UNIT 3: INOCULATION OF EARTHWORMS AND VERMICOMPOSTING PROCESS

Key learning outcomes:

At the end of this unit, you will be able to:

1. ***Identify correct species of earth worms***
2. ***Describe Process of Vermicomposting and Inoculation of earthworms***
3. ***Describe maintaining favourable condition in to vermi bed***
4. ***Describe preparation of feed and manage Vermicomposting unit***
5. ***Describe control of predators , pest and disease attack***
6. ***Describe harvest of Vermiwash***

Introduction

Earthworms are hermaphrodites. Each worm has both male and female organs. They are small tube like organisms who tirelessly work to turn the earth from lowest strata of earth to top. Worms tunnel deeply in the soil and bring subsoil closer to the surface mixing it with the topsoil. This makes the formation of multitude of linear tunnels minute in diameter but deeper below the subsurface. These tunnels last long even after the worms are dead. These tunnels facilitate infiltration of water into subsurface, reduce runoff, help in harvesting rainwater. Such stored moisture is slowly released to crop at summer season. In this process of tunneling it also maintains the soil structure and enables the processes of aeration. This act makes EARTHWORM as a Real Farmer who toils day long tilling the fields. In the fields of organic cultivation we could see the reserve moisture throughout the year. The latent hard work of a large number of worms helps the crop survive when the other areas are parched.

Earthworms live on what we call WASTE. Yes, they feed on the vegetable wastes we throw; leaves shed from trees and any form of organic matter available in soil, and living organisms such as nematodes, protozoan, rotifers, bacteria, fungi which are harmful to plant growth. Their intake per day is one third of their body weight. The organic matter the earthworms consume gets digested in their bodies and gets excreted in the form of casts, a type of soil aggregate rich in nutrition. Thus Earthworms facilitate improving soil fertility and deposits on the surface. Their role gains significance because they convert larger organic matter into simple accessible form.

This is also the Nutrition cycle. Slime, a secretion of earthworms, contains nitrogen. Nitrogen is an important nutrient for plants. The sticky slime helps to hold clusters of soil particles together in formations called aggregates. These have greater role in porosity which helps in aeration and physical property of soil. The micro-tunnels provide good root growth as they are lined with readily available nutrients and make it easier for roots to penetrate deep into the soil. They save the fertilizer cost. Vermicompost supplied many minerals needed for the complete crop growth. The pest load was very less due to available farmers' friends (natural predators and parasites) which took care of the pest control.

The farmer had no need to go for much pesticide spray as the pests were below Economic Threshold Level. These were the visible advantages. Beyond this there were more advantages like the vegetables had longer shelf life, tasted better, and many more…

SESSION 1: IDENTIFICATION OF CORRECT SPECIES OF EARTHWORMS

Of about 350 species of earth worms in India with various food and burrowing habits ***Eisenia foetida,*** **Eudrillius engenial** and ***Perionyx excavatus are*** some of the species that are reared to convert organic wastes into manure. A combination of epigeic species that form no permanent burrows and live on the surface, Anecic that form semi-permanent and vertical burrows extending from the surface and Endogeic that typically live throughout the deeper layers may be considered.

Three Types of Earthworm

- Anecic (Greek for "out of the earth") – these are burrowing worms that come to the surface at night to drag food down into their permanent burrows deep within the mineral layers of the soil. Example: the Canadian Night crawler.
- Endogeic (Greek for "within the earth") – these are also burrowing worms but their burrows are typically more shallow and they feed on the organic matter already in the soil, so they come to the surface only rarely.
- Epigeic (Greek for "upon the earth") – these worms live in the surface litter and feed on decaying organic matter. They do not have permanent burrows. These "decomposers" are the type of worm used in Vermicomposting.

