****

 **Skill TRAINING Manual**

 **ON**

 **Vermicompost producER**

****

****

 **K. Samuel Sangtam, Z. James Kikon, N. Khumdemo Ezung, Pijush Kanti Biswas**

**Krishi Vigyan Kendra. Mokokchung**

**Nagaland -798601**

**SKILL TRAINING MANUAL**

**ON**

**VERMICOMPOST PRODUCER**

**Compiled by:**

**K. Samuel Sangtam, Z. James Kikon, N. Khumdemo Ezung, Pijush Kanti Biswas**

**Krishi Vigyan Kendra. Mokokchung**

**Nagaland -798601**

**CONTENTS**

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Title** | **Page No.** |
|  | **General Introduction** | **1** |
|  | **General activities of earthworms*** Life cycle of earthworm
* Ideal environment for earthworms
 | **2-4** |
|  | **Role of earthworm in improving soil fertility** | **5-6** |
|  | **Classification of earthworm** | **7** |
|  | **Earthworm species suitable for processing organic waste*** Basic characters suited for vermicomposting:
 | **8-9** |
|  | **Vermitechnology*** Important and scope of vermin-technology
 | **10** |
|  | **Vermicompost producer*** Role of Vermicompost producer
 | **11** |
|  | **Selection of Site** | **12** |
|  | **Organic Waste** | **13-14** |
|  | **Tools and Equipments used in vermicomposting** | **15** |
|  | **Vermicomposting*** Types of vermicompost
* Preliminary treatment of compost materials
* Requirement of vermicompost
* Preparation and maintenance of base culture
* Feeds for earthworm
* Preparation of vermin-beds
* Laying in the beds/filling of vermin-beds
* Care and release of earthworm
* Maintenance of vermicompost bed
* Vermicompost efficiency
* Precaution during the process
* Harvesting of vermicompost
* Sorting of earthworm
* Transport of live earthworm
* Pests and Diseases of vermicompost
* Common problems and their solutions
 | **16-25** |
|  | **Vermi-Wash*** Uses of vermin-wash
 | **26** |
|  | **Packaging and Marketing*** Packaging
* Marketing
 | **27** |
|  | **Advantages of Vermicompost*** Nutrient content of vermicompost
 | **28-29** |
|  | **How to use Vermicompost?*** Advantages of applying vermicompost
 | **30** |
|  | **Conclusion** | **31** |
|  | **Economics of Vermicompost unit** | **32** |
|  | **First Aid and Precautions** | **33** |

**INTRODUCTION**

In the past decades, agricultural development were increased significantly based on external inputs to achieved short term productivity which resulted in improper use of local resources. Thus, damaged the environmental resources and indigenous know-how where agriculture can hardly be perceived as sustainable. Problems that emerged are varied, notably, heavy dependence on fertilizers, increased micro-nutrient deficiency, reduced cultivation area, depleted soil water table, increased dependence on chemical fertilizer and pesticides and deterioration of soil health.

 Modern agricultural system or chemical farming system aimed at attaining higher production for matching growing demand of growing population in past few decades. More emphasis was given to intensive agricultural practices which brought the Green Revolution during 1970s in India resulted in self sufficient in respect of food production by using high yielding varieties, higher levels of inputs like chemical fertilizer and plant protection etc which deteriorated soil health and created environmental imbalance. Thus, to overcome the increased usage of chemical fertilizers without adequate organic recycling vermiculture has a great role to play for supplementing the soil fertility. Earthworms according to Aristotle “The intestine of the earth” and considers them as agent to restore soil fertility. Charles Darwin term it as, long before man started ploughing the land, the land was regularly ploughed and still continues to be thus, ploughed by earthworm. Earthworms are organisms who by nature tilt the soil and also contribute nutrients and organic matter for the benefit of plants, by improving soil health. They play a major role in degrading organic waste materials and thus maintain the nutrient flux in the system. Thus, to overcome such situations biological components like utilization of earthworm activities in the form of vermicompost need attentions which have been pointed out by numerous world renowned biologists like J. E. Satchell, E. Lofty and M. S. Swaminathan.

