicomposting is a natural and biological process in which earthworms are mainly used in converting organic wastes into manure, which are rich in nutritional content and are used as biofertilizers, in sewage treatments and in other organic farming.

Green Manures

Green, undecomposed material used as manure is called "green manure."

Green manuring can be defined as the practise of ploughing and turning un-decomposed green plant tissue into the soil for the purpose of improving the physical structure as well as the fertility of the soil. The plants that are grown for green manure known as green manure crops.

Green manures

Green Manure *in-situ* **Green Leaf Manure**

Green Manure *in-situ*

In this system, green manuring crops are grown and buried in the same field.

Green manuring is growing in the field plants and is incorporated into the soil after sufficient growth.

The most important green manure crops are sunnhemp, dhaincha, and clusterbeans.

Advantages

1. Improves soil structure
2. Increases water holding capacity and
3. Decreases soil loss by erosion

Sun hemp

Dhaincha

Green Leaf Manures (GLMS)

Green leaf manures (GLMs) are organic manures made from leaves collected from all available sources and used to supply essential plant nutrients to the soil and increase soil fertility in a healthy manner.

- Application of green leaves and twigs of trees, shrubs, and herbs collected from elsewhere is known as "green leaf manuring."
- Forest tree leaves are the main source of green leaf manure. Plants growing in wastelands, field bunds, etc., are another source of green leaf manure.
- The important plant species useful for green leaf manure are neem, mahua, wild indigo, Glyricidia, Karanji (*Pongamiaglabra),*calotropis, avise (*Sesbania grandiflora*), subabul and other shrubs.

Advantages

1. Green manuring improves soil structure, increases water holding capacity and decreases soil loss by erosion.
2. Growing green manure crops in the off season reduces weed proliferation.
3. Green manuring helps in the reclamation of alkaline soils.

Neem

Calotropis (Erukkam)

Avise (Agathi)

Subabul

CHAPTER 2

ENRICHED FYM AND COMPOST

Preparation of Enriched Farmyard Manure

Generally P is fixed by the soil constituents and makes it unavailable for the crop uptake. It also depends upon pH. In case of acidic, red and laterite soils, the dominant cations found is Fe^{2+}, Al^{3+} and Mn^{2+}. These cations and their hydroxides react with $H_2PO_4^-$ and form insoluble complexes. Similarly, in alkaline and calcareous soils, the P is fixed by Ca, Mg and form dicalcium phosphate dihydrate, tricalcium phosphate and octacalcium phosphate and the phosphorus use efficiency get reduced. The P use efficiency ranges from 10-15 per cent. Therefore, instead of applying the P in the form of SSP (or) rock phosphate directly to the field, incubating the P fertilizer with farm yard manure for specific period and the organic acids and organic anions released from FYM during the decomposition by microbes compete with $H_2PO_4^-$ for fixation sites with Fe, Al and the availability of P get increased.

Objectives of enriched FYM

- To reduce the fixation of P by Fe, Al, Mn, Ca,Mg and other cations.
- For solubilizing the applied and native phosphorus
- To increase the P use efficiency by the crops.

Method of preparation

(a) Materials required

- 1 cart load of FYM (300 kg)
- 50 kg SSP (or) rock phosphate
- Clay

(b) Procedure

Select a shady place and place the well decomposed FYM and add 50 kg of SSP (or) rock phosphate, mix them well and make a heap. Plaster the heap with clay materials and keep them undisturbed for about 45 days. After 45 days, collect the materials and can be applied to the field. While applying the manure, the recommended N and K fertilizer can also be mixed with the manure and applied.

Compost

- It is a type of organic manure that is produced from organic waste, such as food waste, pruning and garden waste, harvest waste, animal manure etc.
- Compost is a material rich in humic substances (humus), which are what give soils a dark color and improve their fertility.

Why composting is necessary?

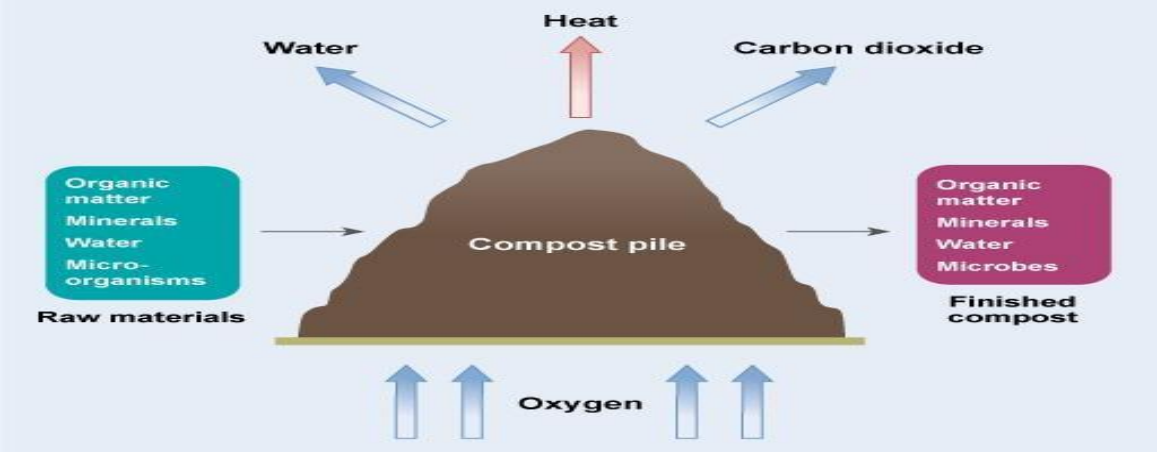
- One of the organic solid waste management methods. The rejected biological materials contain complex chemical compounds such as lignin, cellulose, hemicellulose, polysaccharides, proteins, lipids etc. These complex materials cannot be used as such as resource materials. The complex materials should be converted into simple inorganic element as available nutrient. The material put into soil without conversion will undergo conversion inside the soil. This conversion process takes away all energy and available nutrients from the soil affecting the crop. Hence conversion period is mandatory.

Definition

- Biochemical process - complex organic wastes are converted into simple molecules, minerals and Humus (Stable end product of the composting process used to maintaining soil fertility)
- Composting is done by the group of micro organisms like bacteria, fungi, actinomycetes, protozoa.

Microbes

Organic wastes $CO_2+H_2O+Humus+Minerals$



Optimum conditions

- Temperature : 15-35^{o}C
- Moisture content : 50-60%
- Carbon: Nitrogen ratio: 30:1
- Oxygen requirement : Aerobicity
- Salt content of waste : Low (<0.5%)
- pH : >5 and <9

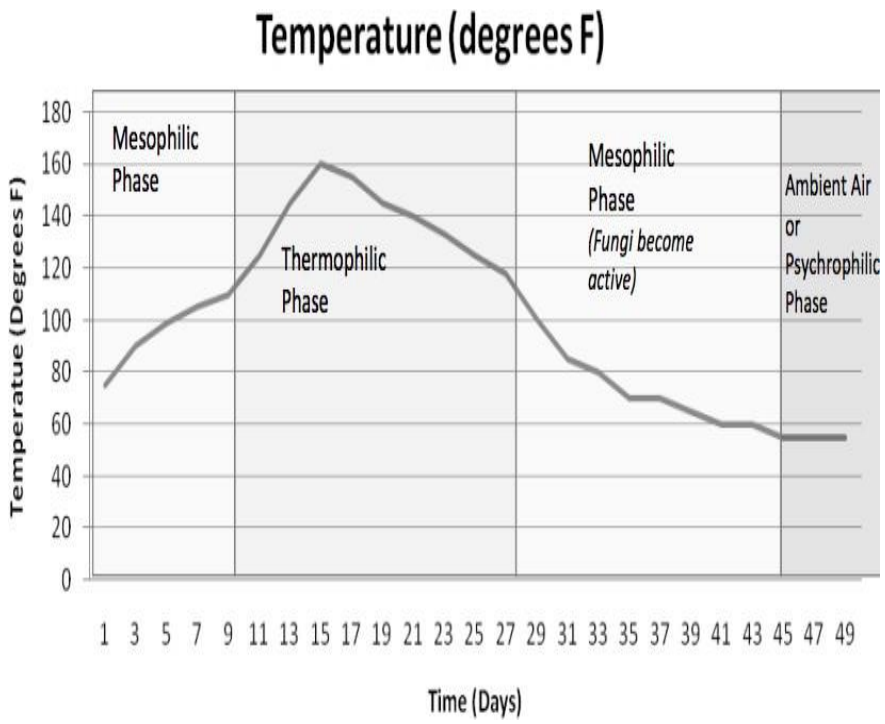
Stages in composting process

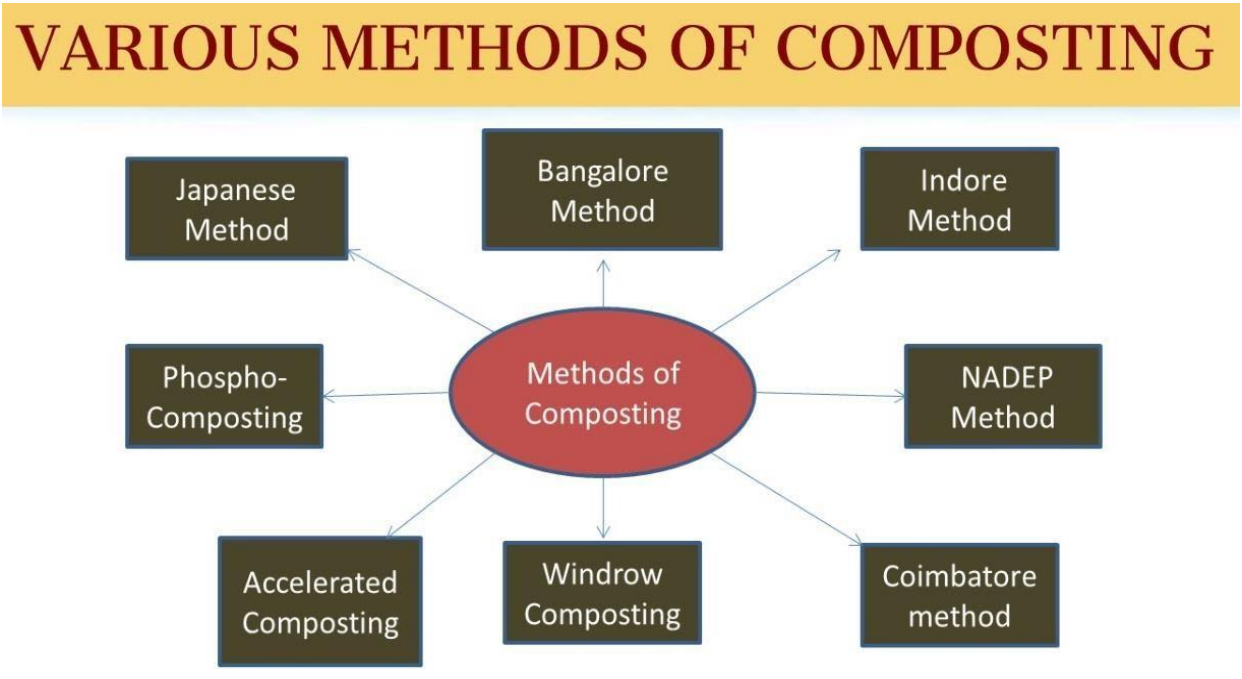
Phase I – Mesophilic Phase 1: It occurs at the beginning of composting when the temperature begins to rise above ambient temperature until reaching 40°C. This phase is also known as the initiation phase.

Phase II – Thermophilic Phase: It is the second phase of the process and begins when the temperature has reached 40°C and could increase to 60°C or 70°C, after reaching a peak it begins to decline.

Phase III – Mesophilic Phase 2: Known as the cooling phase. Starts when the temperature is dropping below 40°C until it reaches room temperature again. Mesophilic phase 2 ends once the composting temperature remains equal to room temperature for at least three consecutive days.

Phase IV – Maturation phase: This phase is very important for the stabilization of the newly formed compounds during composting. The maturation phase begins once the process has reached room temperature and remains the same for at least three consecutive days. This phase can last a long time, but it is recommended that it be at least 30 to 60 days.





Common composting methods

- Heap method
- Trenches/pit method

Heap method

Pit method

Composting procedure

Waste collection

- Crop residues accumulated in different locations are to be brought to compost yard. Water resource should also be available in sufficient quantity.

Shredding of waste materials

- It is advisable to shred all the waste using shredder machine. Particle size of 2 to 2.5 cm is recommended for quick composting.

Mixing of waste materials

- Green colored waste materials like freshly harvested weeds (rich in nitrogen), and brown colored waste material like straw, coir dust, dried leaves and dried grasses (rich in carbon). In any composting process these carbon and nitrogen rich material is to be mixed together to make the composting quicker rather.

Compost heap/pit formation

- *Heap:* minimum 4 feet height should be maintained for composting. The composting area should be elevated one and have sufficient shade. Place the waste materials with intermittent layers of animal dung are essential. After heap formation the material should be thoroughly moistened.
- *Pit:* Placing wastes in trenches of suitable size, say, 4.5 m to 5.0 m long, 1.5m to 2.0 m wide and 1.0 m to 2.0 m deep. Waste is placed in the trenches layer by layer. Each layer is well moistened by sprinkling cow dung slurry or water. Trenches are filled up to a height of 0.5 m above the ground.
- The compost is ready for application within 3 to 4 months.

Bioinputs for composting

- Biomineralizer consortium contains groups of microorganisms, which accelerate the composting process.

Aerating the compost material

- Normally to allow the fresh air to get inside, the compost heap should be turned upside down, once in fifteen days. In this process top layer comes to bottom and bottom layer goes to top. This process also activates the microbial process and compost process is hastened.

Moisture maintenance

- Throughout the composting period 60% moisture should be maintained.

Compost maturity

- Compost is ready for application within 3 to 4 months

Maturity of compost (maturity indices)

- Colour – bark brown, Odour - earthy
- pH - neutral
- EC - <0.5dSm^{-1}
- C/N ratio (Optimum 20:1)
- Plant nutrient content - High
- Humification index - Present
- Phytotoxic compounds – free

Compost Enrichment

- The harvested compost should be heaped in a shade, preferably on a hard floor. The beneficial microorganisms like *Azotobacter* or *Azospirillum, pseudomonas, Phosphobacteria* (0.2%) and rock phosphate (2%) have to be inoculated for one ton of compost. Forty per cent moisture should be maintained for the maximum growth of inoculated microorganism. This incubation should be allowed for 20 days for the organism to reach the maximum population. Now the compost is called as enriched compost. The advantage of enriched compost over normal compost is the quality manure with higher nutrient status with high number of beneficial microorganisms and plant growth promoting substances.

Compost application

- One hectare of land 5 tons of enriched biocompost is recommended. It can be used as basal application in the field before taking up planting work.

Benefits of Compost

- Quality and enriched manure from the crop and animal residues available in the farm. The manure contains both nutrients and beneficial microorganisms.
- There is improvement in the physical, chemical and biological properties of the soil due to regular addition of biocompost.
- Quality products will be obtained from the crop due to improvement in the soil fertility status.
- Soil organic matter content increased and soil biodiversity also improved due to enhanced soil organic matter content.

CHAPTER 3

VERMICOMPOST PRODUCTION

Vermicomposting is the process by which earth worms are used to convert organic materials (usually wastes) into a humus like material known as vermicompost (organic manure).

