Lesson 4

Managing of vermicomposting process

Learning outcomes

- The trainee knows the five basic stages of vermicompost production.
- The trainee explains step by step the production of vermicompost.
- The trainee knows the materials that should not be present in the production environment.
- The trainee knows the prerequisite for adding animal manure to the production environment.
- The trainee knows the abiotic factors that need to be monitored in vermicompost production.
- The trainee knows the optimum moisture range for the production environment.
- The trainee explains the processes required to keep the production environment between optimum moisture values.
- The trainee knows the temperature range that the production environment should have.
- The trainee explains the relationship between temperature and moisture in the production process.
- The trainee explains the functional necessity of aerating the pile during the production process.

- The trainee knows the optimum pH range for the production environment.
- The trainee explains the relationship between the pH value of vermicompost and the physiological processes of the plant.
- The trainee knows pH regulator materials.
- The trainee evaluates the effects of the C:N ratio on the vermicompost process.
- The trainee explains the physiological importance of phosphorus, salt and ammonium for earthworms and plants.

Instructions for the trainer

- The instructor shares theoretical knowledge through presentation.
- The trainer introduces the equipment to be used to measure the abiotic parameters to be monitored during the vermicompost production process.

Basic requirements: Projector, computer, thermometer, moisture meter, bokashi bin.

4. Managing of vermicomposting process

Vermicompost production method is a complex process in which many physical, chemical and biological factors are effective. Many factors such as location, temperature, humidity, pH, composition, diversity and quantity of microbial elements and type and quantity of earthworms affect the vermicompost production process. The success of the vermicompost production process requires the production of fertilizer with physical, chemical, and biological content suitable for the demands of the market. For the production of vermicompost with these determined properties, it is an important requirement to keep all parameters that may affect the process under control. Vermicompost production indicates the management of five basic stages (Figure 8).

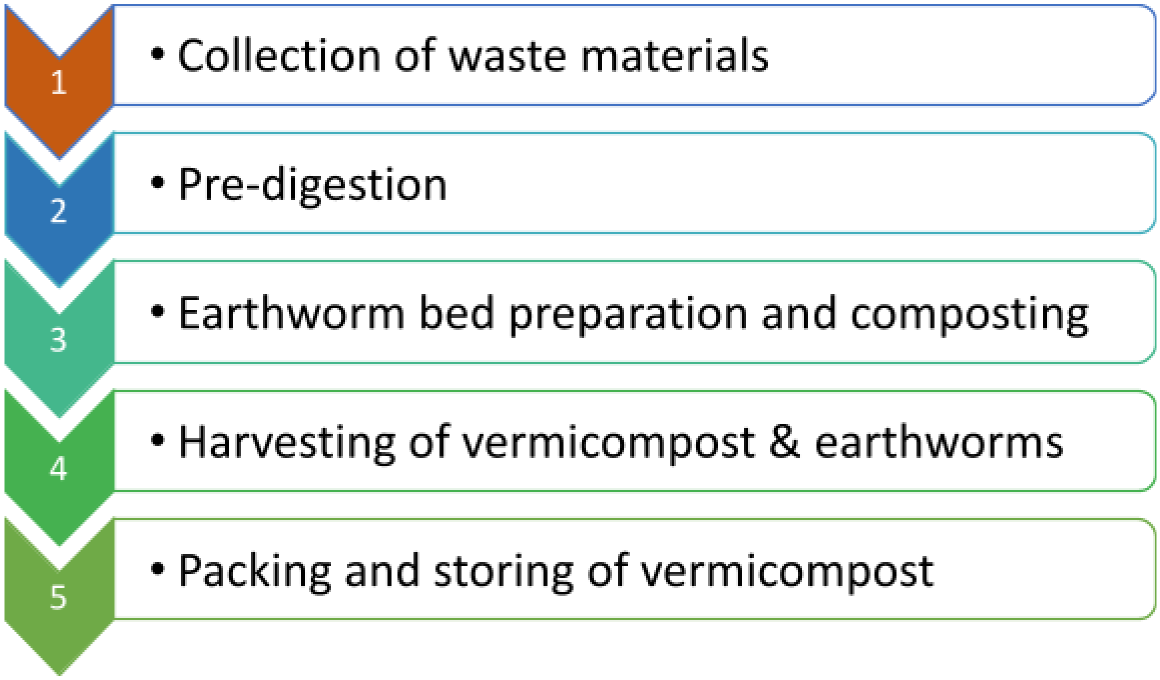

Figure 8. Basic process steps in the management of vermicompost production

Collection of waste material: The collected waste materials should be seperated from glass, plastic, ceramics, and some animal wastes (dairy wastes, fat, meat, etc.), reduced in size, and stored in a proper place.

Pre-digestion: Pre-digestion of organic waste should be done for at least 20-25 days by heaping the material along with cattle dung slurry and regular watering. This process partially digests the material and fit for earthworm consumption. Addition of higher quantities of acid-rich substances such as citrus wastes should be avoided. Any organic wastes – cow dung, crop residues, farm wastes, vegetable market wastes, and fruit wastes can be used as a raw material for composting. Use of wet dung should be avoided for vermicompost production. At least 20-25 days old cow dung should be used to avoid excess heat generation.