**GENERAL ACTIVITIES OF EARTH WORMS**

Earthworms live in diverse habitats. Generally, they live in top 30-40 cm layers of soil which is moist and has plenty of organic matter. Earthworms are omnivores but they mostly derived from dead organic matter, which generally doesn’t occur abundantly in the soil. As a result they are adapted to shallow large quantities of soil for extracting sufficient nourishment from it. The main activity of earthworms involves the ingestion of soils, mixing of different soil components and production of surface or sub-surface castings. They consume soil organic matter and convert it into humus within a short period of time and thereby increase the soil fertility. Within 24 hours they can pass soil almost equivalent to their own weight through the elementary canal.

Earthworms participate in this soil forming process in four ways

1. Through their influence on soil pH
2. As agents of physical decomposition
3. By promoting humus formation
4. By improving soil structure

*Influence on soil pH:*The pH of the intestinal contains of earthworm is remarkably stable around neutral to slightly alkaline. This has a profound effect on the overall level of soil pH and on the course of organic decomposition. At neutral pH, the decomposition is faster. Earthworms also grind rock particle, and neutralize acid that are produced during the decomposition process.

*Physical decomposition*: The passage of organic material through the earthworm gut results in the physical decomposition due to muscular grinding action of gizzard, aided by ingested silica granules.

*Humus formation*: The process of humus formation is characterised by selective breakdown of cellulose into a complex mixture of various organic acid, ammonia acid, polyphenols and sugars. The presence of proteolytic, cellolytic and lignolytic enzymes in the gut of earthworms suggests that they play an active role in humus formation.

*Improvement of soil structure:* The physical comminuation of organic particles, the ameliorations of soil pH, the enhancement of microbial decomposition activity, all these result of earthworm activity contribute to soil fertility. These effects are further reinforced by mixing of the soil from different strata in the soil profile. Burrowing species are instrumental in this mixing process and they seem to act at two levels. Firstly by ingesting a mixture of organic and mineral particles, they promote formation of organo-minerals complexes. Crumb formation is also promoted by the secretion of a thin, translucent peritrophic membrane within which faecal particle is packed before they are discharged as casts from the body. This discreet packaging of soil materials improves soil porosity by aeration and drainage qualities. Structural improvement is also further enhanced by creation of burrow system.

Secondly, by casting at surface, earthworm bring organo-mineral crumbs from the deeper parts of the soil profile to the surface. Deep burrowing species also draw fragments of organic materials from the soil surface into their burrow in mineral soil.

**Life cycle of earthworm:**

* Earthworm is a hermaphrodite.
* A pair of earthworm lays 100 eggs or cocoons within 3-6 months.
* Cocoons resemble the shape of coriander seeds. Thorn like structure will be protruding from the 2 sides of cocoon. At first it appears white in colour, but as it proceeds it becomes black in colour.
* Young worms will come out within 2-3 weeks.
* 3-4 baby worms will come out from one egg.
* Earthworm reproduces through bisexual reproduction.
* Earthworm live for about 28 months.

**Ideal environment for earthworms:**

The following are the environmental conditions, which are vital and may affect the breeding, cocoon production and hatching of young earthworms.

**Temperature**:In vermicomposting, temperatures are generally kept below 35oC (Riggle and Holmes, 1994). Most worm species used in vermicomposting required moderate temperatures from 10-35oC. While tolerances vary from species to species, temperature requirements are generally similar.. In general, earthworms tolerate cold and moist conditions far better than they can hot and dry conditions (Slocum,2001).

**Moisture:** Earthworm requires plenty of moisture for growth and survival. They need generally moisture in the range of 60-75%. The soil should not be too wet else it may create an anaerobic condition and drive the earthworms from the bed (Ronald and Donald 1977a). It is very important to moisten the dry bedding material before putting them in the bin, so that the overall moisture level is at balance.

**pH:** Edward and Lofty (1976) and Chan and Mead (2003) have reported that earthworms are pH sensitive and generally most of them survive at pH ranging from 4.5 to 9. The alternation of pH in the worm bed is due to the fragmentation of the organic matter under a series of chemical reactions. As cited by Edwards and Bohlen, (1996) in Chan and Mead, (2003), the soil pH is a major factor limiting the abundance and distribution of earthworms.