What Worms Need - The Five Essentials

Compost worms need five basic things:

1. An hospitable living environment, usually called "bedding"
2. A food source
3. Adequate moisture (greater than 50% water content by weight)
4. Adequate aeration
5. Protection from temperature extremes

Types of earthworms

- Epigeic – Surface living
- Endogeic – 30cm below ground
- Anecic – upto 3 m below ground

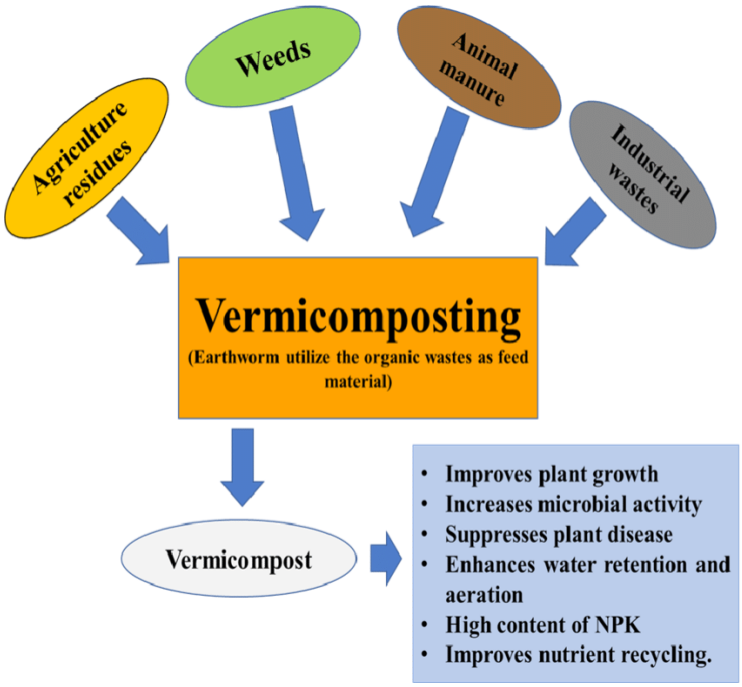
Epigeic – Surface living

- African worm (Eudrillus euginiae)
- Tiger worm or red wrinkle (Eisenia foetida)
- Asian worms (perinonyx ecavatus)

African earthworm

Tiger worm or Red wrinkle

Asian worms



Vermicompost Production Methodology

i) Selection of suitable earthworm

For vermicompost production, the surface dwelling earthworm alone should be used. The African earthworm (*Eudrillus engenial),* Red worms (*Eisenia foetida)* and composting worm (*Peronyx excavatus)* are promising worms used for vermicompost production. The African worm (*Eudrillus eugenial)* is preferred over other two types, because it produces higher production of vermicompost in short period of time and more

ii) Selection of site for vermicompost production

Vermicompost can be produced in any place with shade, high humidity and cool. Abandoned cattle shed or poultry shed or unused buildings can be used. If it is to be produced in open area, shady place is selected. A thatched roof may be provided to protect the process from direct sunlight and rain.

iii) Containers for vermicompost production

- A cement tub may be constructed to a height of 2½ feet and a breadth of 3 feet. The length may be fixed to any level depending upon the size of the room. The bottom of the tub is made to slope like structure to drain the excess water from vermicompost unit. A small sump is necessary to collect the drain water. Silpaulin sheet (vermibed) also used as container for vermicompost production.

Vermibed - Silpaulin sheet

vi) Vermiculture bed

- Vermiculture bed (3 cm) can be prepared by placing after saw dust or husk or coir waste or sugarcane trash in the bottom of tub / container. A layer of fine sand (3 cm) should be spread over the culture bed followed by a layer of garden soil (3 cm). All layers must be moistened with water.

v) Raw materials for vermicompost production

- Cattle dung (except pig, poultry and goat), farm wastes, crop residues, vegetable market waste, flower market waste, agro industrial waste, fruit market waste and all other bio degradable waste are suitable for vermicompost production. The cattle dung should be dried in open sunlight before used for vermicompost production. All other waste should be predigested with cow dung for twenty days before put into vermibed for composting.

vi) Pre-digestion of waste materials

- Collected different organic waste materials were shredded into small pieces and thoroughly mixed with 30 per cent of cow dung and kept for 20 days for pre-digestion under shade condition in open area

vii)Putting the waste in the container

- The predigested waste material should be mud with 30% cattle dung either by weight or volume. The mixed waste is placed into the tub / container upto brim. The moisture level should be maintained at 60%. Over this material, the selected earthworm is placed uniformly. For one-meter length, one-meter breadth and 0.5-meter height, 1 kg of worm (1000 Nos.) is required. There is no necessity that earthworm should be put inside the waste. Earthworm will move inside on its own.

viii) Watering the vermibed

- Daily watering is not required for vermibed. But 60% moisture should be maintained throughout the period.

ix) Harvesting vermicompost

- In the tub method of composting, the castings formed on the top layer (with in 45 days) are collected periodically. The collection may be carried out once in a week. The harvesting of casting should be limited up to earthworm presence on top layer. This periodical harvesting is necessary for free flow and retain the compost quality.

x) Harvesting earthworm

- After the vermicompost production, the earthworm present in the tub / small bed may be harvested by trapping method. In the vermibed, before harvesting the compost, small, fresh cow dung ball is made and inserted inside the bed in five or six places. After 24 hours, the cow dung ball is removed. All the worms will be adhered into the ball. Putting the cow dung ball in a bucket of water will separate this adhered worm. The collected worms will be used for next batch of composting.

xi) Storing and packing of vermicompost

- The harvested vermicompost should be stored in dark, cool place. It should have minimum 40% moisture. Sunlight should not fall over the composted material. It will lead to loss of moisture and nutrient content. It is advocated that the

harvested composted material is openly stored rather than packed in over sac. Packing can be done at the time of selling.

Nutrient value of vermicompost

S.no	Nutrients	Status
1	Organic carbon	9.5-18.00 per cent
2	Nitrogen	0.5-1.5 per cent
3	Phosphorus	0.1-0.3 per cent
4	Potassium	0.15-0.55 per cent
5	Sodium	0.06-0.3 per cent
6	Iron	2 – 9.30 mg kg-1
7	Zinc	5.70 – 11.50 mg kg-1

Benefits of vermicompost

- Easy to apply, handle and store
- Does not have bad odour
- Rich in all essential plant nutrients
- Contains valuable vitamins, enzymes and hormones
- Rich in beneficial micro flora
- Free from pathogens, toxic chemicals and weeds
- Provides excellent effect on overall plant growth
- Improve soil structure, texture, aeration and water holding capacity
- Neutralizes the soil protection
- Prevent nutrient loss in soil
- Minimize the pest and disease incidence
- Enhances the organic matter decomposition in soil
- Production of vermicomposting is highly feasible and producers can gain a considerable amount of economic benefits

Doses*:*

- The doses of vermicompost application depend upon the type of crop grown in the field/nursery. For fruit crops, it is applied in the tree basin. It is added in the pot mixture for potted ornamental plants and for raising seedlings. Vermicompost should be used as a component of integrated nutrient supply system.

Field crops : 5-6t/ha, Fruit crops: 3-5kg/plant, Pots: 100-200g/pot

Economics of vermicompost production in silpaulin sheet

I. Cost of investment for production of vermicompost from one tone of organic wastes

- a. Silpaulin sheet 250 GSM (size 12'x4'x2') : Rs. 2500.00
- b. Cost for earthworms (3 kg) : Rs. 1500.00
- c. Maintenance of earthworms (3 months) : Rs. 300.00
- d. Biofertilizer for enrichment of vermicompost : Rs. 150.00

Total expenditure : Rs. 4450.00

II. Grass income

a. Quantity of vermicompost harvest : 600 kg
b. Rate of one kg of vermicompost : Rs.15.00
c. Income from vermicompost (600kg x Rs.15.00) : Rs. 9000.00
d. Earthworm harvest for sale (Rs.500/kg) : 3 kg/ tone
e. Income from worms (3kg x Rs.500) : Rs. 1500.00Total income (3 months) : Rs. 10500.00

III. Net income (Income – Expenditure) : Rs. 10500-4450
: Rs. 6050.00

PROFIT: Rs. 6050.00/ ONE SILPAULIN SHEET IN 3 MONTHS

**Note: Silpaulin sheet and Earthworms are one time investment only. For the next batch onwards only maintenance cost and bio fertilizer cost were involved.*

CHAPTER 4

LIQUID ORGANIC MANURES – PANCHAKAVYA

Liquid organic manures are products obtained from the fermentation and/or decomposition of organic matter such as crop residues, animal dung, urine and other plant material. Liquid organic manures provide nutrients for the plants and can work as a pest control. **Liquid organic manures are:** Panchagavya, Desakavya, Jeevamruth, Sanjivak, Sasyagavya, Bijamrita Amritpani, Kunapajala, Vermiwash and Seaweed Extract

Benefits of organic manure

- Improve structure and texture of soil
- Provide plant nutrients
- Improve soil properties
- Increase soil fertility
- Cost effective
- Increase biological activity
- Reduce soil erosion
- Lower water consumption

Panchagavya

- Sanskrit word Panchagavya means **"Five cow-derivatives"**
- Ayuvedic medicine also called as **Cowpathy**

Panchagavya, an organic product has the potential to play the role of promoting growth and providing immunity in plant system. It is a mixture prepared by mixing five ingredients from the cow dung, cow urine, milk, curd and ghee.

Panchagavya ingredients

It consists of nine products viz. jaggery, ghee, banana, Tender coconut and water. When suitably mixed and used, these have miraculous effects.

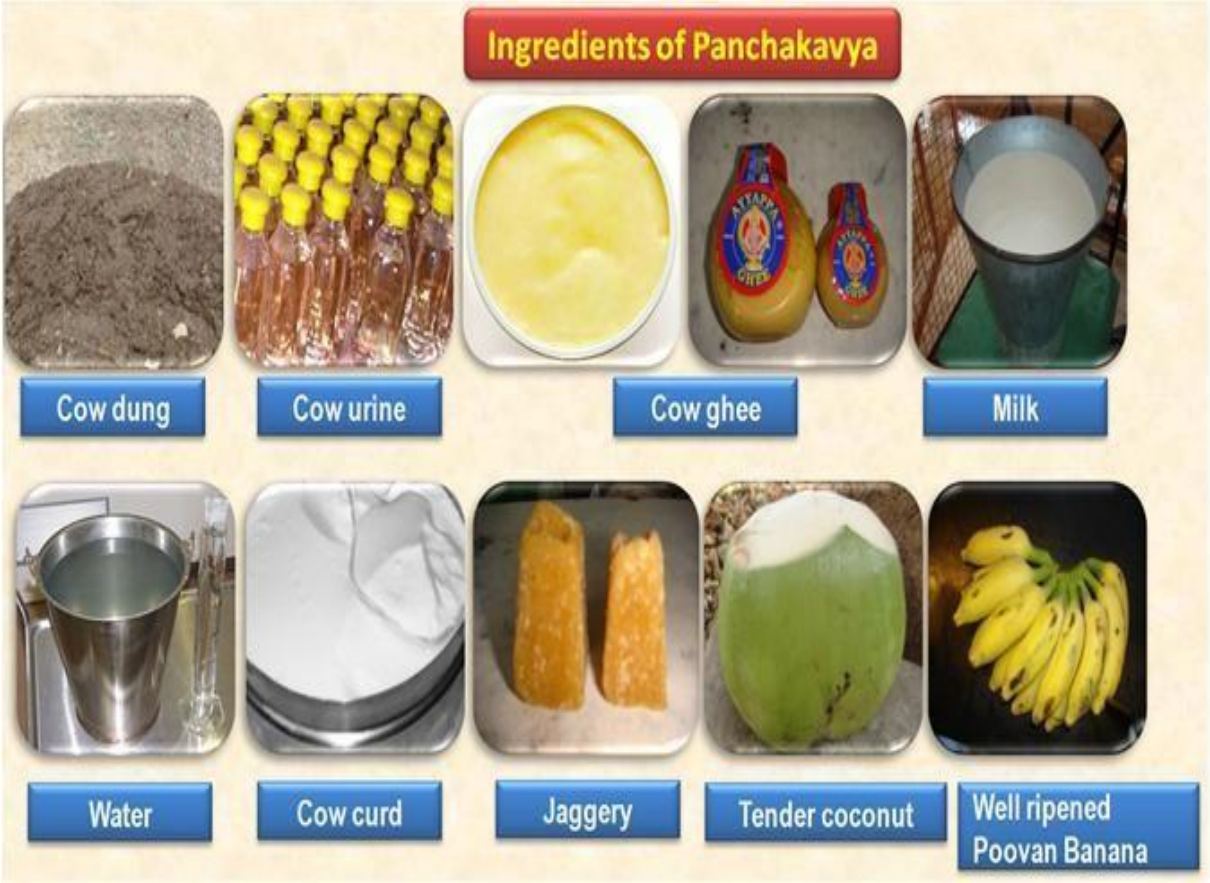
- Cow dung - 7 kg
- Cow ghee - 1 kg

Mix the above two ingredients thoroughly both in morning and evening hours and keep it for 3 days

- Cow Urine - 10 liters
- Water - 10 liters

After 3 days mix cow urine and water and keep it for 15 days with regular mixing both in morning and evening hours. After 15 days mix the following and panchagavya will be ready after 30 days.

- Cow milk - 3 liters
- Cow curd - 2 liters
- Tender coconut water - 3 liters
- Jaggery - 3 kg
- Well ripened poovan banana – 12 nos.



Preparation method

- All the above items can be added to a wide mouthed mud pot, concrete tank or plastic can as per the above order.
- The container should be kept open under shade. The content is to be stirred twice a day both in morning and evening.
- The Panchagavya stock solution will be ready after 30 days. (Care should be taken not to mix buffalo products.
- The products of local breeds of cow is said to have potency than exotic breeds).

- It should be kept in the shade and covered with a wire mesh or plastic mosquito net to prevent houseflies from laying eggs and the formation of maggots in the solution.
- If sugarcane juice is not available add 500 g of jaggery dissolved in 3 liter of water.

Properties of panchagavya

- Contains almost all the major nutrients, micro nutrients and growth hormones required for crop growth.
- Predominance of fermentative microorganisms (yeast and lactobacillus) and addition of jaggery and coconut as substrate for their growth.

Application of panchakavya

Spray system:

- 3 % solution was found to be most effective compared to the higher and lower concentration investigated

Flow system:

- The solution of panchakavya mixed with the irrigation water at 50 liters per hectare either through drip and flow irrigation

Seed and seedling treatment:

- 3 % solution of panchakavya can be used to soak the seed or dip the seedling before planting. Soaking for 20 minutes is sufficient.

Seed storage:

- 3 % of panchakavya solution can be used to dip the seed before drying and storing them.

Periodicity

- Pre flowering phase: Once in 15 days, two sprays depending upon duration of crops
- Flowering and pod setting stage: Once in 10 days, two sprays
- Fruit/Pod maturation: Once during pod maturation stage

Suitable Crops: Fruits, Vegetable, Spice, Aromatic and Flower crops

Effect of Panchakavya

Leaf:

- Plants produce bigger leaves and develop denser canopy.

Stem:

- Trunk produces more side shoots and branches, which are sturdy and capable of carrying maximum fruits to maturity.

Roots:

- Rooting is profuse, dense and remain fresh for a long time,
- Spread and grow into deeper layers,
- Maximum intake of nutrients and water

Yield:

- Harvest is advanced by 15 days in all the crops.
- It not only enhances the shelf life of vegetables, fruits and grains, but also improves the taste.

Drought Hardiness:

- A thin oily film is formed on the leaves and stems, thus reducing the evaporation of water
- Deep roots allow the plants to withstand long dry periods

Cost of panchagavya: Rs.40/Liter

CHAPTER 5

LIQUID ORGANIC MANURES – DASAKAVYA, JEEVAMRUTHAM AND VERMIWASH

Dasagavya

- "Gavya" is th term given to cow's products comprising of cow dung, cow urine, cow's milk, curd and ghee, which have miraculous effects on plant growth when suitably mixed.
- Dasagavya, is an organic preparation made from ten products in the form of panchagavya and certain plant extracts. It is effective against certain pests and diseases.

Plants recommended

- Neem (*Azadirachta indica*)
- Adathoda (*Adathoda vasica)*
- Katamanaku (*Jatropha curcas*)
- Pungam (*Pongamia pinnata*)
- Notchi (*Vitex negundo*)
- erukam (*Calotrophis)*
- umathai (*Datura metel*)
- *Thumbai - Leucas aspera*
- Kolingi (*Tephrosia purpurea*)

Preparation method

- The plant extracts are prepared by separately soaking the foliage in cow urine in 1:1 ratio (1 kg chopped leaves in 1 litre cow urine) for ten days.
- The filtered extracts of all the plants are then added @ 1 litre each to 5 litre of the panchagavya solution.
- The mixture is kept for 25 days and stirred well, meanwhile, to ensure thorough mixing of panchagavya and the plant extracts.

Mode of use

Dasagavya solution is filtered to avoid clogging of sprayer nozzles

Recommendation

- Foliar spray at 3 % concentration
- Soaking of seeds or dipping of seedlings roots in 3 % solution for 20 minutes before planting

Periodicity

- Weekly sprays during crop growth for all vegetables and plantation crops.

Benefits

- Increases growth, yield and quality of the crops
- Controls pests like aphids, thrips, mites and other sucking pests
- Controls diseases like leaf spot, leaf blight, powdery mildew etc.

Cost of panchagavya: Rs.500/Liter

Jeevamrutha

Jeevamrutha is a low budget preparation that makes the soil enriches and helps to grow micro-organisms and improve mineralization of the soil. Jeevamrutha is prepared from native cow's urine, dung, jaggery, and horse gram. It is the right time to use cow-based products in the agriculture field. The fungal infections and tick burning are effectively kept under control by Jeevamrutha. Jeevamrutha was spray in the

nursery and given with irrigation every night in the main fields. don't use chemical fertilizer or pesticide during the whole period of cultivation.

Ingredients for Jeevamrutham

- Water 200 liters
- Desi cow dung 10 kgs
- Desi cow urine 10 liters
- Jaggery 1 kg
- Flour of any pulses 2kg
- A handful of fertile soil from your farm

Preparation of Jeevamrutham

- For preparation Jeevamrutham, you need a 200-liter tank or a water barrel is required.
- You should add 10kgs of cow dung into the water. with the help of a stick Stir the mixture in clockwise.
- After put the handful of fertile soil from your farm in to the mixture.
- And add 10 liters cow urine to the mixture. Stir it well again clockwise.
- Finally, you must add remaining the semi powdered jaggery and the flour to the mixture.