Earthworm bed preparation and composting: The earthworm bed prepared for vermicomposting must ensure the five basic things to obtain quality vermicompost from a short span of time. Vermicompost production can be done in any place which is having shades, high humidity and cool. Abandoned cattle shed, or poultry shed or unused buildings can also be used. If it is to be produced in the open area, artificial shading should be provided. The waste heaped for vermicompost production should be covered with moist gunny bags.

The five basic necessities are listed below:

- Hospitable living environment, called as bedding
- A food source
- Adequate moisture
- Adequate aeration
- Protection from extreme temperatures

Harvesting of vermicompost and earthworms: The vermicompost is ready within 75-90 days and ultimately the material becomes black, granular, lightweight, moderately loose, crumbly and humus-rich. Watering must be avoided two to three days before emptying the beds to facilitate the separation of worms from the compost. There are several different methods for harvesting vermicompost. These are inducing the migration of earthworms, screening or sieving, pyramidal heap, and manual harvesting.

Packing and storing of vermicompost: The harvested vermicompost should be stored in dark and cool place as sunlight will lead to loss of moisture and nutrient content. Moreover, harvested vermicompost material should be stored in open rather than packed in sacs. Packing should be done at the time of selling and laminated sac is always advisable. During compost storage in open place, periodical sprinkling of water should be done to maintain moisture level and beneficial microbial population. Vermicompost can be stored for longer periods of one year without loss of its quality, if its moisture is maintained at 40% level [20].

It can be follow up for step by step vermicomposting production process;

- Selection of suitable earthworm species.
- Choosing the site of the vermicomposting unit in a cool and shady site.
- Organic waste with cowdung and chopped dried leafy materials are mixed in the proportion of 3: 1 ratio.
- A compost heap is structured and allowed to decompose for 15 to 20 days.
- Vermiculture bed of 3 cm is to be prepared by placing after saw dust or leaves or husk or coir waste or sugarcane trash in the bottom of the application site.
- 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.
- Partial decomposed materials obtained from the first step are to be laid over the bed.
- Water is to be sprayed over it to make the moisture availability up to 50%.

- Adult earthworms are released in the upper layer of the bed.
- Beds should be kept moist by sprinkling of water (daily) and by covering with gunny bags/polythene.
- Earthworms should remain undisturbed for its multiplication.
- Bed should be turned once after 30 days for maintaining aeration and for proper aerobic decomposition.
- The fully prepared vermicompost looks like dark brown colored granules, appearing like a handful of dry CTC (crush-tear-curl) tea.
- The vermicompost is fully prepared within 75-90 days.
- When raw material is completely decomposed it appears black and granular.
- Then it is sieved further and should be separated from any contamination before use in the crop field.

4.1. Maintenance for Vermicompost

The vermicompost production process requires monitoring and control of many abiotic and biotic parameters. The most important abiotic factors which impact the vermicomposting process include moisture, pH, temperature, aeration, pH value, C:N ratio, ammonia and salt content.

4.1.1. Moisture:

A strong relationship exists between the moisture content of organic wastes and the growth rate of earthworms. A comparative study on the vermicomposting process and earthworm's growth at different temperature and moisture ranges showed that 65–75% is the most suitable range of moisture at all ranges of vermicomposting temperature [38]. The bedding used for vermicomposting must be able to hold sufficient moisture as earthworms respire through their skins and moisture content in the bedding of less than 45% can be fatal to the worms. Although epigenic species, E. fetida and E. andrei can survive moisture ranges between 50%

and 90%, but they grow more rapidly between 80% and 90%. The bacteria also plays a vital role in vermicomposting. Its activity decreases in moisture content lower than 40% and it almost stops in lower than 10% [20, 39].

Vermicompost production process is always better to maintain a humid environment, but without becoming waterlogged, as this reduces the amount of oxygen available. Shuffling the substrate can help in the necessary aeration and distribution of any liquid that may accumulate. It should be wettest on the surface, to keep most of the activity there. You must pay attention to the ambient temperature, especially in warm periods, to prevent the worms from drying out. Moistened rags or layers of cardboard or paper can be used to cover the vermicompost if the environment dries quickly.

Experience and observation will tell us if the humidity is correct. Worm skin must have a wet/fresh appearance. However, a stick hygrometer can be useful for measuring humidity, especially for beginners. If you do not have a hygrometer, you can take a handful of compost in your hand; when you squeeze it hard, about 2 or 3 drops should drip from your fist. If there are many more, the humidity is excessive and it would be advisable to add some chopped paper or cardboard, mixing them in the compost. If, on the other hand, nothing comes out, the vermicompost would be too dry and it would be advisable to add some water.

Irrigation of worms should be done with non-chlorinated water (not from the tap), preferably by sprinkling. This can be done manually or through micro-sprinklers in a larger installation. Drip irrigation is another option, but obviously it can stress the worms. If you have to add water by hand, do it very gently.

The irrigation frequency will not always be the same and will depend on the ambient temperature, the interior of the pile, the texture of the compost, etc. So it can be every few days or weeks, or as short as hours in extreme temperatures. Fairly periodic observation is important.