**Feed:** The first step in starting a vermicomposting unit is to arrange input of feed materials for the earthworms. These can be in the form of nitrogen rich material like goat manure, cattle dung and pig manure. When the material with high carbon content is used with C/N ratio exceeding 40:1, it is advisable to add nitrogen supplements to ensure effective decomposition. All organic matter should be added only as limited layer as an excess of the former may generate heat (Ismail, 1997). Generally, 5-10% of the feed is assimilated in the body of the earthworms and the rest are exerted in the form of a nutrient rich cast (CAPART, 1998).

***Points to remember:***

* Temperature below 35 oC should be maintained for vermicomposting *i.e*., 10-35 oC.
* Earthworms generally require a moisture range of 60-75% for proper growth and survival.
* Being pH sensitive, most of the earthworms survive at pH ranging from 4.5 to 9.
* If C:N ratio is > 40:1, addition of nitrogen supplements is required.

**ROLE OF EARTHWORMS IN IMPROVING SOIL FERTILITY**

Additions of earthworms or vermicompost improve the soil physical properties such as porosity, water holding capacity, soil aggregation, hydraulic conductivity and infiltration. It improves the chemical properties of soil such as pH, available nutrient content and organic carbon content favouring plant growth.

**pH:** The pH of soil increases by the use of vermicompost. Vermicast are closer to neutral pH range than the surrounding soil and the possible factors that act on pH may be NH4 secretion and secretion from the calciferous glands. Conversion of organic N and to NH3 and further to NH4 temporarily reduces the pull of H in the soil. Earthworm significantly raised the pH of humus and effect of earthworm on soil pH is due to an increase in the concentration of ammonical N.

**Organic carbon:** The higher humifying capacity of worms is due to the accelerated humification process by the gut micro flora, especially the lignolytic micro flora in the egesta while the organic waste pass through the earthworm gut.

**Available nutrients:**

**Nitrogen (N):** Use of vermicompost increases available N content of soil and increased N recovery. The higher degree of decomposition and mineralization in vermicompost is one reason for high N content of soil. It can also be due to the earthworm carcasses. The microbial activation by the earthworm and excretion by earthworm are more important in N cycling then the additional N brought into the soil in the earthworm biomass. Microorganisms in the gut of some earthworm species, using mucus secreted from the gut epithelium as an energy source, may fix atmospheric nitrogen in significant quantities and these acts as the source of N for plant growth.

**Phosphorous (P):** Application of vermicompost increases the total and available P2O5 content in the soil. Higher P status of soil treated with vermicompost is because of greater mineralization of organic matter with the aid of microflora associated with earthworms. Increase P2O5 availability is also due to the increase phosphatase activity. The presence of P solubilising organism in vermicompost enhances the biological solublization of P, thereby increasing the available P2O5 status of soil.

**Potassium (K):** Increased availability of K due to the addition of vermicompost is due the increased concentration of available and exchangeable K contents in cast compared to the surrounding soil. Earthworm increases the availability of K by shifting the equilibrium among the forms of K from relatively unavailable form to more available form.

**Calcium (Ca):** Species with active calciferous glands absorb excess Ca from their diet and transfer it to calciferous glands from which it is excreted via the digestive tract.

**Magnesium (Mg):** The increase availability of Mg due to vermicompost application is due to higher concentration of exchangeable Mg in the worm casts then the surrounding soil. Worm casts have higher concentration of exchangeable Ca and Mg than underlying soil. The increased in available cations are related to the higher content of plant tissue in cast then surrounding soil.

**Micronutrients:** Increase Copper (Cu) availability by vermicompost application is due to the humic acid like components in vermicomposts which content appreciable amount of Iron (Fe) and Cu in the inner sphere complex

In addition to the supply of major and micro nutrients required by the plants, earthworms stimulate plant growth by the segregation of plant growth promoting substances into the casts. Plant growth stimulation is attributed to the presence of plant growth factors and group B vitamins produce by earthworms. Several indole substances have been isolated from the body tissue of earthworm. Presence of auxin like substances or substance that modifies the effects of the plant auxins have been detected in casts of certain species of earthworms. The increase in B vitamins in soil is not directly due to earthworms, but by the microorganisms whose population and activity are stimulated by the presence of earthworms. Vermicompost application enhances the activity of beneficial microbes like N2 fixers and colonization by micorrhizal fungi and hence plays a significant role in N2 fixation and phosphate mobilization leading to better uptake by plants.