- The above mixture should be kept in a shaded place and away from sunlight.
- The mixture should be stirred a thrice a day (10 min every day) for 4 days.
- And Cover the water barrel or tank with a breathable jute bag.
- After the fermented process complete and Jeevamrutham is prepared for the use.
- This jeevamrutham can be used for 2-3days. Do not use Jeevamrutham after seven days.

Types of Jeevamrutham

- The liquid state of Jeevamrutham (explained above)
- The semi-solid state of Jeevamrutham
- Dry Jeevamrutham (Ghana Jeevamrutham)

Semi-solid state Jeevamrutham

- The Ingredients 5 liters cow urine,100kg cow dung,1 kg of pulses flour,1 kg jaggery and a handful of fertile soil.
- Take a small amount of water and Mix all of them.
- Make the mixture as a small ball and keep these balls in direct sunlight to dry them.
- Keep the dried balls near the mouth of sprinkler or dripper.
- The microbes get activated again. When the waterfalls on the semi-solid Jeevamrutham

Ghana Jeevamrutham

- Take 200kg of cow dung manure and spread manure uniformly on the floor to form a layer.
- Take 20 liters of liquid Jeevamrutham and add to the manure.
- Mix the mixture completely.
- After that heap of the cow dung and closed it again using jute bag for 48 hours.
- Allow it for fermentation. After that spread on the ground for dry in the sunlight.
- After drying collect dry manure and kept it in jute bags in the room.
- you can store Ghana Jeevamrutham for six months.
- you can use 200kg ghana Jeevamrutham per acre in the sowing period.
- Use 50kg of Ghana Jeevamrutham in between two crops and you will Amazing yield.

Jeevamrutham Irrigation and dosage

Jeevamrutham is given by Irrigation through like a drip, canal water, sprinkler.

When you spraying Jeevamrutham, you can dilute the mixture and then spray it.

- First dosage – After One-month seed sowing takes 100-liter water and add 5 liters of filtered Jeevamurtham. And Stir it well and spray it to one acre of Vegetable Crops. In summer, spray early morning or evening. and In winter any time can be sprayed.
- Second dosage – After 21 days the first spray. Take 150 liters of water and add 10 liters of filtered Jeevamrutham spray.
- Third dosage – After 21 days the Second spray. Take 200 liters of water and add 20 liters of filtered Jeevamrutham per acre.
- Fourth dosage – When fruits are beginning up. Take 200 liters of water and add 6 liters sour buttermilk can be sprayed for one acre.

Benefits of Jeevamrutham

Jeevamirtham is an organic fertilizer that plays a very important vital role in promoting the growth rates and immunity to plant systems. It provides an environment to microorganisms that help the plants to grab the nutrients such as phosphorous, nitrogen and potassium to the plants. The earthworm is broken down into molecular form by the microbes in the jeevamrutham, so that; it can be easily absorbed by the roots. These microbes waste in the soil thereby making the soil more fertile. The downward and upward movement of the earthworms loosens the soil. It helps plants to absorb nutrients from the soil easily.

Vermiwash

- By product obtained from vermicompost unit
- It is liquid extract collected after the passage of water through the different layers of worm culture unit
- Eco friendly natural organic fertilizer
- Helps to develop resistance against various diseases and pests in plant
- Initiating the flowering and act as a biopesticide
- Dost not have any adverse effect on soil plant and environment

VERMIWASH

CHAPTER 6

AZOLLA PRODUCTION

Introduction to Azolla

Azolla is a free floating aquatic fern which appears as a green mat over water and can rapidly grows on the surface of water.

Characteristics of azolla

Azolla grows in fresh water and is naturally available mostly on moist soils. Float on the water surface individually or in mats. Azolla consist of floating rhizome and small overlapping leaves and roots. Roots from growing branches remained suspended in water.





Uses of azolla

Azolla is used as a biofertilizer in wet land rice. The fully grown Azolla is incorporated into the soil as green manure crop and provides nitrogen source to rice.


Apart from this Azolla is also used as feed for cow, goat, sheep, fish, pig and poultry. Hence many farmers attract toward the Azolla cultivation. Feeding Azolla to poultry birds improves the weight of broiler chicken and increases the egg production of layers birds. In cattle it showed an overall increase of milk yield upon feeding along with the regular diet.




Steps of Azolla mass production

1. Selection of location
2. Azolla bed preparation
3. Production of azolla
4. Maintenance of the azolla bed
5. Harvesting of azolla

Selection of location

- The location for azolla production should be away from direct sunlight and must be partially shade.

Azolla bed preparation

- Dig out the soil of required size for pond construction and level the soil after that spread the plastic sheet around the ground to prevent water loss. Readymade silpaulin covers for azolla mass production can also be used instead of pond construction.
- Sieved fertile soil of about 15 kg mixed with 5 kg of cow dung and water, need to be spread uniformly in the bed. Biogas slurry can also be used instead of cowdung.

- Maintain water level to about 10 cm.

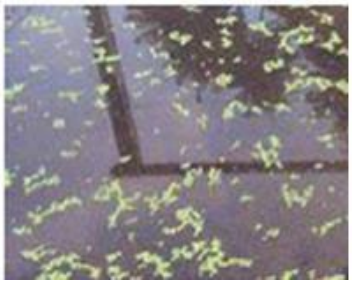
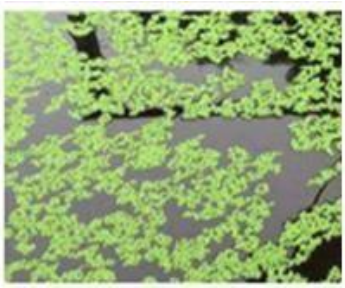

Production of azolla

- About 1 kg of fresh azolla culture is needed for a bed of 12 x 4 x 1 feet size which needs to be applied uniformly in the bed.
- Mix the contents of azolla bed once in three days without disturbing the floating azolla culture.
- The entire azolla cultivation bed is covered with a green shade net over the top to avoid exposure to direct sunlight.


Maintenance of the azolla bed

- Application of about one kg of cow dung and about 10 grams of super phosphate once in two weeks will ensure better growth of azolla.
- Any litter or aquatic weeds seen in the pond should be removed regularly.


Stages in the growth of *Azolla*


0^{th} - 1^{st} Day (Cover 10 percent area)

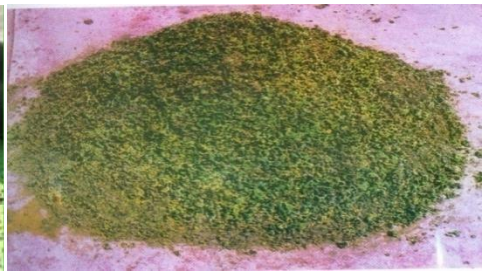
5^{th} - 8^{th} Day (Cover 50 percent area)

15^{th} - 20^{th} Day (Cover 100 percent area)

Harvesting of azolla

- Depending on the initial quantity of culture added, environmental conditions and nutrition the growth of azolla will be complete in about two to three weeks time.
- Allow 15-21 days period for multiplication of Azolla. After multiplication, harvest Azolla to obtain around 5 kg of Azolla from each bed.
- Plastic sieves can be used to harvest the biomass from the azolla bed.
- About one third portion of azolla left behind during harvesting which is further multiply in the azolla bed by adding required quantity of nutrients, so that azolla can be harvested in routine basis.





Requirements for azolla mass production

1. Water: Maintenance of adequate water level in the azolla bed is essential.10-15 cm fresh water is necessary in multiplication bed.
2. Temperature: The optimum temperature for luxurious growth of azolla is 25 to 30ºC.
3. Light: Azolla prefers to grow well under partial shade.
4. Relative Humidity: The optimum relative humidity requirement is 85 to 90 percent.
5. Soil pH: Azolla grows well in slightly acidic soil having 5 to 6 pH.
6. Nutrition: Azolla does not require nitrogenous fertilizer for its growth. Phosphorous is desirable for good biomass production.

Important points to be note down

- If the total salt content of the water used for growing azolla is high, it will adversely affect the growth.
- Azolla should be harvested regularly to avoid overcrowding.
- The azolla bed needs to be emptied once in six months and cultivation has to be restarted with fresh azolla culture and soil.
- Azolla has to be washed thoroughly with fresh water to remove the smell of dung before using as livestock feed.

CHAPTER 7
SERICULTURE

- Greek 'Sericos' meaning 'silk'
- English 'culture' meaning 'rearing'
- Cultivation of mulberry to produce leaf
- Rearing of silkworm to convert leaf to cocoon
- Reeling of the cocoon to obtain silk yarn
- Weaving to convert yarn to fabrics
- Silk - Fibrous protein of animal origin – '**Queen of Fibres'**
- 95% of commercial insect silk

Types of silkworm

- Mulberry silikworm, *Bombyx mori* - mulberry silk
- Non-mulberry silk or Vanya Silk
- Temperate Tasar Silk - ***Antheraea myiitta***
- **Tropical Tasar or Oak Tasar Silk -** ***Antheraea proyeli***
- Muga silk - ***Antheraea assamensis***
- Eri silk – ***Philosamia ricini***

Importance of sericulture

1. India - **second largest silk producer** next to China
   - Producing all the four commercial types of natural silk
   - Mulberry, tasar, muga and eri silkworm
2. Sericulture - agro based rural industry
   - large labour involvement - higher income generation potential.
3. Sericultural activities - village based
   - Prevents migration of people from rural to urban
4. Suitable to small and marginal farmers
5. Mulberry ensures higher income per unit area than agri crops Sericulture gives income 5 to 6 times a year
6. Provides self-employment opportunities - educated unemployed youth
7. Requires simple appliances - easily available in rural areas
8. Once the plantation is established - continue to yield for 10 to 12 years
   - Maximum turnout with minimum investment
9. In drought conditions, most of the agricultural crops do not revive
   - Mulberry - perennial crop sprout and yield leaves
10. Waste from silkworm rearing - recycled as inputs in garden
11. Dried mulberry twigs and branches – used as fuel
12. Mulberry and silkworm have pharmaceutical values
13. Silkworm - used as a tool for genetic and biotechnological studies

Economic Importance

- ✓ Sericulture - good source for earning foreign exchange Mulberry silk - 92% of total silk produced in India
- ✓ China and India are the two main producers and more than 60% of the world's annual production

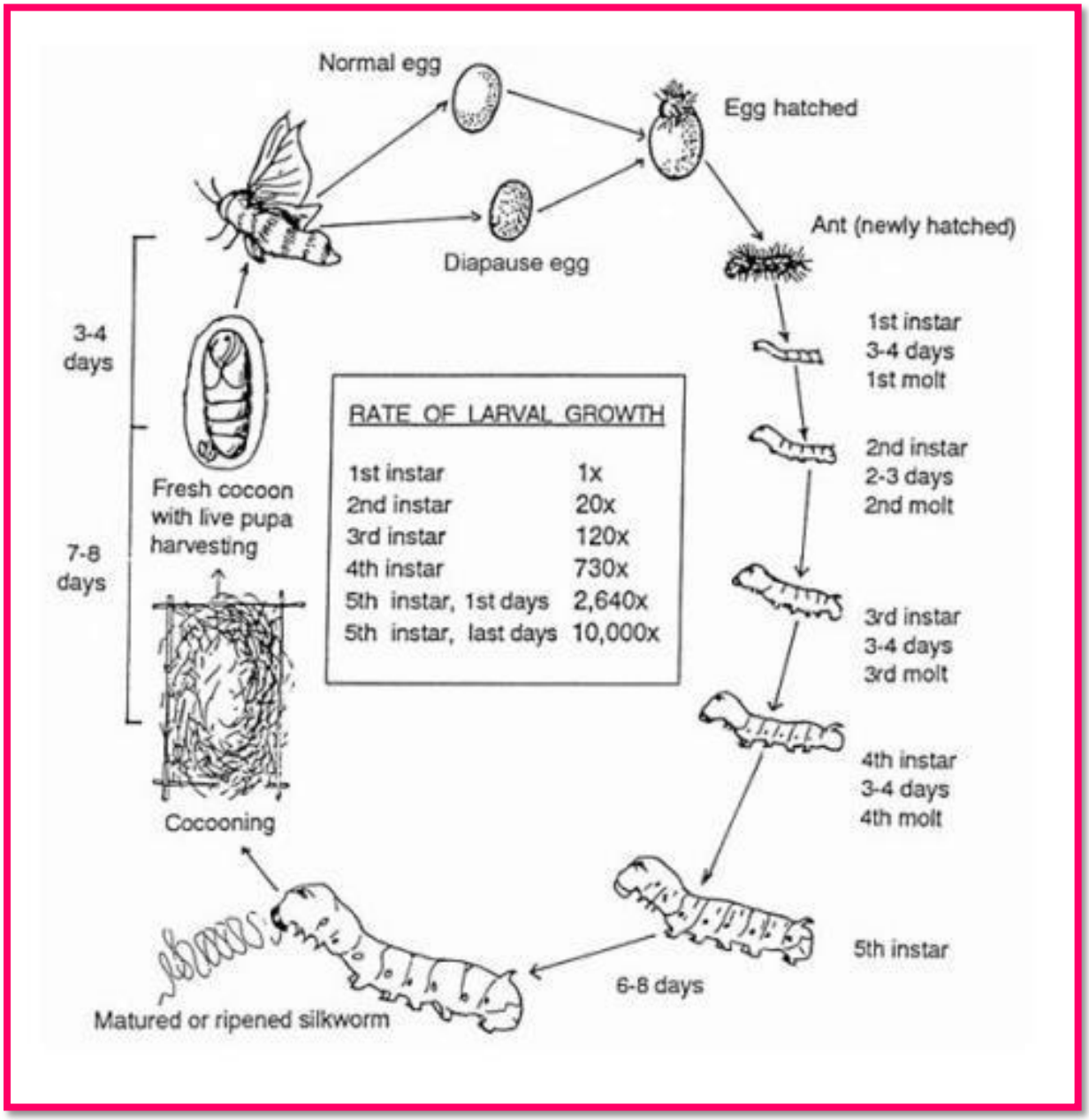
History of Sericulture

- Silk was discovered in China by the Empress, Si- Ling
- The first authentic reference - Chronicles of the Chou- King of China (2,200 BC).
- Empress Si-Ling the worms destroying the mulberry trees - gather the cocoons - she accidentally dropped one of them into a bowl of hot tea. While trying to recover the cocoon from the hot liquid with a spoon, she discovered that a very fine and very long lustrous thread unwound itself from the cocoon. She discovered silk and the process of obtaining it from the cocoons.

Organizations in sericulture industry

- International Sericulture Commission (ISC) established in Lyon, France in the year 1948 - only inter-governmental organization.
- Central silk Board (CSB) established in 1949 (Bangalore) .

Life cycle of silkworm



Rearing House

- Separate house - ideal for rearing of silkworm
- To provide optimum temperature of 26-28 ^{0}C and RH of 60-70% for the growth of silkworm
- Avoid
    * Damp condition
    * Stagnation of air
    * Direct and strong drift of air
    * Exposure to bright sun light and radiation

  Ensure
    * An equable temperature and humidity
    * Good ventilation.

Features

- ❖ Rearing house - brushing capacity and the method of rearing
- ❖ Rearing area
    - 2 sq. ft/ dfl for floor rearing
    - 3 sq. ft/ dfl for shoot rearing
- ❖ Rearing house - main rearing hall, an ant room (8 x 8 ft) and leaf preservation room
- ❖ Maintain a separate chawki (Young age) room
- ❖ Rearing house should face east-west direction
- ❖ Rearing house - to maintain the required environmental conditions
- ❖ Growing trees around rearing house helps to maintain favourable environment

Mulberry Genotypes (*Morus* spp. ; Family: Moraceae)

The important characteristic feature of the members of the family Moraceae is the presence of idioblast which is nothing but the enlarged epidermal cell in the leaf. Some

Important species of mulberry are as follows:

1. White mulberry - *Morus alba*
2. Black mulberry - *M. nigra*
3. Red mulberry - *M. rubra*
4. Russian mulberry - *M. tartarica*
5. Indian mulberry - *M. indica*
6. Creamy mulberry - *M. serata*

Selection of planting material

Generally the mulberry plants are raised from semihard wood cuttings.

The cuttings are selected from well established plants of 8-12 months old. Only full grownthick main stems, free from insect and disease damages. having a diameter of 7-10 mm arechosen for preparation of cuttings.

The cutting should be of 15-20 cm with 3-4 active buds and should have 45°slanting cut at the bottom end. Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark.

Manually/power operated mulberry cutters (stem cutting machine) is available for quick cutting of propagative material.