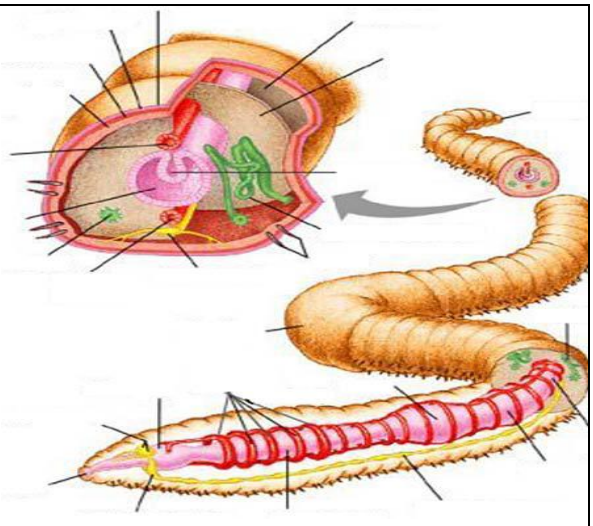
For vermicompost production, the surface dwelling earthworm alone should be used. The earthworm, which lives below the soil, is not suitable for vermicompost production. The African earthworm (*Eudrillius engenial),* Red

worms (*Eisenia foetida)* and Asian worm or composting worm (*Perionyx excavatus)* are promising worms used for vermicompost production. All the three worms can be mixed together for vermicompost production. The African worm (*Eudrillius engenial)* is preferred over other two types, because it produces higher production of vermicompost in short period of time and younger ones in the composting period.

		
African earthworm	Red worm	Asian worm

The worms feed on any biodegradable matter and Vermicomposting units are ideally suited for locations with generation of considerable quantities of organic wastes. One earthworm reaching reproductive age of about six weeks lays one egg capsule (containing 7 embryos) every 7-10 days. Three to seven worms emerge out of each capsule. Thus, the multiplication of worms under optimum growth conditions is very fast. The worms live for about 2 years. Fully grown worms could be separated and dried in an oven to make 'worm meal' which is a rich source of protein (70%) for use in animal feed.

Among all the above earthworm species, the most commonly used one is Eisenia foetida which is commonly known as the “compost worm”, “manure worm”, “red worm”, and “red wiggler”. This is extremely tough and adaptable worm, It is indigenous to most parts of the world and can be found on most Indian farms wherever piles of manure have been left to age for more than a few months.

	
E. foetida worms	Section of E foetida worm

Commercially raised worms are usually of the epigeic type. **E. foetida** is certainly not the only epigeic worm, but it is the one most often used for composting purposes in Northern climates. It can handle a wide temperature range (between 0 and 35ºC) and can actually survive for some time almost completely encased in frozen organic material (as long as it can continue to take in nourishment). Its cocoons (eggs) have been shown to remain viable after having been frozen for several weeks. In addition, it can take a lot of handling and rough treatment. Perhaps most importantly, like most if not all litter-dwelling worms, the compost worm has the capacity for very rapid reproduction. This is an evolutionary necessity for a creature whose natural environment is extremely changeable and hazardous and whose natural supplies of food are of the "boom or bust" variety. All of these characteristics make ***E. foetida*** the natural choice for those who wish to do their vermicomposting outdoors, year-round, in climates with harsh winter conditions.

SESSION 2: PROCESS OF MAKING VERMICOMPOST

Vermicomposting process may vary according to various factors such as location (indoor, outdoor), intensity of care and scale of production (backyard, commercial), systems used (windrow, worm bins, bioreactors), methods of feeding and preparation of organic materials (gradual, batch, meso philic, combined thermophillic and meso philic composting).

For backyard batch composting following the windrow or outdoor pile method, it is common to combine thermophillic (high temperature) composting in which a maximum pile temperature of about 60-65°C is targeted. This is referred to as the pre-Vermicomposting stage during which complex organic compounds are degraded by microorganisms. At the end of this thermophillic stage, the temperature of the pile gradually drops and the composting process becomes meso philic (moderate temperature). This signals the right time to commence the second stage in which the right species of earthworm is introduced.

As a practical guide in Vermicomposting, the following procedure (thermophillic + meso philic process) is provided:

1. Select a container or bed or bin of appropriate dimensions as mentioned above wherever Vermicompost is to be prepared.

2. **Prepare the following materials or provide at the right time:** Carbon- and nitrogen-rich organic materials, spade, ground space, hollow blocks, stakes, plastic sheets or used sacks, water and water sprinklers, shading materials, nylon net or any substitute to cover the beds, and composting earthworms (e.g. **Eisenia)** Nitrogen-rich substrates refer to animal manures, legumes, and fresh grass clippings, while others, particularly those colored brown and dry, are generally classified as carbon-rich substrates.