Thus, earthworms can be made use of for building soil fertility and thereby increasing and maintaining crop productivity.

 ***Points to remember:***

* Vermicompost increases the soil pH by increasing the concentration of ammonical N and also improves the organic matter in soil.
* Besides supplying macro and micro nutrients required by the plants, earthworms also produce plant growth promoting substances
* Vermicompost application enhances the activity of beneficial microbes like N2 fixers and phosphate mobilizers leading to better uptake by plants

**CLASSIFICATION OF EARTHWORM**

 There are more than one thousand eight hundred (1800) known species of earthworm and this can be sub divided in the groups. The morpho-ecological groupings described by Bouche (1977), relate to several factors including general size, shape and pigmentation, burrow construction, position in the soil profile, source of foods and reproductive potential. The three group of earthworm are:

1. Epigeics: These are surface dwellers serving as efficient agent of communication and fragmentation of leaf litter, have a small body size (10-30cm) with uniform body coloration and exhibit a high reproductive rate, they have no effect on the soil structure, as they cannot dig into the soil, e.g. *Eisenia foetida*, *Eudriulus eugeniae* and *Parionyx excavatus.* These are ‘muck’ or compost worms which live within organic material.
2. Endogeics: These create horizontal branching burrows within the soil driving nutrition from the organically rich soil they ingest. They have major impact on the decomposition of death plant roots, thus, these worms are important in soil formation process such as mixing and aeration. They have variable body size and are weakly pigmented, eg. *Allobophora chorotica* (green worm), *Aporrectodea caliginosa* (grey worm).
3. Aneciques: This are deep burrowing, tends to make vertical burrows upto 3 feet in depth, have a large body size, are strongly pigmented, show surface feeding and casting behaviour, and exhibit a low reproductive rate in the field, eg. *Aporrectodea longa* (Black headed worms), *Lumbricus terestris*.

***Points to remember:***

* Epigeics are the small bodied surface dwellers which break down the leaf litters. E.g: *Eisenia foetida, Eudrillus eugeniae, Paryonyx excavates.*
* Endogeics are the horizontal burrowers which decompose the plant roots along with mixing and aerating the soil. E.g: Green worm, Grey worm.
* Aneciques are large bodied deep burrowers exhibiting surface feeding and casting behaviour. E.g: *Lumbricus terestris*, Black headed worm.

**EARTHWORM SPECIES SUITABLE FOR PROCESSING ORGANIC WASTE**

 Although there are literally thousands of species of earthworms, only a few have been used on a wide scale and research adequately for use in organic waste processing. The species used most commonly include *Eisenia foetida* (Red wiggler), *Lumbricus rubellus* (Red worm), *Eudriulus eugeniae* (African night crawler) and *Parionyx excavatus etc.* Among all the species that have been research adequately, *Eisenia foetida* has been proved best for processing organic waste, and the growth and reproduction patterns of this species have also very fast.

*Eisenia foetida* is an epigeic worm that prefers to live in organic manure or compost. It is widely known as red wiggler or manure worms or brandling worms. It can process large amounts of organic matter and, under ideal conditions, can eat equivalent to its body weight each day. Under perfect conditions a mature breeder produces a cocoon every 7-10 days. It takes about three week development in the cocoon for one to several baby worms to hatch. The newly emerged worms look just like the grown-ups, only lighter in colour and much smaller. They will mature to breeding age approximately 60-90 days.

**Basic characterstics of earthworm suitable for vermicomposting:**

1. Capable of inhabiting in high percentage of organic materials.
2. Adaptability with respect to environmental factors.
3. High fecundity rate with low incubation period.
4. Smallest period of interval from hatching to maturity
5. High growth rate, consumption, digestion and assimilation rates
6. Least vermin stabilisation time (period of inactivity after initial inoculation of organic wastes)

The most common non-burrowing earthworm species suitable for vermicomposting under Indian conditions are:

***Eisenia foetida:***Popularly known as **European worm or Tiger worm** is perhaps world mostly used earthworm in vermicomposting. In fact, many vermin culturist have been selling this worm only under different names like red worm, pink worm or purple worm, tiger worm, brandling worm or even vermiculture or vermicompost worm.