Method of planting

Spacing	Irrigated	Dry
Ridges and furrows	60 x 60 cm	90 x 90 cm
Pit system	90 x 90 cm	90 x 90 cm

Time of planting

Plant during rainy season

Avoid planting during winter and summer months

Planting

Plant the well rooted and sprouted saplings at a depth of 15-20 cm

- Earth up and level the area around the saplings
- Gap fill during monsoon months

Environmental requirements for different stages of silkworm

- Silkworm larvae – sensitive to temperature, relative humidity, quality and quantity of leaf supply and methods of rearing

1. Temperature
    - Above 30 ^{0}C – larval period shortened
    - Below 20 ^{0}C – Prolonged larval period
    - Optimum temperature: 20 – 28 ^{0}C
    - Young age larvae – resistant to high temperature

2. Relative humidity
    - Young age larvae require high RH
    - Low RH – required at the time of mounting
    - Too dry condition – retarded growth of larvae
    - Too much of RH – favours disease outbreak
    - Regulating RH – paraffin paper, wet foam, sprinkling of water over the leaves

3. Air
    - Important role in regulating rearing room temperature and RH

4. Light
    - Silkworms – photosensitive – tendency to crawl towards dim light
    - Complete darkness – Shortened larval period
    - Bright light – Irregularity in growth and moulting
    - Uniform moult – 16 hrs light & remaining period is dark
    - Dim light during day time and dark at night is normally ideal.

5. Leaf quality
    - Influenced by soil, pruning, fertilizers, rainfall, irrigation etc.

Rearing Equipments

1. Rearing stands – wooden or bamboo stands - placed rearing trays containing silkworm
2. Rearing trays – Split bamboo or plastic trays used for rearing silkworms

3. Antwells – Rectangular concrete bowls containing water – to prevent ants movement
4. Paraffin paper – Used to cover the rearing trays to maintain humidity and prevent withering of leaves
5. Chopsticks – Tapering bamboo rods required for picking up younger larvae – to avoid any injuries
6. Feathers – White feathers required for brushing freshly hatched larvae
7. Cleaning nets – Cotton or nylon - used for changing the rearing beds
8. Chopping boards, knives and mats – to chop the mulberry leaves
9. Leaf baskets – Bamboo – used for transport of mulberry leaves from field to the rearing house
10. Mountages – Circular baskets with spiral walls about 5 cm width to facilitate the mature worms to attach their cocoons

Commercial races of South India

- Tamil Nadu White (TW) – Multivoltine, white cocoon
- Pure Mysore (PM) - Multivoltine
- Hosa Mysore (HM) - Multivoltine
- Kalimpong A (KA) - Bivoltine
- C. nichi - Bivoltine / Multivoltine
- Nandi - Hybride between KA x NB4D2
- Chamundi - Hybrid NB7 x NB 18

Bed Disinfectants

- Disinfectant is a chemical that facilitates a place or area or appliance free from germs. The disinfectants can be grouped as:
- Halogens – Chlorine, Iodine
- Heavy metals – $HgCl_2$, Metaphen, Protargol etc.,
- Phenols – Lysol, Creosols etc.,
- Alcohols – Ethyl and Isopropyl.
- Aldehydes – Formaldehyde, Para formaldehyde
- Ethylene oxide – Carboxide and cryoxide.

CHAPTER 8
APIARY – HONEY PRODUCTION

Honey bees are reared in artificial hives for the production of Honey and Bee wax and additionally they play major role in pollination . The practice of rearing bees is called Apiculture or Bee keeping. The place where the hives are maintained is called an Apiary.

Importance of Bees

1. Bees help in pollination thus ensures food security and environmental biodiversity (30 percent of 1500 crop species depend on pollination from bees)
2. They prude income from Honey,propolis,royaljelly,wax,bee venom
3. They require minimum resources like land ,labour etc.
4. No competition for bee food (pollen and Nectar) from the livestock feed.
5. Agro-tourism.

The pre-requisites which are considered must to start beekeeping are as follows

- Knowledge and training on bee keeping
- Knowledge on local bee flora
- Sufficient local bee flora
- Knowledge of migratory bee keeping

Apiary site requirements

- Site should be dry and High RH will affect bee flight and ripening of nectar.
- **Water:** Natural or artificial source of water should be provided.
- **Wind breaks:** Trees serve as wind belts in cool areas.
- **Shade:** Hives can be kept under shade of trees. Artificial structures can also be constructed to provide shade.
- **Bee pasturage and floorage:** Plants that yield pollen and nectar to bees are called bee pasturage and floorage. Such plants should be plenty around the apiary site.

Bee species

There are five important species of Honey Bee as follows:

1. *Apisdorsata* (The Rock Bee) Apidae
2. *Apisceranaindica*(The Indian Hive bee) Apidae
3. *Apis florae* (The Little Bee) Apidae
4. *Apismellifera*(The European or Itllian Bee) Apidae
5. *Trigonairridipennis*(Dammer Bee) (Sting less Bee) Meliponidae

Indian bee

We maintain Indian bee (*Apisceranaindica)*

Characters of Indian bee:

1.They make multiple parallel combs on tress and cavities in darkness.

2.The bees are larger than *Apis florae* but smaller than *Apismellifera*.

3.They produce about 5 kg of honey per year per hive.

4.They are more prone to swarming and absconding.

5.They are native of India,Asia.

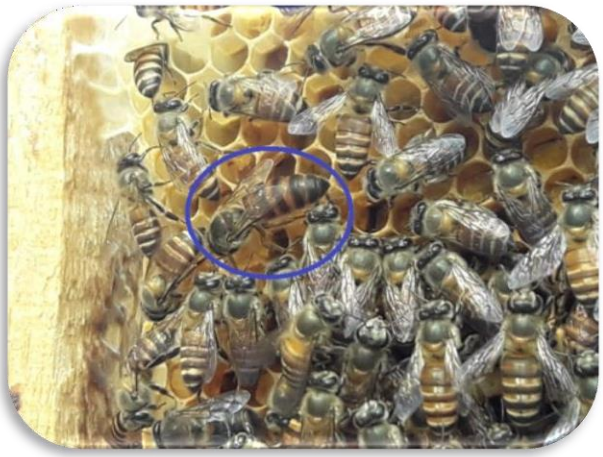
Castes of honey bees:

Every honey bee colony comprises of a single queen, a few hundred drones and several thousand worker castes of honey bees. Queen is a fertile & functional female, while worker is a sterile female and the drone is a male insect.

Queen and worker develop from fertilized egg while drone develops from unfertilized egg. Further differentiation of queen and worker depends on the quality and quantity of food that is fed to the queen or worker larvae.

The Queen:

There is only one queen in a colony. It is considerably larger than the members of other castes. Her wings are much shorter in proportion to her body. Because of her long tapering abdomen, it appears more wasp-like than other inmates of the colony. The queen is the only individual which lay eggs in a colony and is the mother of all bees. It lays upto*2000* eggs per day in *Apismellifera.* Five to ten days after emergence, she mates with drones in one or more nuptial flights. When her spermatheca is filled with sperms, she will start laying eggs and will not mate any more. She lives for 3 years. The queen can lay either fertilized or sterile eggs depending on the requirement.



Queen

The Drone:

The drones are the male bees. They are much larger and stouter than either the queen or the workers although their body is not quite as long as that of the queen. They have no sting; a suitable proboscis for gathering nectar is also absent. They are, therefore, physically incapable for the ordinary work of the hive. Their only function is to impregnate the young queen a task which they are unable to perform until they are about 10 days of age. They also help in maintenance of hive temperature. The number of drones in a colony often is very large amounting to hundreds and sometimes to thousands. The drones are produced by unfertilized eggs of the queen, or by those workers which take up the reproductive function due to the absence of a queen in a colony. The normal life-span of a drone is 57 days. Mating takes place in the open when the queen is in flight. The drone dies in the act or immediately afterwards. Its abdomen has to burst open to allow the genital organ to function.

Drone

The Worker:

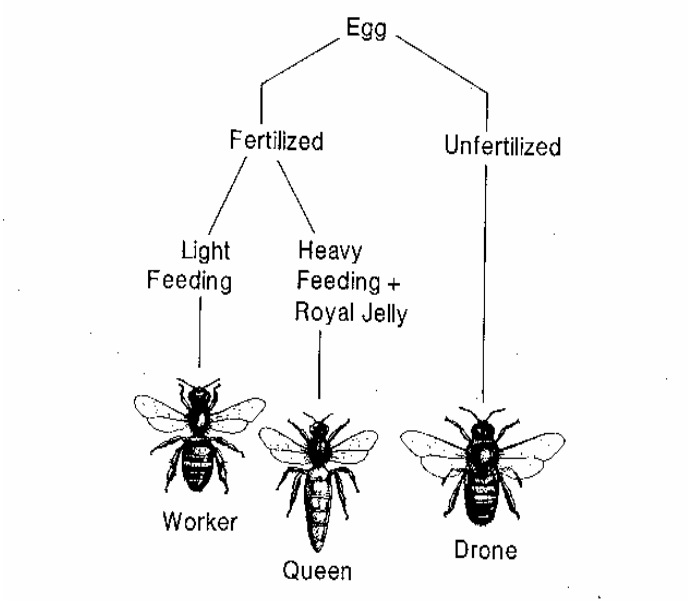
The workers are the smallest inhabitants of the beehive. They form the bulk of the population. The number of workers in a colony varies from 1,500 to 50,000. They are imperfect females incapable of laying eggs. On certain occasions when the colony is in need of a queen, some of the workers start laying eggs from which only drones are produced. These workers, called *laying workers,* are killed as soon as a new queen is introduced or produced in the colony.

The life-span of a worker is about 4 weeks during active season and 8 to 10 weeks during less active season. Their range of flight varies from 1,000 to 1,500 m. The division of work within a colony among the worker bees is based on the age of the individual and on the needs of the colony. Normally, the young bees, immediately after their emergence, do the work of cleaning cells and feeding older larvae. When they are grown and their hypopharyngeal glands have developed, they secrete the royal jelly with which they feed the younger larvae. These bees are called *nurse bees.* For the first 2 to 18 days of their life, the bees perform indoor duty inside the hive, including comb construction when some young bees start secreting wax. Later on they become foragers, collect water, pollen, nectar and propolis (bee-blue). Pollen is a nitrogenous food and is essential for brood - rearing and young bees.

Worker bees

Period	Work activity
Days 1–3	Cleaning cells and incubation
Day 3–6	Feeding older larvae
Day 6–10	Feeding younger larvae
Day 8–16	Receiving nectar and pollen from field bees
Day 12–18	Beeswax making and cell building
Day 14 onwards	Entrance guards; nectar, pollen, water and propolis foraging; robbing other hives

Sex differentiation in bees

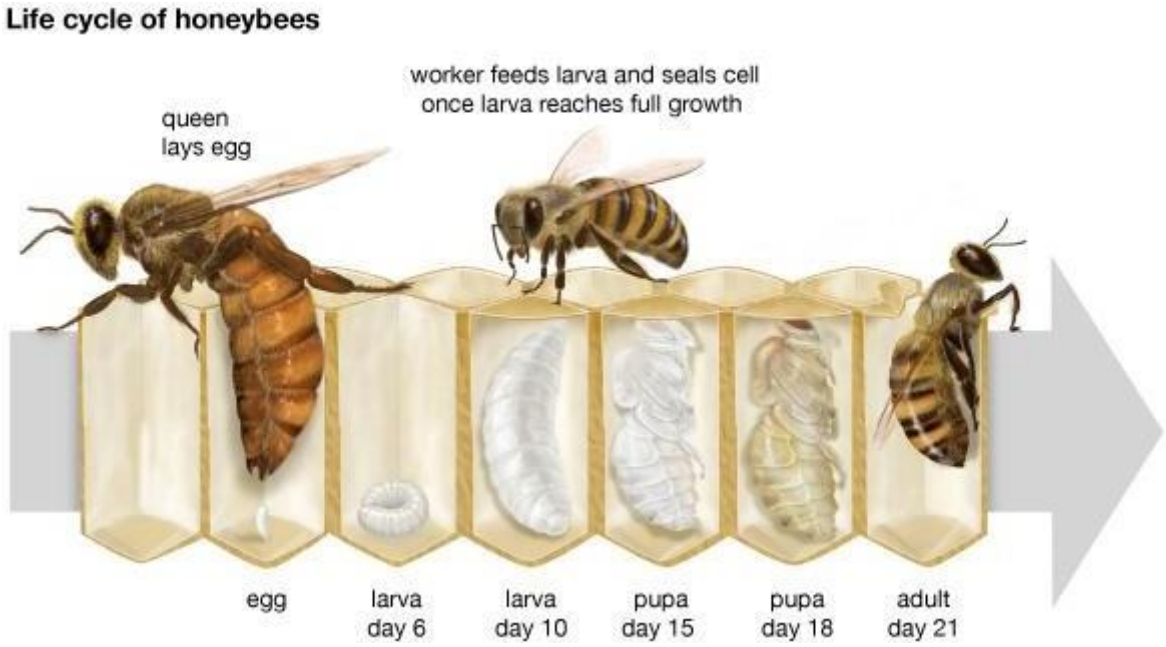


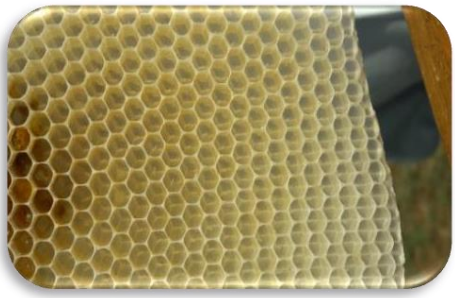
Life cycle of honey bees

The life of a honey bee colony is perennial. The three types of honey bees in a hive are: queens (egg-producers), workers (non-reproducing females), and drones (males whose main duty is to find and mate with a queen). Honey bees hatch from eggs in three to four days. They are then fed by worker bees and develop through several stages in the cells. Cells are capped by worker bees when the larva pupates. Queens and drones are larger than workers, so require larger cells to develop. A colony may typically consist of tens of thousands of individuals.

Development from egg to emerging bee varies among queens, workers, and drones. Queens emerge from their cells in 15–16 days, workers in 21 days, and drones in 24 days. Only one queen is usually present in a hive. New virgin queens develop in enlarged cells through differential feeding of royal jelly by workers. When the existing queen ages or dies or the colony becomes very large, a new queen is raised by the worker bees. When the hive is too large, the old queen will take half the hive and half the reserves with her in a swarm. This occurs a few days prior to the new queen hatching. If several queens emerge they will begin piping (a high buzzing noise) signalling their location for the other virgin queens to come fight. Once one has eliminated the others, she will go around the hive chewing the sides of any other queen cells and stinging and killing the pupae. The queen takes one or several nuptial flights. The drones leave the hive when the queen is ready and mate, and mate in turns, dying after doing so. After mating the queen begins laying eggs. A fertile queen is able to lay fertilized or unfertilized eggs. Each unfertilized egg contains a unique combination of 50% of the queen's genes and develops into a haploid drone. The fertilized eggs develop into either diploid workers or virgin queens if fed royal jelly.

The average lifespan of a queen is three to four years; drones usually die upon mating or are expelled from the hive before the winter; and workers may live for a few weeks in the summer and several months in areas with an extended winter.





Egg

Larva & Pupa (Sealed)

Differing stages of development

Stage of development	Queen	Worker	Drone
Egg	3 days	3 days	3 days
Larva (successive molts)	8 days	10 days	13 days
Cell Capped	day 8	day 8	day 10
Pupa	4 days	8 days	8 days
Total	15 days	21 days	24 day

Bee hive :

Bee hives were designed after the discovery of “Bee Space” or “Bee Passage” by L.L.Langstroth. It is the optimum distance to be left in between two adjacent comb surfaces in a bee hive which is essential for normal movement and functioning of bees. It is too small for comb construction and is too large for propolis deposition. It varies with honeybee species. Eg.For Indian bees – 7-9 mm and Italian bees – 10 mm.

Types of bee hives

Different types of bee hives were in use in various parts of our country. They are pot hive, book hive, Madhusagar hive, house hive, nucleous hive, single walled and double walled Dadant hives, British standard hive, Langstroth hive, Jeolikote hive and Newton hive. Of all these types, the one designed by Rev.Fr.Newton is the most popular one in South India. Newton's hives, BIS hives and Marthandam hives are suited for rearing Indian bees. Langstroth hives are suited for rearing Italian bees. We use **Marthandam hives** for rearing **Indian bees**.

Marthandam hive

Parts of hive

Stand :

The bee hive is mounted on a stand.the height of the stand is 45 cm and indene powder is dusted around the stand to protect the hive from ants.

Stand

Bottom board (or) Floor board:

It forms the floor of the hive made up of a single piece of wood or two pieces of wood joined together. Wooden beading are fixed on to the lateral sides and back side. The board is extended by10 cm in front of the hive body which provides a landing

latform for bees. Size of alighting board is 40x28 cm .it is mounted on the stand.

Floor board

Brood Chamber:

It is a four sided rectangular wooden box of cross section without a top and bottom. It is kept on the floorboard. A rabbet is cut in the front and back walls of the brood chamber. The brood frames rest on the rabbet walls. Notches on the outer surface of the side walls are useful for lifting. The four sides of the chamber are joined by special joints. In brood frames, bees develop comb to rear brood. Size of brood chamber is (outer dimensions) 29x29x17 cm. There will be 6 frames. Length and height of frame is 20.5x14.0 cm .