3. Mix carbonaceous with nitrogenous organic materials at the right proportions to obtain a C: N ratio of about 30:1. For example, rice straw and fresh manure are mixed at about 25:75 ratio by weight. But for practical application, a 1:1 or 50:50 ratio by volume can be tried as basis in mixing the organic waste with cattle dung

4. **Prepare the vermi bed** by spreading plastic sheets or used sacks on the ground to prevent mixing of the soil with the compost during harvesting. Pile two layers of hollow blocks in square or rectangular pattern. Secure the blocks by sinking stakes through the holes. Remove completely growing vegetation surrounding the bed and sweep away plant debris that may serve as food and induce the earthworms to migrate outside OR

   Make a bed of 10 cm height using any of the base materials (coir waste, paddy husk, sugar cane trash etc. collected. Give a layer of soil on it. Sprinkle water on it to get a moisture level of 40-45%.The bed should appear wet. Provide shade.

5. Fill the vermi bed with the organic materials and water sparingly. The size of the pile can vary but in general, a volume of at least 1 cubic meter (1 m3) is desired to allow thermophillic heating. A pile 1 m wide, 2 m long and 0.5 m high will have this volume. To conserve moisture and heat, the pile is covered from the top to the sides with plastic sheets or any substitute materials.

6. Wait for at least 15 days for the thermophillic process of composting to end. This process is characterized by a rapid increase in temperature of the pile (it can be checked manually with an open palm on top of the pile) followed later by a gradual decrease. During this period give turning to the material 2-3 times at 4-5 days interval. When temperature approaches ambient temperature (<35°C, the height of the pile also subsides), remove the covering. Sprinkle with water if necessary, and then commence Vermicomposting proper by introducing the right species of earthworm. Effluent slurry from bio-gas plant can also be best used for this in place of manure.
7. Stock the partially decomposed organic materials with composting earthworms, e.g., **Eisenia foetida** by releasing them on top of the pile. The earthworms will immediately move downward. A stocking rate of about 500 g of earthworms is sufficient for an original pile of 1 m3 but it can be lesser or more, depending on availability. Heavier stocking rate will mean faster rate of vermicast production.
8. Mulch the pile with coconut coir dust or grasses to prevent excessive loss of moisture. Then cover with nylon net or any substitute material like coconut fronds to serve as barrier against birds and other earthworm predators. The pile can also be covered with gunny cloth. Maintain sufficient moisture and aeration throughout the composting process. By sprinkling water over the cloth periodically. Add 5-10 % neem cake in the feed mix. Neem cake in small quantities has beneficial effect on the growth of worms. The worms feed actively on organic matter and assimilate only 5-10 % and rest is excreted as loose granular mounds of vermi castings on the surface away from the feed source, thus the worms will convert the feed mix into vermi castings in 60 days. The vermicompost once formed completely will give the smell of moist soil.
9. Take out the vermi compost and make a heap in sunlight on a plastic sheet. Keep for 1-2 hours .The worms will gather at the bottom of heap. Remove vermicompost on top and the worms settled down at the bottom can be carefully collected for use in the next batch of vermi composting.


'Eisenia foetida' species of vermi culture added to the bed prepared.

Finished Product -vermicompost

Preventive measures

- The floor of the unit should be compact to prevent earthworms' migration into the soil.
- 15-20 days old cow dung should be used to avoid excess heat.
- The organic wastes should be free from plastics, chemicals, pesticides and metals etc.
- Aeration should be maintained for proper growth and multiplication of earthworms.
- Optimum moisture level (30-40 %) should be maintained
- 18-25^{o}C temperature should be maintained for proper decomposition.

SESSION 3: MAINTAINING FAVOURABLE CONDITIONS OF MOISTURE, AERATION AND TEMPERATURE IN THE VERMI BED

Moisture

The need for adequate moisture is important. The bedding used must be able to hold sufficient moisture if the worms are to have a livable environment. They breathe through their skins and moisture content in the bedding of less than 50% is dangerous. With the exception of extreme heat or cold, nothing will kill worms faster than a lack of adequate moisture.

The ideal moisture-content range for materials in conventional composting systems is 45-60%. In contrast, the ideal moisture-content range for Vermicomposting or vermiculture processes is 70-90%.

Aeration

Worms are oxygen breathers and cannot survive anaerobic conditions (defined as the absence of oxygen). When factors such as high levels of grease in the feedstock or excessive moisture combined with poor aeration conspire to cut off oxygen supplies, areas of the worm bed, or even the entire system, can become anaerobic. This will kill the worms very quickly. Not only are the worms deprived of oxygen, they are also killed by toxic substances (e.g., ammonia) created by different sets of microbes that bloom under these conditions. This is one of the main reasons for not including meat or other greasy wastes in worm feedstock unless they have been pre-composted to break down the oils and fats.