***Eudriulus eugeniae*:** Known as **African worm or night crawlers** is a large worm that grows extremely rapidly and is reasonably prolific, but they are poor temperature tolerant, difficult to handle during harvest. It is good to use under tropical conditions particularly in Southern India this species is recommended. This species is perhaps fastest growing and second most widely used earthworm in vermitechnology for composting.

***Perionyx excavatus***: is extremely prolific earthworm, an ideal species under tropical conditions easy to handle and harvest but is unable to withstand adverse temperature conditions.

***Points to remember:***

* *Eisenia foetida* is the most common species used in vermicomposting popularly known as **European worm or Tiger worm**.
* *Eudriulus eugeniae* popularly known as **African worm or Night crawlers** is a large worm that thrives well under tropical conditions and is perhaps fastest growing earthworm in vermitechnology.

*Parionyx excavatus* is easy to handle and harvest but it cannot withstand adverse temperature conditions.

**VERMI-TECHNOLOGY**

 Vermitechnology is a method of converting wastes into useful products through the action of earthworm comprising three main processes Vermiculture, Vermicomposting, Vermi-conservation.

1. **Vermiculture:** It is the mass culturing of earthworm in cast production and commercializing of live worm for other purposes.
2. **Vermicomposting:** is the practice of using concentrations of earthworms to convert organic materials into usable vermicompost or worm casting is termed as vermicomposting.
3. **Vermi-conservation:** The practice of conserving earthworms from environmental threats for maintaining ecological balance is termed as vermin-conservation.

**Importance and scope of vermin-technology in organic farming:**

Organic farming is a socially acceptable and environmentally sound food production system for the fragile hill ecosystem of north eastern hill region of India. Jhum farmers rely on inherent soil fertility due to deposition of nutrients upon decomposition of organic matter and nutrient fixation by various microbes. Farmers in the region have been practising such cultivation system for the centuries, though with low productivity and income.

Organic farming is a production system which avoids, or largely excludes, the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives. The objectives of environmental, social, and economic sustainability can be met through organic farming. The key characteristics of organic farming include protecting the long-term fertility of soils by maintaining organic matter (OM) levels, fostering soil biological activity, nitrogen (N) self-sufficiency by the inclusion of legumes, effective recycling of OM including crop residues and livestock wastes, and weed through vermitechnology. The region as a whole having a potential of 46 million tonnes of manure including crop residues and livestock excretes, which almost equivalent to the requirement for organic production in identified areas (Bujarbaruah, 2004). Crop residues account for 1.66 times of rice grain, 2.32 times of maize grain, 1.66 times of pulses and 1.33 times of oilseeds.

***Points to remember:***

* Vermicompost is important in organic farming as it increases organic matter and fosters soil biological activity.

**VERMICOMPOST PRODUCER**

Vermicompost producer is an individual who should be familiar with working in agricultural environment and possess willingness to take up initiative in vermicomposting production, must be tolerant to handling organic waste, farm or dairy waste, should not have vermin-phobia or be averse to living organisms that thrive in soil/underground, must also possess an alert mind, physically active and be willing to work for long hours in open area, be responsible for own outcomes and independently take decisions on what is best for the enterprise.

**Role of vermicompost producer:**

 The role of vermicompost producer is to be competent in the following job role.

1. Identify and arrange resources/inputs for vermicompost unit which includes selection of correct species of earthworm, site locations for vermin-beds etc.
2. Undertake good quality vermicompost production using appropriate techniques including preparation of vermin-bed, ensure proper environmental conditions, control predators, harvest vermicompost, vermin-wash and earthworms.
3. Undertake basic entrepreneurial activities for small vermicompost unit including financial arrangement, pooling of resources, marketing linkages etc.
4. Practice health and safety at the work place and should be well versed with health and safety measures in terms of personal as well as other’s safety.