Brood Chamber

Brood Frames

Super Chamber:

It is kept over the brood chamber and its construction is similar to that of brood chamber. Super frames are hung inside. The length and width of this chamber is similar to that of brood chamber. Surplus honey is stored in super chamber. The height of the chamber is 9.5 cm. The inner height of the frame is 6.0 cm.

Super Chamber

Hive Cover:

It insulates the interior of the hive. It protects the hive against rain and sun.

Frames:

The frames are so constructed that a series of them may be placed in a vertical position in the brood chamber or the super chamber so as to leave space in between them for bees to move. Each frame consists of a top bar, two side bars and a bottom bar nailed together. Both the ends of the top-bar protrude so that the frame can rest on the rabbet.

Brood Frame

Super Frame

Equipment required for beekeeping

Smoker

The smoker is next in importance to the beehive itself. No honeybee will ever allow a beekeeper to harvest its honey without a fight. The tropical honeybee is noted for its aggressiveness, and the beekeeper is warned not to conduct any brood control or harvest without using his smoker.

The smoker has two main parts: the container, which is a metallic can, big enough to carry enough dry material to last at least 40 minutes; and the bellows section, which puffs air into the container to drive the smoke out of the can. The container is loaded with wood shavings, smouldering cow-dung or any dry material which provides white smoke. (No oil or kerosene should ever be used in a smoker.) The smoke renders bees docile, so that the beekeeper can work undisturbed.

Knife

A knife may be required to pry open top-bars or frames which are usually glued to the hive body by the bees. The knife is also useful for cutting a portion of the comb attached to the hive body, separating two combs joined together, and cutting out the honeycomb from the top-bar during the honey harvest. A knife can perform almost all the functions of the hive tool, but the hive tool cannot be used to cut bee combs as neatly as is required.

Brush

Bees must sometimes be brushed gently into a container or a hive. A brush with soft hairs is useful for this, but if the beekeeper can easily obtain a strong, large quill like an ostrich or turkey feather, there is no need to acquire a brush. Indeed, the quill of a big bird is better than any artificial device for this purpose.

Protective dress:

i) Bee veil: It is worn over face for protection against stings. It should be made up of black nylon netting screen (12-mesh). Screen wire (or) fabric are the preferred materials Veils should be made to fit snugly around the hat and to fit tightly to the shoulder leaving enough space between veil and face.

ii) Overalls: White overalls are occasionally worn. Light coloured cotton materials are preferable since they are cooler and create less risk for antagonizing bees.

iii) Gloves: Bee gloves are made of tightly-knit cloth (or) soft leather. They cover the fore arms. The gloves are useful for the beginners to develop confidence in handling bees. But handlings of frames will be cumbersome if gloves are worn.

iv) High boots: A pair of gum boots will protect the ankles and prevent bees from climbing up under trousers.

Artificial feeding(sugar feeding.)

Bees do not visit each and every flower. They visit only flowers having ample pollen and nectar (non-toxic to them) and it should be within their reach. Therefore, the bee flora of a particular region is most important for the bee industry. Whenever there is a dearth of nectar and pollen in nature and the stock of these materials is not in the hive, then artificial feeding becomes imperative.

Feeding sugar solution to honey bees

The dearth periods vary from region to region in this country. If the bees are not fed artificially during dearth period, they start starving and dwindling, develop wander lust and ultimately abscond. White sugar syrup is a cheap substitute of honey but no pollen substitutes have been tried in this country although different pollen substitutes have been found useful elsewhere. Attempts to replace sugar syrup by cheap cane jaggery to the colonies resulted in the absconding of bee colonies because in most of the cases they did not accept it and suffered from starvation; in some cases if they accepted it they suffered from dysentery.

During unfavourable condition and during the construction of brood combs, we should give sugar feeding to the bees in 4-5 days interval. The ratio of concentration of sugar solution should be 1:1. We should not handle the bees after the sugar solution and become ferocious.

Recovering of bee hive:

During our study, we found a difficulty of swarming in one of the bee hives. Swarming is the escape of the bee hives of certain quantity of bees from bee hive. It makes the colony become weak. Due to low population of nurse bees (3 to 4 days old),the queen is not fed with adequate royal jelly. Hence egg laying capacity of queen is reduced.

In order to recover the queen and the colony, we exchange some of brood combs which are full of egg, larva, pupa from the healthy bee hive to weak colony. In this method, very soon the colony will have large number of nurse bees. These bees with secrete royal jelly and feed the queen and the day old larva. Then, the egg laying capacity of queen is increased and the colony is recovered.

Brood frame from strong hive

Transferred brood frame after one week

Mounting of super frames:

Honey bees construct the brood combs one by one. After the completion of final comb(6^{th}), super frames are mounted. Those superframes are mounted by using the last brood comb. The selected comb is trimmed to the size of super frame and tied up with the empty super frame by banana fibre. And the empty brood frame is kept in the center of the brood chamber. By the next week the new comb is constructed by bees and the similiar process is done for mounting of all super frames. This process will continue upto to the mounting of all super frames. The selected brood comb should be free of eggs, larva and pupae or less compared to another brood frames.

6 thbrood frame **Attaching of selected brood comb to super frames**

Harvesting of honey

After mounting of all super frames, the bees will save honey in the super combs. After filling the honey in the each shell, they ceil the shell with wax. After ceiling the entire comb, the honey is ready for harvesting. the honey is extracted from the comb using honey extractor after removing the ceil using knife. The extraction of honey the empty comb is reused as super comb.

Honey extractor

This equipment consists of cylindrical drum containing a rack or box inside to hold the super frames. The box is fixed to a rod at the centre and it can be rotated by a set of two gear wheels. The frames with, honey cells are decapped by a sharp knife after dipping it in hot water and fixed to the slots provided in the box which is rotated by the handle. The rotation should be very gentle and slow at first and the speed of revolution increased gradually. With some experience the correct speed can be learnt. The honey in the cells is forced out in droplets by the action of the centrifugal force and can be collected in vessels through an exit in the drum. As cells are constructed on both sides of the comb, by changing the sides of the frames and again rotating, the honey contained in the cells on the other side can also be drained off. Particular care should be taken while handling heavy combs or those which are flimsily attached to the frames.

The extraction of honey should be done a distance away front the hive. Otherwise the workers get attracted by the odour of the honey and comb and may annoy the operator.

Honey extractor

Role of honey bees in cross pollination

Bee visits plants for its food, nectar and pollen. This floral fidelity of bees is due to their preference for nectars having sugar contents and pollens with higher nutritive values. Besides getting food for the bees as a result of their visit pollinate a number of crops.

Qualities of honeybees which make them good pollinators

- Body covered with hairs and has structural adaptation for carrying nectar and pollen.
- Bees do not injure the plants
- Adult and larva feed on nectar and pollen which is available in plenty
- Considered as superior pollinators, since store pollen and nectar for future use
- No diapauses is observed and needs pollen throughout the year
- Body size and proboscis length is very much suitable for many crops
- Pollinate wide variety of crops
- Forage in extreme weather conditions also

Effect of bee pollination on crop

- It increases yield in terms of seed yield and fruit yield in many crops
- It improves quality of fruits and seeds
- Bee pollination increases oil content of seeds in sunflower
- Bee pollination is a must in some self incompatible crops for seed set

Crops benefited by bee pollination

Fruits and nuts: Almond, apple, apricot, peach, strawberry, citrus and litchi

Vegetable and Vegetable seed crops: Cabbage, cauliflower, carrot, coriander, cucumber, melon, onion, pumpkin, radish and turnip.

Oil seed crops: Sunflower, niger, rape seed, mustard, safflower, gingelly.

Forage seed crops: Lucerne, clover.

Management of bees for pollination

- Place hives very near the field source to save bee's energy
- Migrate colonies near field at 10 per cent flowering
- Place colonies at 3/ha for Italian bee and 5/ha for Indian honey bee
- The colonies should have 5 to 6 frame strength of bees, with sealed brood and young mated queen
- Allow sufficient space for pollen and honey storage

BEE PRODUCTS

Honey

Flowers nectar is a solution of sugars and other minor constituents that bees collect and concentrate into honey. It is a sweet, viscous fluid, produced by honeybees. It is collected as nectar from nectarines at base of flowers. Also collected from nectar secreted by plant parts other than flowers known as extra floral nectaries. It is collected also from fruit juice, cane juice etc.

Honey containing super frame

Composition

Pigments: Carotene, chlorophyll and xanthophyll are the important pigments present in honey.

Minerals: Potassium, Calcium, Phosphorus, Sodium, Magnesium, Manganese, Copper, Sulphur, Silica and Iron are the minerals present in honey.

Vitamins: Vitamin B1 (Thiamine), B2 (Riboflavin), Nicotinic acid, Vitamin K, Folic acid, Ascorbic acid and Pantothenic acid are the vitamins present in honey.

Physical properties of honey

- Honey is hygroscopic. If exposed to air it absorbs moisture
- Honey is a viscous fluid.
- Heating of honey reduces viscosity
- Specific gravity of pure honey is 1.35 to 1.44 gms/cc
- Refractive index of honey, helps to find moisture content measured using refractometer

Uses of honey

Honey has value as a food and as a medicine

As a food: Honey is valued everywhere as a sweet and tasty food. At times of food shortage it is a useful carbohydrate source that contains trace elements and adds nutritional diversity to poor diets. Honey often has an important place in traditional food preparation.

As a medicine or tonic: In many parts of the world, honey is used as a medicine or tonic and as a special treat for children. Modern medicine is increasingly using honey for a variety of treatments.

Beeswax

Beeswax is the material that bees use to build their nests. It is produced by young honeybees that secrete it as a liquid from special wax glands. Worker bees secrete wax when they are 14 to 18 days old. On contact with air, the wax hardens and forms scales, which appear as small flakes of wax on the underside of the bee. About one million wax scales make 1 kg of wax. Bees use the wax to build the well-known hexagonal cells that make up their comb, a very strong and efficient structure. Bees use

the comb cells to store honey and pollen; the queen lays her eggs in them, and young bees develop in them.

Composition and property

Alcohol's and fatty acids 70 to 74 per cent; free acids 13 to 15 per cent; saturated hydrocarbons 12 to 15 per cent; vitamin A 40961U; specific gravity 0.95; melting point 65°C.

Processing

Beewax is obtained from the cappings collected during honey extraction. Wax is obtained from old combs that are unfit for use and from combs damaged during honey extraction. Best grade wax is obtained from cappings where the recovery per cent is higher.

Uses

- Mainly used by candle industry
- Used for preparing comb foundation sheets
- Used in cosmetics like cold creams, lipsticks and rouges
- Used in pharmaceutical and perfume industry (ointments, capsules, pill coating and deodorants)
- Used for preparing shoe polish, furniture etc. for water proofing
- Used in adhesives, chewing gums and inks etc.

Bee Pollen

Bee pollen is not the same as allergy-causing pollenthat is carried by the wind. It rarely causes allergy symptoms. It is actually the male seed of a flower blossom which are collected by the honey bees and mixed with the bees' digestive enzymes. Bee pollen is low in calories but rich in proteins, amino acids, vitamins, minerals, enzymes, beneficial fatty acids, carbohydrates, and bioflavonoids which are anti-viral, antibacterial and helpful in lowering cholesterol, stabilising and strengthening capillaries. Its ability to rejuvenate the body, stimulates organs, enhances vitality and accelerate rate of recovery makes it a popular tonic among athletes andsportsmen.

Pollen In Brood Frames

Royal jelly

Royal jelly is the queen bee's extraordinary source of food. It is a blend of secretions from the salivary glands of the worker bee and contains a high concentration of vitamins B5, B6, and amino acids and is believed to be a potent antioxidant a special rejuvenating substance that promotes tissue growth, muscle and cell regeneration.

Propolis

Honey bees collect sticky resins that ooze from the buds of some trees and conifers. After chewing them and mixing them with their saliva and other substances, Propolis or sometimes called "sticky glue" is formed. Propolis is of vital importance for the survival of the honey bees in the beehive. Not only does it protect them against diseases, it also helps fight against climatic changes, such as wind and cold. Because of its antibacterial, antifungal, antiviral, anti-inflammatory and antioxidant effects, Propolis has been shown to have outstanding value for a wide variety of illnesses. It is also used as ointments for healing cuts and wounds.

Bee bread

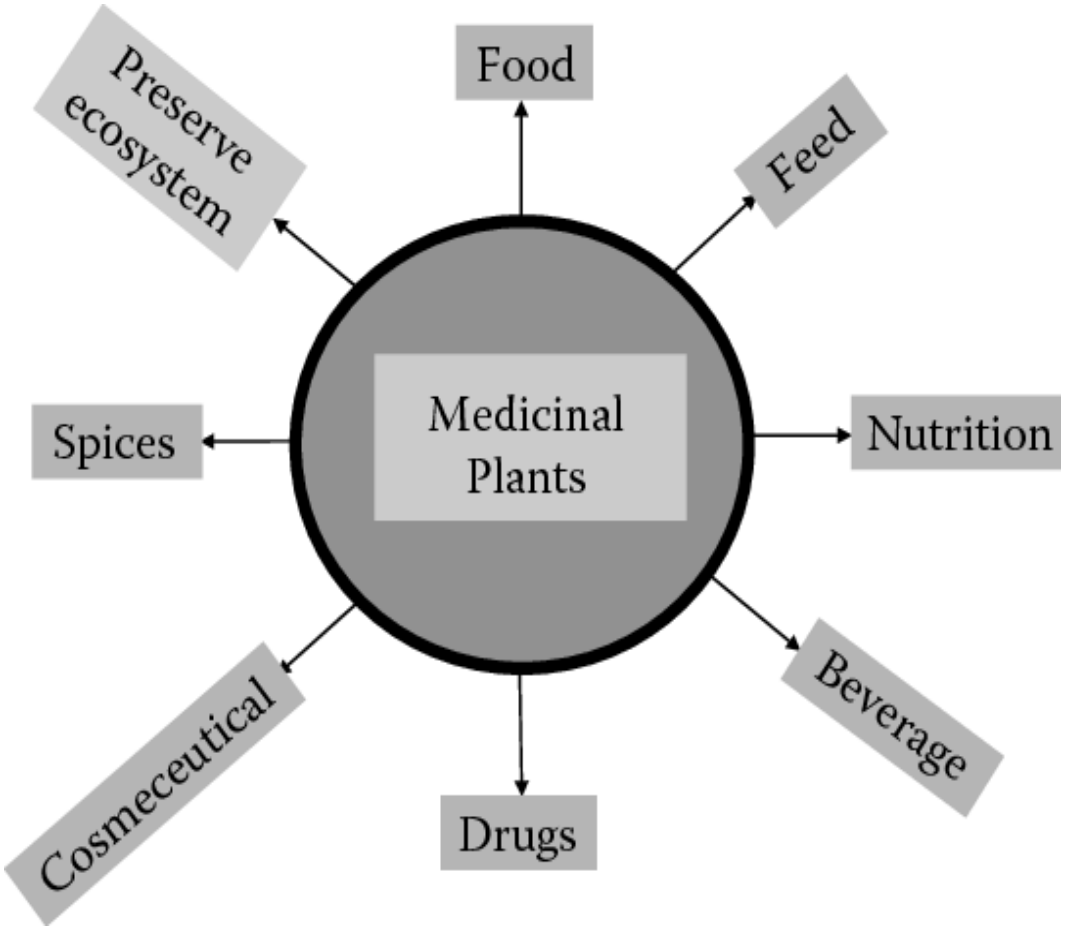
What an interesting name, right? Bee bread is actually the main source of food for most larvae and bees. It is fed to all larvae except those that are selected to become queens; the queen larvae are fed royal jelly instead. Comprised of all essential amino acids, high contents of vitamins especially vitamin K, enzymes, and flavanoids, bee bread is made of pollen mixed with bits of honey, bee wax, and bees' digestive enzymes and is known to be useful in treating anemia, hepatitis, insomnia, stress, failing memory, cholesterol and disgestive tract disorder. Nowadays, it is rare to find bee bread. Occasionally, you may find a honey specialty shop carrying bee bread specially made for promoting kids' physical and mental growth, improving memory, and weight gain. You will have a higher chance of getting it direct from the bee farms and beekeepers.

CHAPTER 9
MEDICINAL GARDENING

Introduction

Our India's traditional systems of medicine known as Ayurveda are purely based on medicinal plants. The term "**medicinal plant**" alternatively 'herb' includes various types of plants or plant parts used as medicine. A garden is exclusively for medicinal plants in known as medicinal garden.