Although composting worms O_2 requirements are essential, however, they are also relatively modest. Worms survive harsh winters inside windrows where all surfaces are frozen: they live on the oxygen available in the water trapped inside the windrow. Worms in commercial Vermicomposting units can operate quite well in their well insulated homes as long as there are small cracks or openings for ventilation somewhere in the system. Nevertheless, they operate best when ventilation is good and the material they are living in is relatively porous and well aerated. In fact, they help themselves in this area by aerating their bedding by their movement through it. This can be one of the major benefits of Vermicomposting: the lack of a need to turn the material, since the worms do that work for you. The trick is to provide them with bedding that is not too densely packed to prevent this movement.

Temperature Control

Controlling temperature to within the worms' tolerance is vital to both Vermicomposting and vermiculture processes. This does not mean, however, that heated buildings or cooling systems are required. Worms can be grown and materials can be vermi composted using low-tech systems, outdoors and year-round, in the more temperate regions of India. The following points are general and are intended to provide background for the more system-specific information.

Low temperatures: Eisenia can survive in temperatures as low as 0°C, but they don't reproduce at single-digit temperatures and they don't consume as much food. It is generally considered necessary to keep the temperatures above 10°C (minimum) and preferably 15 °C for Vermicomposting efficiency and above 15 °C (minimum) and preferably 20 °C for productive vermiculture operations.

Effects of freezing: Eisenia can survive having their bodies partially encased in frozen bedding and will only die when they are no longer able to consume food. Moreover, tests have confirmed that their cocoons survive extended periods of deep freezing and remain viable.

High temperatures: Compost worms can survive temperatures in the mid-30s but prefer a range in the 20s (°C). Above 35°C will cause the worms to leave the area. If they cannot leave, they will quickly die. In general, warmer temperatures (above 20°C) stimulate reproduction.

Worm's response to temperature differentials: Compost worms will redistribute themselves within piles, beds or windrows according to temperature gradients. In outdoor composting windrows in winter time, where internal heat from decomposition is in contrast to frigid external temperatures, the worms will be found in a relatively narrow band at a depth where the temperature is close to optimum. They will also be found in much greater numbers on the south-facing side of windrows in the winter and on the opposite side in the summer.

SESSION 4: PREPARATION OF FEED AND MANAGING VERMICOMPOSTING UNIT

The important parameters that are required to be looked into while preparing feed and managing the Vermicomposting unit are:

pH: Worms can survive in a pH range of 5 to 9 . Most experts feel that the worms prefer a pH of 7 or slightly higher. The range of 7.5 to 8.0 was found optimum). In general, the pH of worm beds tends to drop over time. If the food sources are alkaline, the effect is a moderating one, tending to neutral or slightly alkaline. If the food source or bedding is acidic (coffee grounds, peat moss) then the pH of the beds can drop well below 7. This can be a problem in terms of the development of pests such as mites. The pH can be adjusted upwards by adding calcium carbonate. In the rare case where they need to be adjusted downwards, acidic bedding such as peat moss can be introduced into the mix.

Salt content: Worms are very sensitive to salts, preferring salt contents less than 0.5%. If saltwater seaweed is used as a feed (and worms do like all forms of seaweed), then it should be rinsed first to wash off the salt left on the surface. Similarly, many types of manure have high soluble salt contents (up to 8%). This is not usually a problem when the manure is used as a feed, because the material is usually applied on top, where the worms can avoid it until the salts are leached out over time by watering or precipitation. If manures are to be used as bedding, they can be leached first to reduce the salt content. This is done by simply running water through the material for a period of time. If the manures are pre-composted outdoors, salts will not be a problem.

Urine content: If the manure is from animals raised or fed off in concrete lots, it will contain excessive urine because the urine cannot drain off into the ground. This manure should be leached before use to remove the urine. Excessive urine will build up dangerous gases in the bedding. The same fact is true of rabbit manure where the manure is dropped on concrete or in pans below the cages."