***Points to remember:***

* A vermicompost producer should be familiar with working in agricultural environment and should not possess vermin-phobia.
* Good quality vermicompost should be produced using appropriate scientific techniques suitable for a particular area.
* Choosing the correct species of earthworm and site selection ensures good quality vermicompost.

**SELECTION OF SITE**

The following important factors need to be considered before the selection of site in vermicompost units for successful implementation.

a. It should be accessible to road for easy transportation of the raw materials as well as the vermicompost.

b. Should select where there are plenty of bio-wastes (agriculture waste).

c. The selected site should be located close to dairy farm or places with high population of cattle to procure cow dung and farm waste.

d. The site should be near to water source.

e. The site should be near to a place where cheap labours are available.

f. The site should be selected in cool, moist and shady areas.

g. The site should be free from water stagnations.

h. The site should be free from termites, rats and red ant activities

**ORGANIC WASTES**

In a country like India where organic wastes pose a serious threat to sustainability of nature/civilization, vermicomposting can play a major role. The scenarios of waste generation in India show an ever-increasing trend. So, in recent years emphasis is being laid on organic matter management. Recycling has been recognized as prime activity in managing the waste load. Vermicomposting not only convert bio-waste into rich manure to substantiate a part of organic manure and fertilizer need of the crops but also improves the soil texture and fulfills the global need of clearing the environment.

 India generates 320 tonnes per annum of agricultural residues such as rice straw, wheat straw, groundnut husk, coffee husk, cotton stalk, rice husk etc. In addition to that 26.6m tonnes of sugarcane trash are generated annually. Urban population of India generates approximately 110 thousand tonnes of solid waste per day major portion being organic. So, before, moving over to vermicomposting, an appreciation of certain points on waste is obviously deairable.

1. Municipal waste: Municipal wastes are largely generated by urban human population and are some of the most problematic, polluting and expensive to dispense. It is beyond reconciliations that conservative estimates India, annually generates 25 million tonnes of MSW and disposal from 4 metropolises alone annually involve expenditure amounting approximately rupees 7-8 corers. These with proper processing (viz., vermicomposting) are expected to generate high economical returns.
2. Animal dung: In India, annual production of cattle and buffalo dung is 2027.80 million tonnes and comprising of 80% of all recyclable organic wastes. Thus, vermicomposting of these for recovery of nutrients at source would be efficient in terms of savings on transportation, time, energy, economics and labour employment.
3. Agricultural waste: Generation of agricultural waste has been estimated to a tune of 320 million tonnes annually. These comprise residues as of rice, wheat straw, groundnut and sugarcane trash. However a marginal part of agricultural waste is put to agriculture use (as soil amendments), and majority is used for cattle feed, fuel and other usage. Most of these on appropriate utilizations in agricultural fields offer potentials of high level of plant nutrients.
4. Waste paper and cotton cloth: These are decomposable organic waste. These if are not being recycled for other useful products can be recycled with vermicomposting.

***Points to remember:***

* Municipal wastes are generally produced by the urban population which is very expensive to dispense.
* Animal dung comprises of 80% of all recyclable organic wastes.
* Agricultural waste generally comprises residues of rice, wheat straw, groundnut and sugarcane trash which contains high level of plant nutrients.

**TOOLS AND EQUIPMENTS USE IN VERMICOMPOSTING**

Some of the important tools and equipments used in vermicomposting are as followings

1. Shovel 2. Spade 3. Crowbars

4. Iron Basket 5. Basket 6. Bamboo basket

7. Dung fork 8. Trowel 9. Plumbing and fitting tools

10. Weighing machine - platform type 11. Power operated shredder

12. Sieving machine with 3 wire mesh sieves

13. Culture tray,bag sealing machine, bags for packing. 14. Wheel barrows

15. First aid box

**VERMICOMPOSTING**

Vermicomposting is simple low cost, low energy biotechnology of nutrient rich vermicompost production by earthworms under optimum conditions for rapid multiplication by feeding bio-degradable materials available in every household, villages and town municipality in India. It is rich in several micro floras like *Azospirillum*, *Actinomycetes* and *Phosporbacillus* which multiply fast through the digestive system of earthworm several enzymes, auxins, and complex growth regulators like gibberellins are found in vermicompost which are not generally present in different soil environment conditions thus, Vermicomposting can be a good option for micro entrepreneurship development in converting the bio-wastes into nutrient rich compost for livelihood improvement.