Benefits of nutritional garden



Plant parts used as medicine

- Leafs - Tulsi
- Flowers - Hybiscus
- Bark - Cinnamon
- Bulb - Onion
- Fruits - Bael
- Root - vettiver
- Seed – Fenugreek

Medicinal leaves

- Aloe vera
  Antimicrobial, woundhealing, dental plaque, canker sores,
- Tulsi
  Indigestion, Heart Diseases, Respiratory Diseases

Medicinal flowers

- Marigold
  Headaches, swelling, toothache, wounds and many skin problems.
- Hibiscus
  Loss of appetite, colds, heart and nerve diseases

Medicinal barks

- Cinnamon
  Gastrointestinal (GI) upset, diarrhea, and gas
- Babool
  Oral problems, Diarrhea and Lose motion, Cough and Cold

Medicinal bulbs

- Garlic
  Lower Blood Pressure, Lower Cholesterol, Support Immunity
- Onion
  Lower blood sugar, oral health, hair growth

Medicinal fruits

- Amla
  Support Immunity, hair care, eye care, blood purifier
- Pepper
  Stuffy nose, sinus infection, dizziness, discolored skin

Medicinal roots

- Turmeric
  Rheumatoid arthritis, skin cancer, small pox, chicken pox, wound healing, urinary tract infections, and liver ailments
- Ginger
  Stomach upset, diarrhea, nausea, common cold, flu, headaches and congestion

Medicinal seeds

- Fenugreek
  Diabetes, reducing inflammation, cholesterol control
- Cumin
  Diabetes, good digestion, cholesterol control, weight loss

Chapter 10

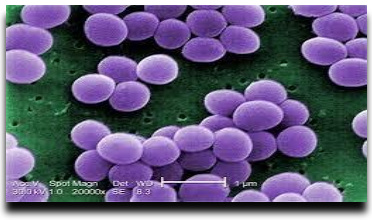
BIOFERTILIZER PRODUCTION

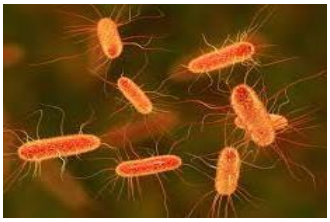
Microorganism/ microbes

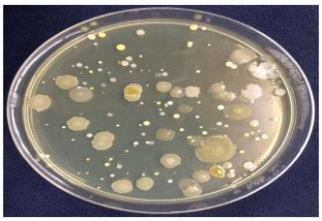
- Microorganisms (microbes) are tiny living things and cannot be seen with naked eyes.
- Microbes can be observed using the equipment called microscope.
- Kinds of microorganisms are bacteria, algae, fungi, and protozoa.
- Microorganisms are present everywhere in soil, water and air.

Microscopic observation

Bacteria

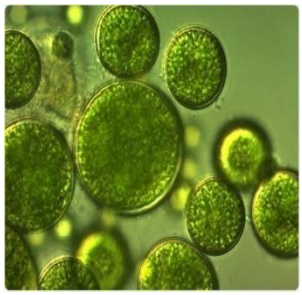






Fungi

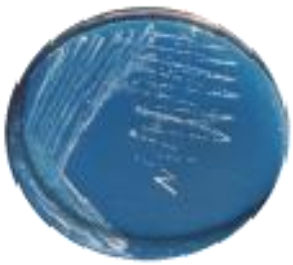
Algae



Biofertilizers: An introduction

- Biofertilizers are beneficial microorganisms which are applied to seeds or soil, and promotes plant growth by increasing the supply or availability of primary nutrients to the host plant.
- Biofertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances.

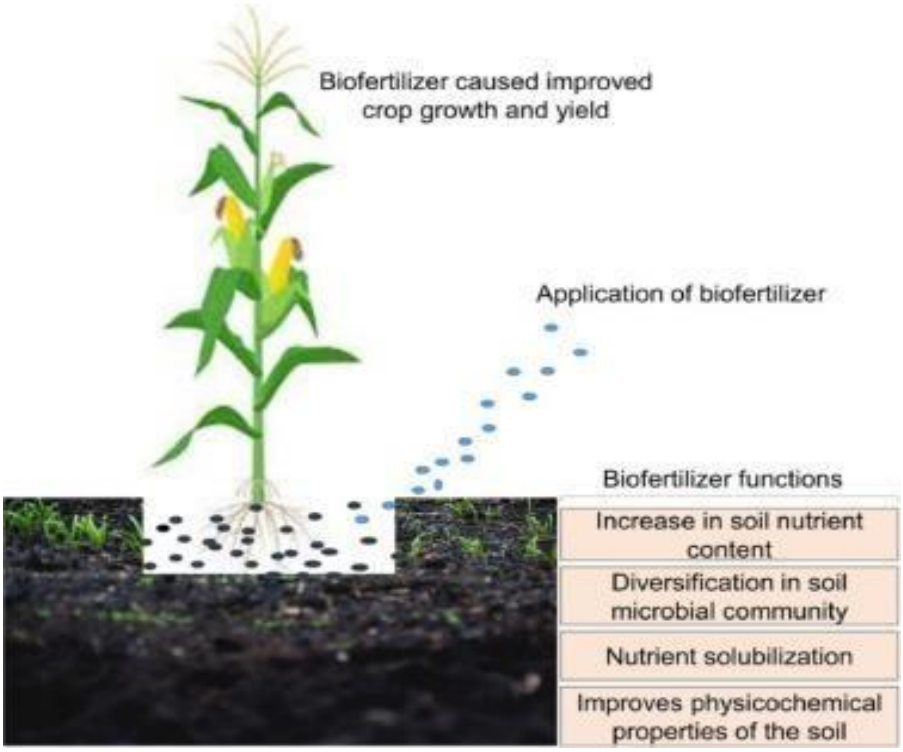




Biofertilizers – importance

- Increases the availability of nutrients to crop plants through nutrient cycling (Nitrogen cycle, Phosphorus cycle, etc.)
- Helps in uptake of nutrients by the plants
- Cost effective, environment friendly and renewable source – supplement chemical fertilizers for sustainable agriculture.
- Liberate growth promoting substances – maintain soil fertility

- Suppress the incidence of pathogens & control diseases
- Increase crop yield – 10-50% and provide sustainability to farming system.



Kinds of Biofertilizers

I. Nitrogen fixers (N)

Rhizobium – in pulses

Azospirillum – in cereals like rice, maize

Azotobacter – in all crops

Gulconacetobacter – in sugarcane

II. Phosphorous solubilizer

Phosphobacterium (*Bacillus megaterium var phosphaticum*)

III. Phosphorous mobilizer

Mycorrhiza (VAM)

IV. Potash releasing bacteria

Frateuria

V. Other kinds of biofertilizers

PPFM (Pink pigmented Facultative Methylotrophs) – for drought mitigation in all crops

PGPR (Plant Growth Promoting Rhizobacteria) – for growth promotion in all crops

Azolla and blue green algae – Nitrogen nutrition in rice crops

Zinc solubilizing bacteria – Zinc nutrition in all crops

Sulphur oxidizing bacteria – Sulphur nutrition in all crops

Formulations of biofertilizer

- ❖ Powder formulation
- ❖ Liquid formulation

Methods of application of Biofertilizers

- ❖ Seed treatment
- ❖ Seedling root dip
- ❖ Soil application

Seed treatment:

- Mix the recommended biofertilizers (1 kg each) in 750 ml rice gruel and make a paste.
- To the paste mix the seeds required for an hectare till the biofertilizer cover the seeds fully.
- Shade dry the biofertilizer treated seeds for about 30 minutes and sow the seeds.


Seedling dipping:

- Mix 1 kg of biofertilizers in 10 lit of water and make a slurry
- Dip the seedling for 20-30 minutes then transplant the seedling.


Soil application: (Broadcasting)

- Mix 2 kg of the biofertilizers with 25 kgs of fully decomposed Farm Yard Manure or sand and broadcast before sowing or transplanting.

Soil application: (Spot application)

- For grown up trees, 20-50 g of each biofertilizer along with fully decomposed FYM should be applied near to the root zone and cover it with soil.

Biofertilizer application for horticulture and tree crops

Nursery application: (100g/sqm)

- Mix the biofertilizer (VAM) along with the soil at the time of nursery bed preparation

Seedling application for polybags: (10g/bag)

- Mix 10 kgs of biofertilizer (VAM) with 1000kg of potting mixture before sowing.

Seedling application for pit: (20g/seedling)

- Apply the biofertilizer at the time of planting in the pit and cover it with soil.

Spot application for existing trees: (200g/tree).

- Spot application around the root zone and cover it with soil and moisture it properly.

Precautions during use of Biofertilizers

- Biofertilizers should not be mixed with chemical fertilizers during storage and application
- Store the biofertilizer under room temperature
- Avoid exposure of biofertilizers to direct sunlight
- Biofertilizers should be used before expiry date
- Specific biofertilizer is used for specific crop

Mass production of Bacterial bioinoculants

Media Preparation

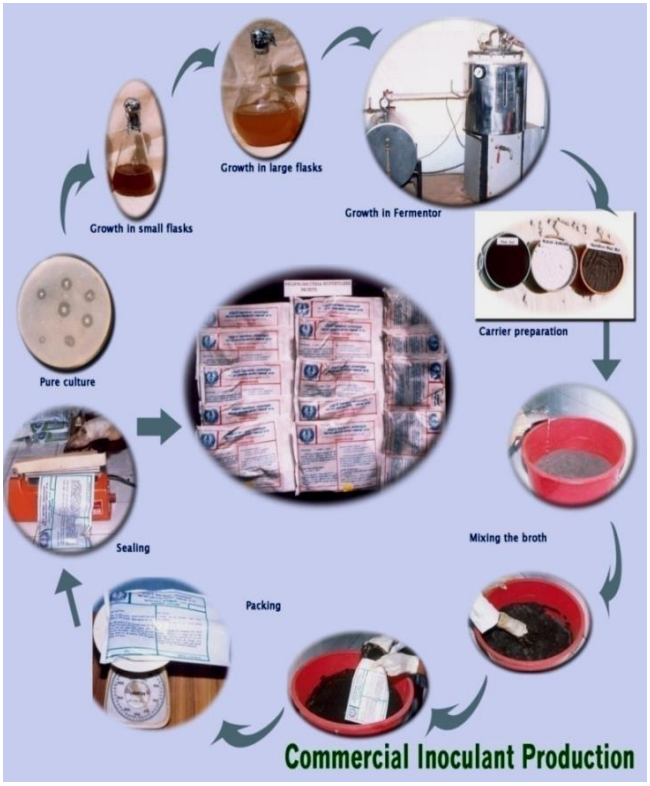
First weigh the chemicals of the medium required for the mass production of biofertilizers. In case of *Rhizobium*, yeast extract mannitol broth is used. Weigh the chemicals of yeast extract mannitol medium without agar, dissolve in water and adjust the pH to neutral with acid or alkali. Then transfer the contents to the fermentors and sterilize by using heat (151bs pressure for 1-2 hrs).

Preparation of Broth

Selected strain of *Rhizobium* is grown in YEM broth for 3 to 9 days depending on the type of growth and check the purity of culture. After checking the purity of the culture, it is transferred to large flask containing sterile liquid medium and incubated for 3 to 9 days. This is known as starter culture. Later the starter culture is transferred to seed tank fermentor containing sterilized medium and incubated for 4-9 days. Large quantity of liquid medium is prepared in large fermentor and sterilized. After adjusting the pH to 6.5 with KOH or H_2SO_4, inoculate main tank fermentor with starter culture under aseptic conditions (1% volume of main tank fermentor).

For other Bacterial biofertilizers, same procedure is followed but only the inoculation period and the medium varies.

Azotobacter : Waksman No. 77 or Ashby's manitol medium
Azospirillum : N free Bromothymol blue medium
Phosphobacteria: Nutrient glucose medium



Checking the Broth

Maintain the broth in a fermentor for 4-9 days. After multiplication is over, broth has to be tested for the following

1. pH test
   The pH must be around 6-8. If it is more than 8 or less than 6, it should be discarded.
2. Growth on Peptone Agar
3. Growth on Yeast Extract Agar medium
   Inoculate the broth on peptone agar and streak the broth on YEMA medium. Observe the plates for characteristic *Rhizobium* colonies. *C*ount the total number of colonies and estimate the population by plating method.
4. Gram's staining

Storage of Broth

It is not desirable to store the broth for not more than 24 hrs even at 4˚C. After fermentation is over it should be mixed with carrier. Normally various types of carriers

are used such as peat, peat soil, lignite, farmyard manure, charcoal, black ash etc. They should provide nutrients for the growth of biofertilizers.

Preparation of carrier materials

Several indigenously available carriers have the ability to support the growth of biofertilizers. The materials used as carrier include peat soil, farmyard manure, compost and press mud with charcoal.

Peat or peat soil is ground to fine powder capable of passing through 100 mm mesh sieve and neutralized with 2% $CaCO_3$ to raise the pH of peat soil to 6.8 to 7 and sterilized in an autoclave at 15 1bs for four hrs.

The physical properties of the carrier are improved by the addition of charcoal which indirectly helps in the better survival of the cells in the inoculants.

Mixing, Curing and Storage of Bacterial Biofertilizers

Mixing

Fermented high count broth of biofertilizers is mixed with carrier material such as peat or peat soil. High count of bacterial biofertilizer broth is mixed with the carrier to attain a moisture content of 40%. The carrier and the broth are mixed either manually or by means of mechanical mixer.

Curing

During the process of mixing, the broth is sprayed to powered peat and left in tubs, in trays or on a floor covered with polythene sheets for 2-10 days at 22-24˚C for curing. Due to curing the heat generated is driven off. The product is again milled and packed in polyethylene bags printed with following instructions.

1. The inoculum shall be packed in a 50-75 µm low density polythene cover
2. Each pack shall contain following information
    a) Name of the product
    a) Leguminous crop for which intended
    b) Name and address of manufacturer
    c) Type of carrier material
    d) Code number
    e) Date of manufacture
    f) Date of expiry
    g) Net quantity needed for 1 acre
    h) Storage instructions “Store in cool place away from direct sunlight”

Storage

The biofertilizer packets are stored at 4^0C to increase shelf life of culture upto 12 months. Store in cool place away from direct sun light.

CHAPTER 11

MYCORRHIZA (VAM) PRODUCTION

INTRODUCTION:

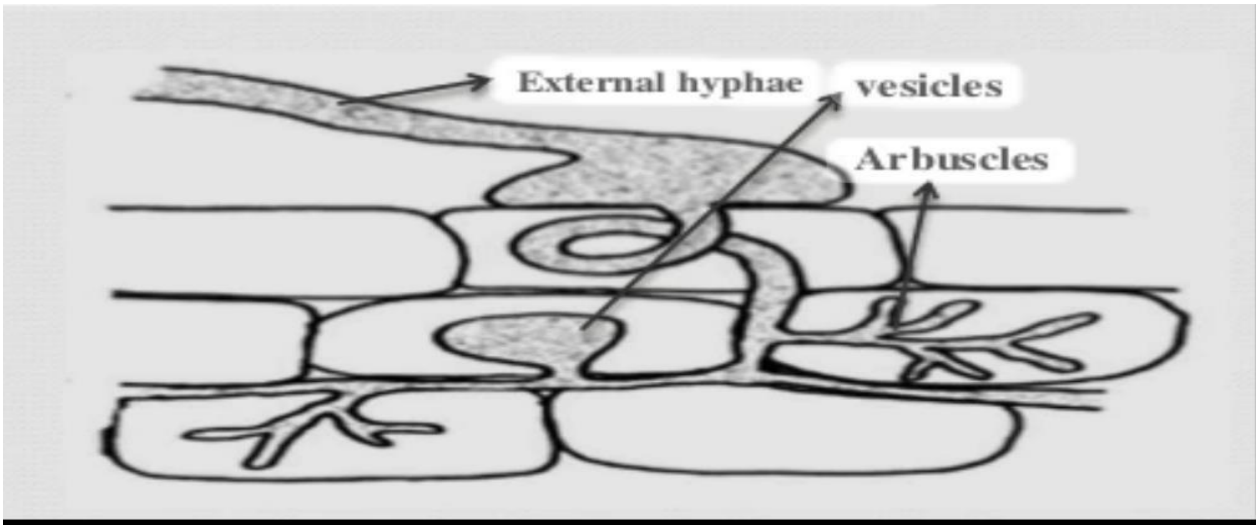
- The term mycorrhiza was taken from Greek language meaning 'fungus root'. term was coined by Frank in 1885
- The mycorrhiza is a mutualistic association between fungal mycelia and plant roots. VAM is an endotrophic (live inside) mycorrhiza formed by aseptated phycomycetous fungi.
- VAM help in nutrient transfer mainly of phosphorus, zinc and sulfur.
- Mycorrhizae is the symbiotic association between plant roots and soil fungus of the 7 types of mycorrhizae,
- VAM plays a great role in inducing plant growth.
- VAM are symbiotic entophytic soil fungi, which colonize the roots of approximately 80% plants.
- The VAM hyphae also help is retaining moisture around the root zone of plants It increases the *resistance* to root borne or soil borne pathogens and Nematodes.
- They also mobilize different nutrients like Cu(copper), K(potassium), Al(aluminum), Mn(manganese), Fe (iron)and Mg (magnesium) from the soil to the plant roots.
- They posses vesicles (sac like structure) for storage of nutrients and arbuscular for funneling them into root system.