Irrigation is related to temperature, so this can also be controlled somewhat by watering/sprinkling. The pile should not be kept below 10 degrees, if possible, nor above about 25 or 30 for most species. If we exceed these values too much, downwards or upwards, we run the risk of them dying.

4.1.2. Temperature:

Earthworm's activity, metabolism, growth, respiration and reproduction are greatly influenced by temperature. The temperature for the stable development of earthworm population should not exceed 25°C. Although E. fetida cocoons survive extended periods of deep freezing and remain viable but they do not reproduce and do not consume sufficient food at single digit temperatures. It is generally considered necessary to keep the temperatures preferably 15°C for vermicomposting efficiency and 20°C for effective reproductive vermiculture operations. Temperatures above 35°C will cause the worms to leave the area or if they cannot leave, they will quickly die. Bacterial activity is also greatly dependent on temperature as it multiplies by two per 10°C increase in temperature and is quite active around 15–30°C.

4.1.3. Aeration:

Earthworms are oxygen breathers and cannot survive in anaerobic conditions. They operate best when compost material is porous and well aerated. Earthworms also help themselves by aerating their bedding by their movement through it. E. fetida have been reported to migrate in high numbers from oxygen depleted water saturated substrate, or in which carbon dioxide or hydrogen sulfide has accumulated.

4.1.4. pH value:

The pH value is also one of the important factors affecting the vermicomposting process. Epigenic worms can survive in a pH range of 5–9. The pH of worm beds tends to drop over time. If the food source/bedding is alkaline, then the pH of the bed drops to neutral or slightly alkaline and if the food source is acidic then the pH of the beds can drop well below 7. The pH can be adjusted upwards by adding calcium carbonate or peat moss for adjusting pH downward can be introduced into the mix. Although microorganisms which are active in vermicomposting which can maintain their activity even in lower pH of around 4 but recommended pH range for compost is around 6.5–7.5.

The pH of vermicompost plays a very important role in plant growth. When the pH of vermicompost is in the optimal range (usually around neutral), it provides an ideal environment for nutrient availability and microbial activity in the soil. This increases the plant's nutrient uptake and supports healthy root development. By maintaining the proper pH we can unlock the full potential of plant growth. The pH of vermicompost significantly affects nutrient availability in the soil. Different nutrients have varying solubilities at different pH levels. When the pH of vermicompost is balanced, it ensures that essential nutrients such as nitrogen, phosphorus and potassium are easily available to plants. However, if the pH is too acidic or too alkaline, some nutrients may become less accessible or even locked in the soil, leading to nutrient deficiencies in plants. Therefore, maintaining optimum pH through the use of vermicompost is vital to maximize nutrient availability and support plant health.

4.1.5. Ammonia and salt content:

Earthworms cannot survive in organic wastes containing high levels of ammonia. Worms are also very sensitive to salts and they prefer salt contents less than 0.5%. However, many types of manures have high salt contents and if they are to be used as bedding, they should be leached first to reduce the salt content, it is done by simply running water through the material for a period of time.

4.1.6. Carbon:Nitrogen (C:N) Ratio:

The major effect of C:N ratio in vermicompost is on bacterial activity, high C:N ratio decreases bacterial activity because of nitrogen shortage that is essential for bacteria and takes part in proteins, amino acids and other structural substances of bacteria. On the other hand low C:N ratio will lead to loss of the nitrogen as in the form of NH_3 to the atmosphere. The worms also hate the high concentration of ammonia and will escape from it. Vermicompost process will progress properly by starting the process with a C:N ratio around 25-30 and it will decrease during the process. Carbon reduces because heterotrophic bacteria use organic material as source of electrons and carbon is oxidized to CO_2 and released to the atmosphere. However, bacterial nitrogen usage is so less than carbon and some kind of bacteria can stabilize atmospheric nitrogen into compost such as Rhizobium. Also, autotrophic bacteria use ammonia as a source of electrons and convert it to nitrite and nitrate which remain in compost unless an anoxic condition occurs. In this condition nitrate and nitrite reduced and nitrogen releases to the atmosphere as N_2 [23, 40].

4.1.7. Phosphorus:

Phosphorus is an essential nutrient for plant growth and is utilized for protein formation, metabolism, photosynthesis, seed germination and flower and fruit formation. However, phosphorus in soil is in mineral form, readily available to plants, but the potential activity of earthworms and phosphate-solubilising microorganisms increases the availability of phosphorus for plants [41, 42].

The increase in total phosphorus during vermicomposting is thought to be due to the mineralization and mobilization of phosphorus as a result of the bacterial and fecal phosphatase activity of earthworms. As organic matter passes through the worm intestine, some phosphorus is converted to a more useful form thanks to the enzyme phosphatase, and further release is thought to be due to microorganisms dissolving the phosphorus present in the castings. Earthworm activity is known to accelerate the conversion of organic phosphorus into the plant-available form of phosphorus. There are numerous scientific studies showing that the treatment of different waste materials with vermicompost leads to an increase in readily extractable phosphorus by 12–21% [43].