Other toxic components: Different feeds can contain a wide variety of potentially toxic components. Some of the more notable are:

- De-worming medicine in manures: particularly horse manure. Most modern deworming medicines break down fairly quickly and are not a problem for worm growers. Nevertheless, if using manure from another farm than your own, it would be wise to consult your source with regard to the timing of de-worming activities, just to be sure. Application of fresh manure from recently de-wormed animals could prove costly.
- Detergent cleansers industrial chemicals, pesticides: These can often be found in feeds such as sewage or septic sludge, paper-mill sludge, or some food processing wastes.
- Tannins: Some trees, such as cedar and fir, have high levels of these naturally occurring substances. They can harm worms and even drive them from the beds.
- It is to be pointed out that pre-composting of wastes can reduce or even eliminate most of these threats. However, pre-composting also reduces the nutrient value of the feed, so this is a definite trade-off.

SESSION 5: CONTROL OF PREDATORS AND PESTS AND DISEASES

Compost worms are not subject to diseases caused by micro-organisms, but they are subject to predation by certain animals and insects (red mites are the worst) and to a disease known as "sour crop" caused by environmental conditions. The following is a brief overview of the most common pests and diseases likely to be experienced in earthworms and during composting in India.

- Moles: Earthworms are moles' natural food, so if a mole gets access to your worm bed, you can lose a lot of worms very quickly. This is usually only a problem when using windrows or other open-air systems in fields. It can be prevented by putting some form of barrier, such as wire mesh, paving, or a good layer of clay, under the windrow.
- Birds: They are not usually a major problem, but if they discover your beds they will come around regularly and help themselves to some of your workforce. Putting a windrow cover of some type over the material will eliminate this problem. These covers are also useful for retaining moisture and preventing too much leaching during rainfall events. Old carpet can be used for this purpose and is very effective.
- Centipedes: These insects eat compost worms and their cocoons. Fortunately, they do not seem to multiply to a great extent within worm beds or windrows, so damage is usually light. If they do become a problem, one method suggested for reducing their numbers is to heavily wet (but not quite flood) the worm beds. The water forces centipedes and other insect pests (but not the worms) to the surface, where they can be destroyed by means of a hand-held propane torch or something similar.
- Ants: These insects are more of a problem because they consume the feed meant for the worms. Ants are particularly attracted to sugar, so avoiding sweet feeds in the worm beds reduces this problem to a minor one. Keeping the bedding above pH 7 also helps.
- Mites: There are a number of different types of mites that appear in vermiculture and Vermicomposting operations, but only one type is a serious problem: red mites. White and brown mites compete with worms for food and can thus have some economic impact, but red mites are parasitic on earthworms. They suck blood or body fluid from worms and they can also suck fluid from cocoons. The best prevention for red mites is to make sure that the pH stays at neutral or above. This can be done by keeping the moisture levels below 85% and through the addition of calcium carbonate, as required.
- Sour crop or protein poisoning: This "disease" is actually the result of too much protein in the bedding. This happens when the worms are overfed. Protein builds up in the bedding and produces acids and gases as it decays. When you see a worm with a swollen clitellum or see one crawling aimlessly around on top of the bedding, you can just bet on sour crop and act accordingly, but fast". The recommended solution is a "massive dose of one of the mycins, such as farmers give to chicken or cattle". Farmers wishing to avoid these or similar antibiotics should work to prevent sour crop by not overfeeding and by monitoring and adjusting pH on a regular basis. Keeping the pH at neutral or above will preclude the need for these measures.

Precautions for compost making

Moisture level in the bed should not exceed 40-50%.Water logging in the bed leads to anaerobic condition and change in pH of medium. This hampers normal activities of worms leading to weight loss and decline in worm biomass and population.

- Temperature of bed should be within the range of 20-30 degree centigrade.
- Worms should not be injured during handling.
- Bed should be protected from predators like red ants, white ants, centipedes and others like toads, rats, cats, poultry birds and even dogs.
- Frequent observation of culture bed is essential as accumulation of cast's retards growth of worms.
- Space is the criterion for grow th and establishment of culture .Minimum space required is 2 square meter per 2000 worms with 30-45 cm thick bed.
- Earth worms find it difficult to adopt themselves in new environments hence addition of inoculum as a bait from earlier habitat helps in early adaptation to new site of rearing.

Best composting tips:

1. Mixture of cattle, sheep, and horse dung with vegetable wastes forms ideal feed for worms.
2. Addition of neem cake in small quantity enhances growth of worms.
3. Biogas slurry aged aerobically for 15 days enhances vermi composting process.