MORPHOLOGY

External hyphae

Arbuscles

Vesicles



Mother Culture

Mother culture can be produced from efficient spores using funnel techniques as well as multiplication in small sized pots. 3-4 cycles will be made for developing the mother culture. Mother culture should have 100 % root colonization and the minimum of 8-10 spores per gram of the inoculum. Mother culture can also be maintained in maize roots continuously.

MATERIALS REQUIRED

Vermiculite

Perlite

Soil & Sand

Cow dung powder

Polythene cover

Polythene bags/earthern pots

Mother culture

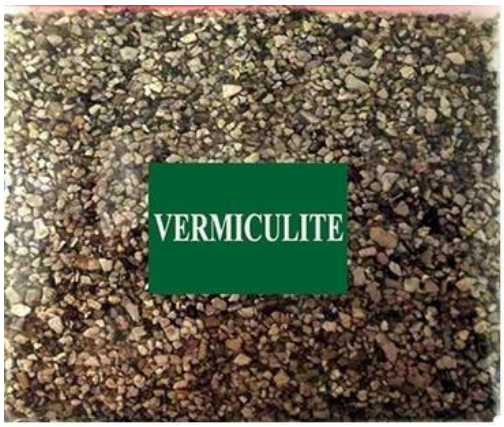
Formaldehyde

Plastic basins

Planting materials

FOR THE PRODUCTION OF 100KG VAM

VERMICULITE - 65 KG



PERLITE - 15KG

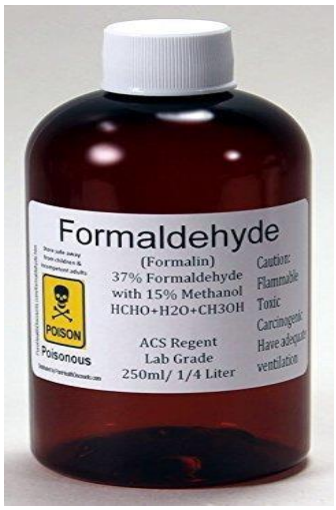
POTTING MIXTURE - 20KG

SOIL- 10 KG

SAND – 6 KG

COW DUNG POWDER – 4KG

FORMALDEHYDE - 250ML



INOCULATED MOTHER CULTURE

PLANTING MATERIALS

MAIZE

SORGHUM

Mass production

- Form a trench (1m x 1m x 0.3m) is and line with black polythene sheet to use this as a plant growth tub.
- Mix 50 kg of vermiculite and 5 kg of sterilized soil and pack in the trench up to a height of 20 cm
- Spread 1 kg of AM inoculum (mother culture) 2-5 cm below the surface of vermiculite
- Sow with surface sterilized Maize seeds (5% sodium hypochlorite for 2 minutes)
- Apply 2 g urea, 2 g super phosphate and 1 g muriate of potash for each trench at the timeof sowing seeds. Further apply 10 g of urea twice on 30 and 45 days after sowing for each trench
- Apply 1 g of micronutrient mixture when there will be a symptom for deficiency
- Test the quality of the inoculum by estimating the AM colonization in root samples on 30th and 45th day
- Grow the stock plants for 60 days (8 weeks).
- Pull out the plants and cut the roots into small pieces Mix the roots thoroughly with vermiculite in the trench
- The inoculum produced consists of a mixture of vermiculite, spores, pieces of hyphae andinfected root pieces.
- Thus within 60 days 55 kg of AM inoculum could be produced from 1 sq m area.
- This inoculum will be sufficient to treat 550 m2 nursery area having 11,000 seedlings

MASS CULTIVATION

Tank for mass cultivation

Sprinkling soil with VAM & Making of furrows

Sowing the seeds

Maize sown VAM pit

AM infected maize plants

Mechanism of Action

- The VAM forms an association with plant roots.
- It penetrates in the root cortex and spreads around the roots of the plant.
- As the name indicates, they posses sac like structure called vesicules which stores phosphorus as phospholipids.
- The other structure called arbuscule helps bringing the distant nutrients to the vesicules and root.

Uses of VAM

- Enhances the feeding areas of the plant root is as the hyphae spreads around the roots.
- Mobilizes the nutrients from distantance to root.
- Stores the nutrients (sp. phosphorus).
- Removes the toxic chemicals (example: phenolics) which otherwise hinder nutrient availability.
- Provide protection against other fungi and nematodes
- It increase growth rate in plants (citrus, maize, wheat, etc.)
- It reduces sensitivity of crop towards high level of salts and heavy metals

CHAPTER 12

BIOPESTICIDES PRODUCTION

The use of microorganisms as bio-control agents is gaining importance in recent years. Bio-pesticides are the living organisms or their derived parts which are used as bio control agents to protect the crops against the insect pests.

Biopesticides

Biological materials and organisms formulated and/or used as pesticide to control abnoxious pests. Include

Macroscopic organisms

Predaceous invertebrates

Parasitic invertebrates

Microscopic organisms

Bacteria, Fungi, Virus, Nematodes

Phytochemical and biochemicals

Insecticidal and behavious modifying

Types of Microbial Bio-pesticides

i) Bacterial Bio-pesticides ii) Fungal Bio-pesticides iii) Viral Bio-pesticides

S.No.	Category	Products	Target pest	Major crops
1.	Bacteria	*Bacillus thuringiensis* *Bacillus sphaericus* *Bacillus subtilis* *Pseudomonas fluorescens*	Lepidoptera Mosquitoes, Flies Fungal pathogens Fungal pathogens	Maize, vegetables, soybean, groundnut, wheat, peas, oilseeds, Rice
2.	Fungi	*Trichoderma viride* *Trichoderma harsianum* *Tnchoderma hamatum*	Fungal pathogens	Wheat, rice, pulses, vegetables, and spices
		Beauveria bassiana *Verticillium lecanii* *Metarhizium anisopliae*	Insect pests such as boll worms, white flies, root grubs, tea	Pulsess, oilseeds, spice, and vegetables

		Paecilomyces lilacinuss *Nomuraea rileyi*	mosquito bugs.	
3.	Viruses	Nuclear polyhedrosis Virus (NPV) Cytoplasmic polyhedrosis virus (CPV) Granulosis virus (GV)	American bollworm, tobacco caterpillar and shoot borer	Sunflower, Vegetables

Methods of application of bio-pesticides

a. Seed Treatment

Prepare 5% jaggery solution by boiling 500 gm of jaggery in 10 litres of water for 15 20 minutes. Depending on the quantity of seeds to be treated sufficient solution has to be prepared.

The solution has to be cooled. Open the pack of bio-pesticide and mix the contents in the above solution. The general recommendation is 10 gm of bio-pesticide/kg of seed. Heap the seeds to be treated on a polythene sheet and the bio-pesticide solution is poured over the seeds and mixed thoroughly. Dry the seeds in shade and sown immediately.

b. Nursery bed

One kilogram of bio-pesticide is mixed with 100 kilograms of good quality soil. Forest soil can also be used. In areas where forest soil is not available, 30 kg of well rotten dung can be mixed with 70 kg of soil to prepare a good soil mixture.

The soil mixture can be used as a nursery soil or it can be mixed with the nursery bed of size 10 square meters.

c. Soil drenching

Prepare a solution by adding 10 gram of bio-pesticide in a litre of water and stir the solution well. Using a rose can to drench the soil with the solution.

d. Seedling dip

Prepare a solution by adding 10 grams of bio-pesticide in a litre of water.

Dip the seedlings in this solution for 30 minutes.

e. Soil application

A mixture is prepared by adding 5 kilograms of bio-pesticide and 100 kilograms of well rotten cattle dung or farm yard manure (FYM).

Broadcast this mixture on soil immediately before ploughing. On a standing crop, after the application of this mixture, light irrigation has to be given.

f. Foliar spray

One kilogram of bio-pesticide is mixed in 150 litres of water and sprayed on the crop.

Biocontrol agents and its production process

Biological control is defined as the reduction of inoculum density or disease producing activities of a pathogen or parasite in its active or dormant stage by one or more organisms accomplished naturally or through manipulation of the environment, host or by introduction of one or more antagonists. Biological control means control of plant diseases using living microorganisms.

The four main mechanisms involved in the biocontrol are,

- Antagonist may parasite the other organism (Parasitism)
- Antagonist may secrete metabolites (antibiotics) harmful to the pathogens (Antibiosis).
- Antagonist may compete with the pathogens for nutrients or space (Competition).
- Antagonist may cause death of the parasite by producing enzymes (Lysis).

A. Trichoderma viride

The fungus, Trichoderma viride is a biocontrol agent, mainly used for the control of root rot diseases of pulses and oil seeds. Molasses yeast medium (Molasses 30ml + Yeast 5g + water 1000ml) is prepared in mass production conical flasks and sterilized at 15lbs pressure for 20 minutes.

T. viride culture is inoculated by taking a fungal disc from 10 day old culture and incubated for 10 days. This serves as mother culture. Molasses yeast medium is prepared in a fermenter and sterilized. Then, the mother culture is added to the fermenter @ 1.5 litre/50 litres of medium and incubated at room temperature for 10 days.The fungal biomass and broth are mixed with talc powder at 1:2 ratio. The mixture is air dried and mixed with carboxy methyl cellulose (CMC) @ 5g/kg of the product. It is packed in Polythene covers and used within 4months.

B. Pseudomonas fluorescens.

It is a bacterial antagonists used for the management of crop diseases. Mass production P. fluorescens is multiplied in sterilized Kings 'B' broth for 48 hours. The pH of the substrate (Peat soil or talc powder) is adjusted to 7 by adding calcium carbonate @150 g/kg.The substrate is then sterilized at 1.1 kg/cm2 pressure for 30 minutes for two successive days. Four hundred ml of P. fluorescens suspension is added to 1 kg of substrate containing 5 g of carboxy methyl cellulose and mixed well. The formulation is packed in Polythene covers and can be stored for six months.

Flow chart for the liquid biofertilizer production

Mother culture

↓

Starter culture

↓

Multiplication in 5lit/10lit /small fermentors

↓

Inoculate 10 % logarithmic phase inoculum in the main fermentor

↓

Allow to multiply till stationary phase of the culture

↓

Fill the broth in the plastic containers using automatic liquid filling unit under aseptic condition

↓

Check the population in the broth of the sealed containers during storage (should be > 10^8 cells /ml)

CHAPTER 13

BIOPESTIDICDES – 3G KARAISAL AND NEEMASTRA

A. 3G karaisal

3G karaisal, an organic product has the potential in insect repellent activity in the field. 3G karaisal consists of four product viz. cow urine, green chilli, ginger and garlic. It is also called as "Agni Asthiram". Agni means fire, Asthiram means Arrow (Bow and Arrow). All the bad insects will run away and will not harm good insects.

Ingredients

- Cow urine - 2 litres
- Green chilli - 1000 gram
- Ginger - 500 gram
- Garlic - 500 gram

Procedure

- Take 500 gram Garlic and Grind it well
- Take 500 gram of Ginger and grind it well
- Take 1000 gram of Green chilli and grind it well
- And Mix all the three solutions well and add 6 Litters of water and 2 litres of cowurine into that and stir the solution.
- Filter them using a clean muslin cloth to collect the particles of ginger, garlic andgreen chilli and squeeze them with hands for proper filtering the paste.
- And keep it in dark place for 48 hours and after that it can be used in filed.

Garlic

Grinding of garlic

Ginger

Grinding of ginger

Chillies

Grinding of chillies

Mixing of all the ingredients

After mixing of all the ingredients

After 48 hrs of incubation

Filtering of the contents

3G Karaisal ready for field application

Cost of production for 3G karaisal

Raw materials and cost per unit	**Quantity required**	**Total cost**
Green chilli (Rs.25/kg)	1 kg	Rs.25
Ginger (Rs.40/kg)	500 g	Rs.20
Garlic (Rs.160/kg)	500 g	Rs.80
Cow urine (Rs.60/litre)	2 litres	Rs.120
	Total	Rs.245

B. Neemastra

Neemastra is a Natural Insecticide / Pesticide mixture to control the dangers of nymph-sucking insects and mealybugs. Neemastra consists of three products viz. cow dung, cow urine, and neem leaves. It controls all leaf-sucking insects, such as leafhopper, mealy bug, whitefly, etc.

Ingredients

- Water – 20 lit
- Cow dung – 1 kg
- Cow urine – 3 lit
- Neem leaf (chopped) – 4 kg

Preparation Method

- Chop the 4 kg neem leaves into small pieces, add 3 lit cow urine and 1 kg cow dung,ferment for 48 hours with intermittent stirring.
- Avoid exposure to sunlight and rain water.
- Mix for one minute every morning and evening.

- Filter squeeze the extract and dilute to 100 lit, use as foliar spray over one acre.
- Useful against sucking pests and mealy bugs.
- It can be used for up to 6 months.

Cow dung and cow urine

Collection of neem leaves

Mixing of all the ingredients

Incubation under shade for 48 hrs

Cost of production for Neemastra

Raw materials and cost per unit	**Quantity required**	**Total cost**
Cow urine (Rs.60/litre)	3 litres	Rs.180
Cow dung (Rs.12/kg)	1 kg	Rs.12
Neem leaves (Rs. 20/kg)	4 kg	Rs.80
	Total	Rs.272

CHAPTER 14

MUSHROOM CULTIVATION

A mushroom or toadstool is the fleshy, fruiting body of a fungus, typically produced above ground, on soil, or on its food source.

Types of mushroom

I. **Edible mushroom**
II. **Poisonous mushroom**

Types of edible mushrooms

1. Button mushroom
2. Oyster mushroom
3. Milky mushroom
4. Paddy straw mushroom
5. Shiitake mushroom

Button Mushroom


Oyster Mushroom


Milky Mushroom


Shiitake mushroom	Paddy straw mushroom
	
Poisonous Mushrooms	
	
Death cap	**Web cap**

Difference between edible and poisonous mushroom		
Characters	Edible mushroom	Poisonous mushroom
COLOUR	White or Grey	Ornamental
SCALES	Absent	Present
SMELL	Pleasant smell	Unpleasant smell
When Cooking		
Using silver spoon	No change in the color of spoon	Color of spoon changes to black
Cooking with onion	No color change in onion	Color of onion changes to black
Presence of Latex	Absent	Present

PREPARATION OF MOTHER SPAWN

Mother spawn:

Mother spawn is nothing but the mushroom fungus grown on a grain based medium. Among the several substrate materials tested by TNAU, Coimbatore, sorghum grains are the best substrate for excellent growth of the fungus. Well-filled, disease- free sorghum grains are used as substrate for growing the spawn materials. The various steps involving in preparation of mother spawn are listed below here under.

i) Wash the sorghum grains in water thoroughly to remove chaffy and damaged grains.

ii) Cook the grains in an autoclave / vessel for 30 minutes just to soften them.

iii) Take out the cooked grains and spread evenly over a Hessian cloth on a platform to remove the excess water.

iv) Mix Calcium carbonate ($CaCO_3$)thoroughly with the cooked, dried grains @ 20 g / Kg .

v) Fill the grains in polypropylene bags up to 3/4th height (approximately 300-330 g / bag), insert a PVC ring , bold the edges of the bag down and plug the mouth tightly with non-absorbent cotton wool.

vi) Cover the cotton plug with a piece of waste paper and tie tightly around the neck with a jute thread.

vii) Arrange the bags inside an autoclave and sterilize under 20-lbs. pressure for 2 hours.

viii) Take out the bags after cooling and keep them inside the culture room and put on the UV light.

ix) After 20 minutes put off the UV light and start working in the culture room. Cut the fungal culture into two equal halves using a inoculation needle and transfer one half portion to a bag. Similarly, transfer another half portion of the culture to an another bag.

x) Incubate the inoculated bags in a clean room under room temperature for 10 days for further use to prepare bed spawn.

Note: The purpose of mixing Calcium carbonate is i) to remove the excess moisture present in the cooked grains, ii) to neutralize the pH of the grains and iii) to avoid caking of grains after sterilization.

Precaution to be observed:

Avoid over cooking of sorghum grains, as over cooking lead to splitting of grains.

Don't dry the cooked grains on the floor. Always dry over hessian cloth spread on a raised platform

Use only recommended dose of CaCo3 for mixing with the cooked grains. Mixing over dose reduces the fungal growth in the inoculated bags.

PREPARATION OF BED SPAWN

Bed spawn:

The method of preparation of bed spawn was same as that of mother spawn. The cooking, filling and sterilization were similar to that of mother spawn. After sterilization, the bags are taken for inoculation.

Procedure:

i) The sterilized bags are placed inside the culture room and put on the UV light.

ii) After 20 minute put off the UV light and take in the well-grown mother spawn.

iii) Transfer spawn from the mother spawn to sterilized bags @ 10 g per bag.

iv) After inoculation the spawn bags are kept in a clean room for fungal growth. (This is first generation of bed spawn)

v) Use the bed spawn after 10 days of inoculation for bed preparation.

vi) Sub culture the first generation bed spawn as mother spawn to produce one more generation, which is second generation bed spawn.

Precautions to be observed:

Avoid over cooking of sorghum grains, as over cooking lead to splitting of grains.

Don't dry the cooked grains on the floor. Always dry over hessian cloth spread on a raised platform

Use only recommended dose of CaCo3 for mixing with the cooked grains. Mixing over dose reduces the fungal growth in the inoculated bags.

Avoid further sub culturing of the second generation bed spawns. This leads to lose of virulence of the spawn lead to reduced yield and repeated sub culturing lead to complete lose of virulence wherein the fungal growth may be noted in the beds but no buttoning is completely arrested.

PADDY STRAW MUSHROOM - BED PREPARATION AND CROPPING

The cultivation of paddy straw mushroom can be done in a thatched house and also under the shade of a tree. Fresh , disease free paddy straw is the ideal substrate . Ten –fifteen kg paddy straw is necessary for preparing one bed. In recent years, it is cultivated inside plastic film houses to maintain the temperature of around 25 -35 □ C and relative humidity of 75-80 %.

Paddy Straw bundle method
Procedure:

- Prepare a raised platform of about 1 m in length and 0.75 m in breadth with a deal wood flanks and keep it over a support by arranging bricks on all four corners.
- The paddy straw is bundled into to weigh about kg each.
- Soak the straw bundles in water for 12-18 hr.
- Then bundles are taken out and drain the excess water
- Place the bundles over the platform with their butt end on one side.
- Build the second layer by placing the butt end towards the other direction. (These 8 bundles make one layer of bed)
- Place the a small quantity of spawn 8-12 cm inside the margin at an interval 15 cm all along the periphery.
- Apply a spoonful of coarsely powdered dhal powder before placing spawn.
- Place the straw bundles at right angles to the previous layer in cris-cross to make the third layer.
- Place the straw bundles with opposite butt ends to make fourth layer.
- Spawn this layer as stated above.
- Place another layer of straw bundles over this and do not apply spawn.
- Pressure the bed to make it as compact as possible and cover it with a transparent polythene sheet.
- Keep the beds undisturbed for for a few days.

Note: Usually the bed will have the necessary humidity, if the straw bundles are properly soaked. If moisture is found to be less, it may be watered using a rose can. On the other hand, if the moisture is found to be excess, polythene cover is to be partly to regulate the

moisture. The success of cultivation depends upon the temperature and moisture in the bed. The optimum temperature of 30- 35 □ C is necessary for developing buttons.

The mushrooms start appearing from all sides in 6-10 days as tiny buttons, which can be harvested in another 4- 5 days. The harvesting is to be done at the button stage itself, since the opened sporocarp will be more fibrous. Usually, 1-2 kg of mushroom can be harvested from 10 kg substrate.

Paddy straw twist method:

Instead of bundled straw, twisted paddy straw can also be used for cultivation

Procedure:

i) Make the straw into twists of about 5-8 m long and 5-10 cm diameter.
ii) Immerse the twists in water for 12 hr.
iii) Take out the straw and drain the excess water.
iv) Place the place them lengthwise over a platform on a zigzag manner.
v) Place a second over this in an opposite direction. (This forms the first layer of the bed)
vi) Sprinkle the coarsely powdered dhal and place small bits of spawn all along the periphery as above.
vii) Build another layer as described above and spawn the layer.
viii) Build up 4-5 layers and spawn as usual.
vii) Compact the bed by pressing and cover it with a polythene sheet.

CHAPTER 15

NURSERY TECHNOLGY

Nursery

It is an area, in which new saplings are raised and nourished until they are ready for sale or transplanting at a permanent place in a field. Raising of seedlings in a nursery is important for various reasons.

Importance of nursery

• It is possible to grow and maintain a large number of plants per unit area.

• Small and expensive hybrid seeds can be raised more effectively due to better care and management.

• When seeds are sown in seedbeds, their germination percentage increases and the vigour of the seedlings also improves

• The management of seedlings can be done in a better way with minimum care, cost and maintenance as the nursery area is small.

• Manipulation of growing conditions for plants becomes easy.

• Better and uniform crop growth can be obtained in the main field by selecting vigorous and healthy seedlings.

• Off-season sowing of seeds becomes possible, which ultimately results in fetching more returns.

• The seed requirement of nursery raised crops is less as compared to direct seed sowing of the same crop due to better management.

• Sowing seeds in a nursery allows additional time for doing preparatory tillage in the main plot. Harvesting of the previous crop can also be prolonged, if needed.

• Management of insect-pests, diseases and weeds is easy in a nursery.

Nursery bed

It refers to a land, which is made free from weeds, stumps, stones, pebbles, etc., and is used for sowing of seeds to raise seedlings and multiplication of different species of plants through asexual means.

Preparation of the nursery bed

Nursery beds can be prepared in three different ways.

Sunken bed

• The soil of the seedbed needs to be sterilized by soil solarisation or with chemicals to avoid contamination by pests and diseases.

• The soil of the nursery bed is thoroughly mixed with rotten farmyard manure.

• This type of nursery bed is prepared in dry and windy areas.

• In dry areas, the bed is kept 10–15 cm below the ground level, which helps in conserving water.

• Sunken bed facilitates the deposition of irrigation water or rainwater for a longer time.

• In case of water scarcity, this type of bed helps to conserve the moisture.

• Such a bed can be easily irrigated during dry season.

• A sunken bed provides protection to the seedlings during high wind conditions as they are covered.

Level bed

• The soil of the seedbed must be sterilised by soil solarisation or with chemicals to avoid contamination by pests and diseases.

• After soil preparation, the recommended dose of manure and fertilisers is mixed in the nursery bed.

• For efficient management, the whole area is divided into uniform size of small beds.

• Usually, a flat bed is 1-metre wide and has length according to the slope of the field.

• Irrigation channels are prepared between the rows of the beds through which each bed is connected.

These also act as drainage channels in case of heavy rain or excess irrigation.

• Such a bed is prepared during non-rainy season (summer and winter) so that there is no water logging.

• Adequate drainage provision is made and preference for sandy or sandy loam soil is given when preparing a flat bed.

Raised bed

• Such a nursery bed is prepared during the rainy season.

• The land is levelled and made free of weeds, stumps, stones, pebbles, etc.

• The soil of the nursery bed is thoroughly mixed with 5–10 kg per sqm rotten farmyard manure.

• This type of bed is prepared about 15 cm high from the ground level. The width is kept at 1–1.5 m and length 3–5 m. This enables adequate drainage during rains and checks water stagnation.

• A space of 3–4 cm is left between two beds in order to carry out cultural practices smoothly.

Sowing of seeds

Methods of seed sowing

Broadcasting

In this method, seeds are broadcast on nursery beds, after which the beds are covered with sieved farmyard manure (FYM) or decomposed compost.

However, this method has disadvantages too, such as the seeds cannot be placed at a desired place and comparatively more quantity of seeds is required.

Line sowing

It is an appropriate method of sowing seeds in a nursery. Sowing in lines improves germination and quality of seedlings. In this method, each seed gets independent space, and grows healthy and vigorously. Here, the diseased seedlings and weeds can be easily managed.

Procedure

On a leveled bed, shallow trenches of certain depths are made with the help of a stick width-wise at adequate spacing. This depends on the size of the seeds. Small seeds are sown at shallow depths and low spacing between rows and vice versa.

The seeds are, generally, sown at a depth of 3–4 times of its diameter. They areplaced singly in rows. Small seeds are mixed with sand for even distribution. The trenches are then covered with fine soil. The beds require light irrigation from sowing to transplanting by means of a fine rose can.

Mulching of seedbeds by polyethylene sheet, paddy straw, etc., helps in quick and uniform germination of seeds. Mulches must be immediately removed after germination.

Seed sowing in plug-trays (pro-trays)

High-value and hybrid seeds are preferred to be sown in plug-trays (pro-trays) instead of open field nursery beds. Pro-trays are made of soft plastic having shallow plugs. These plugs are filled with planting medium.

Coco peat, a by-product of the coir industry having high water-holding capacity, is commonly used as a medium in pro-trays.

Procedure

In this technique, plugs are filled with coco peat. Depressions of 0.5 to 1 cm are made at the

centre of the plugs with the help of fingertips for sowing the seeds. One seed is sown in each plug.

The seeds are placed in the depressions and covered with coco peat. These pro-trays are covered with a polythene sheet and kept like that for few days or till germination starts.

After germination, the polythene sheet is removed and water is sprinkled with a fine nozzle can. Annual seeds are commonly sown in pro-trays filled with coco peat or other growing media.

Precautions taken during seed sowing

• The seeds must be healthy and free from infection.

• Small seeds are sown after being mixed with sand for equal distribution

.• The seeds must be sown at the right depth.

• The seeds must be sown at adequate spacing to avoid overcrowding.

It also ensures that the seedlings get sufficient nutrients, water, sunlight and air.

Besides, the soil must neither be too dry nor too wet to avoid drying or rotting of the seeds or seedings.

CHAPTER 16

INTEGRATED FARMING SYSTEM

Integrated Farming System (IFS):- A sub system of a high level land usesystem like a village or a watershed which includes crop production, raising livestock, fishery, poultry, beekeeping etc. on a particular farm with a objective of higher profitability without altering ecological and socio-economic balance on one hand and to meet the national goals on the other hand.

Integrated Farming System (IFS) also defined as biologically integrated farming system which integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs, secures sustainable production of high quality food and other products through ecologically preferred technologies, sustain farm income, eliminates or reduces sources of present environment pollutions generated by agriculture and sustains the multiple function of agriculture.

Integrated Farming System (IFS) is a combination of many systems, it attempts to increase farmers income using natural resources on sustainability basis which can be obtained by integrating crop husbandary with allied enterprises is called as IFS.

Objectives of IFS:-

- Efficient recycling of farm and animal wastes.
- Minimizing the nutrient losses.
- Maximizing nutrient use efficiency.
- Adoption of efficient cropping systems and crop rotations.
- Complementary combination of farm enterprises.
- Definition – Enterprise in farm business is defined as the production ofsingle crop or a kind of stock.
- Generally farmers take more than one enterprise on their farms.
- The main objectives of the farming is to get maximum profit withminimum expenditure by combining enterprises.
- The combination of enterprises on a farm is influenced by the relationshipthat exists between the enterprises.

Types Enterprise relationships:-

1) **Independent enterprises:-** These enterprises do not have direct bearing on each other. There is no effect on the other enterprise when level of one enterprise is increased or decreased.

2) Complementary enterprises:- Are those enterprises which helps each other in production and do not compete for resources.

3) Competitive enterprises:- Are those enterprises which compete each other for the resources.Farmers have limited resources and therefore all crop and livestock enterprises become competitive at some point.

4) Supplementary enterprises:- Are those which do not compete for resources but to increase income of the farmers. A small poultry enterprise is supplementary to other enterprise of the farm.

Integrated Farming System (IFS):-

1. Productivity:- Integration of crop and allied enterprises helps to increase economic yield per unit area per unit time. Intensification of cropping and allied enterprises in space and time dimension found to increase the productivity.

2. Profitability:- Produce/waste material of ne enterprise can be used for other enterprise at least for crop, thus reducing the cost of production and increasing profitability per rupee investment.

3. Sustainability:- Huge quantity of inorganic fertilizers, pesticides, herbicides are required to meet the food requirement of increasing population @ 2.2 % every year. Abundent use of such material causes soil degradation and pollution. The productivity of soil gets drastically reduced in due course of time. IFS provides an opportunity to sustain production through organic supplementation and effective utilization of byproduct of linked components.

4. Balanced food:- IFS link varied nature of enterprises to provide nutrious food viz., vitamins, proteins, carbohydrates, fat, minerals etc. from the same area. This solves the malnutrition problem of poor peoples.

5. Environmental Safety:- Abundant use of inorganic fertilizers, pesticides, herbicides make the soil, water and environment polluted. Similarly, residues of some crops, waste material also pollute the environment after decomposition. However in IFS waste material, byproducts of one composite are effectively recycled using for other component and by-product of that component as organic manure to enrich the soil. Use of bioagent or crop protection also minimizes the pesticides.

6. Recycling of waste:- By-product of the crop husbandary can be effectively recycled for preparation of compost. Some of the by-product can be used as feed. This reduces the cost of production of one enterprise at the cost of other. Thus net income of farm is increased.

7. Saving energy:- Energy crises can be served to same extent by utilizing organic waste to generate biogas which can be used for cooking, lighting etc.

8. Adoption of new technology:- Big farmers are fully aware with the new technologies because of using improved varieties, package of practices. But small and marginal farmers are not able to adopt for want of money. In IFS linking of

cropping with dairy, mushroom, sericulture, floriculture there is a flow of money throughout the year.

9. Money round the year:- In conventional farming income is expected once at the end of cropping season. However, IFS provides flow of money round the year by way of disposing eggs, milk, edible mushroom, honey, cocoons of silkworm etc.

10. Availability of fodder, fuel and timber:- IFS utilizes every part of land. Growing of fodder trees on border will not only provide fodder but also enrich the soil by fixing

atmospheric nitrogen. In multistroyed cropping includes of fodder component like cowpea as second or third tier also meet the fodder crises. The current production of fuel wood is about 20 million ton which needs to be increased to eighteen folds.

11. Employment round the year:- Crop-livestock integration increase labour requirement through the year, other activities like mushroom cultivation, sericulture, apiculture also needs labor. Hence IFS provides employment to family members as well as outside labour throughout the year.

12. Agro-industries:- Linking of various components in IFS, the production definitely increased to commercial level. Surplus production leads to development of agro based side industry.

13. Increase input efficiency:- IFS provides better scope to use available inputs more efficiently. This leads to increase benefit: cost ratio.

14. Standard of living:- IFS leads to produce milk, eggs, fruits, honey, edible mushroom and generate bioenergy for farmers family and commercial purpose. There is regular flow of money at frequent interval through out the year.

15. Avoid degradation of forest:- There is a vast gap between demand and production of fuel wood and timber. Users encroaches/destroy the forest area to bridge the gap. Forest lands get degraded and eroded due to denudation of forest. IFS linked with Afforestration and provide safety against degradation of lands, besides supplementation of fuel, timber and fodder.

Types of Allied Enterprises:-

1. Dairy Farming
2. Sheep and Goat farming
3. Poultry farming
4. Duck farming
5. Turkey rearing
6. Piggery
7. Rabbit farming
8. Bee keeping
9. Pigeon rearing
10. Aquaculture

11. Sericulture

12. Mushroom cultivation

Bio-gas plant:- Is a complex biogas process. The cellulose materials are brokendown to methane and carbon-di-oxide by different groups of micro-organisms.

Types of Bio-gas plant:-

1. Float dome type:- KVIC Vertical and Horizontal Pragati, Ganesh Model .

2. Fixed dome type:- Janata, Deen Bandhu Model .

Selection of site:-

- The site should be close to kichen or the place of use to reduce the cost ofgas distribution system.
- Similarly, it should be nearer to the cattle shed to reduce the cost of transportation of dung.
- Land should be levelled and slightly above the ground level to avoid inflow or runoff of water.
- There should be clear sunshine on the plant during most part of the day.
- Gas production is higher in summer followed by rainy season and winter.

Size of Bio-gas Plant:-

- The size of the bio-gas is decided by the no. of family members and availability of cattle.
- 1m3 capacity plant requires 2-3 animals and 25 kg of dung.
- This is sufficient for 4-6 family members.
- It is better to have a plant of 2 m3 to fulfill the requirement of 6-10 members.

Bio-Gas Slurry:- Slurry is obtained after the production of bio-gas. It is enrichedmanure.

Enterprise Integration:-

- ❖ Livestock is the best complementary enterprise with cropping
- ❖ Installation of a biogas plant in crop-livestock system will make use of the wastes besides providing manure and gas for cooking and lighting.
- ❖ In wetland there is a better scope for fishery, duck and buffalo rearing. Utilizing rice straw, mushroom production can be started.
- ❖ Under irrigated condition sericulture, poultry, piggery with arable crop is better.

- In rainfed farming, sheep and goat, sericulture, agroforestry etc
- In the integrated system enterprises with complementary relationship should be selected to avoid competition.

Interrelationship among different enterprises:-

a. Crop-Livestock interaction:- Crop-livestock interaction takes place in two main systems. First interaction is without full integration defined as segregated system. Farmers own animals and herders might grow crops.

b. Aquaculture-Crop integration/interaction:-

A large quantity of salt and manure is added to the fish pond every year on an average 25 kg pond silt produce1kg of green fodder. Rice is found to be increased by 10% due to synergistic effect of fish on rice. Weeds and insects also controlled by fish.

c. Aquaculture-Bio-gas-Livestock Integration/Interaction:-

Cattles in aquaculture utilizes the fodder produced through application of silt to the crop. Fish in pond feed on the zoo-planktons and phytoplankton, bacteria etc. Ducks acts as a Bio-aerators as they aerate the pond through their legs. Bio-gas plant generate the gas used for cooking and lighting.

IFS units

Cattle unit

Duckery unit

Goatery unit

Composting unit

Vermicompost unit

Biogas unit

Bioproducts production unit

Poultry unit