**Types of vermicomposting:**

1. Pits below the ground: Pits made for vermicomposting are 1 m deep and 1.5 m wide. The length varies as required.
2. Heaping above the ground: The waste material is spread on a polythene sheet placed on the ground and then covered with cattle dung. The heap method of vermicompost preparation is better than the pit method.
3. Tanks above the ground: Tanks made up of different materials such as normal bricks, hollow bricks, stones, asbestos sheets and locally available rocks can be used for vermicompost preparation. Tanks can be constructed with the dimensions suitable for operations. Tank with a dimension of 1.0 m (3 feet) width, 4.5 m (15 feet) length and 0.6 m (1.5 feet) height was found suitable for easy handling and uniformed vermicomposting.
4. Cement rings: Vermicompost can also be prepared above the ground by using cement rings. The size of the cement ring should be 90 cm in diameter and 30 cm in height.
5. Commercial model: Different commercial model for vermicomposting were developed by various institutions as per the needs of the farmers.

**Preliminary treatment of composting materials:**

1. First step is proper collection, sorting or separation of compostable and non-compostable materials like plastics, stones, glass, ceramic, and metals.
2. Biodegradable agro waste material is cut into small pieces by means of cutting machine and separate the compostable materials then spread in a layer upto1 ft and exposed to sun for a day or two.
3. Agro-Industrial Wastes: Mixing with animal dung in 3:1 proportion and later subjecting it for Vermicomposting.
4. The biodegradable agro waste is allowed to its partial decomposition for 10-15 days for achieving better activity of earthworm and nutrient enriched vermicompost production.

**Requirements for vermicomposting:**

There is no special material required for Vermicomposting. Still for planning any programme certain scientific points are required to be kept in mind for optimal result.

1. Vermibeds /container: - It is very important to select the composting bed side carefully. A side under shade in an area on an upland or elevated level to prevent water stagnation in pits during rain is ideal. Vermibeds or container may be of any shape or size but size of 1x10-20x0.6 meter tank (W x L x H) is ideal and easy to handle.
2. Waste material: Any bio-degradable materials available e.g., animal dung, agriculture waste, forestry waste, waste paper and cotton clothes, city refuse, bio-gas slurry and industrial waste.
3. Bedding materials: This is the lower most layer of earthworm feed substrate that is required to be Vermicomposted. Banana stem peels, coir pits, coconut leaves, sugarcane trash, stem of crops, grasses or husk waste or discarded cattle feed can be used.
4. Earthworm culture: - The most popular earthworm species applied or cultures in vermicomposting are *Eisenia foetida, Eudrilus eugeniae* and *Perionyx excavates*. Their potential in the utilization of organic waste reveals that they are excellent worms which were found effective in nutrient poor soils as well as in manure.
5. Feeding materials: Feeding mostly used for feeding epigeic species of earthworms are : a. Animal dung like cow dung, sheep dung, horse dung, goat dung and poultry droppings(minimum of 7 days) b. Cow dung + sheep dung + pig dung mixed in equal proportion or quantities c. Cow dung or mixed dung + rice polish in the ratio 10:3
6. Cover of feed substrate: This is required for reducing moisture loss and also save worms from extra movements. Moist gunny bags also helped in conservation of moisture.
7. Moisture content: In order to maintain the moisture content of composting to 30-40% water is sprinkled at regular intervals. Water management is most important criteria in Vermiculture as worms require moisture for their survival. Too little yields the worms and too much chases them away. Watering and monitoring of the Unit should continue for 30 days. Juvenile earthworms should appear by this time which is a healthy sign.
8. Temperature: Scientist have found that worms eat and breed best at a temperature of 25oc (degree Celsius). Thus, optimum level of temperature i.e. 10- 35oC has to be maintained during vermicomposting.
9. pH: pH of substrate should be between 6.8-7.5. For measurement of vermicompost pH paper strip or pH meter can be used.
10. Effect on C: N ratio: Plant roots in general cannot assimilate the mineral Nitrogen unless the Carbon /Nitrogen (C/N) Ratio is in the order of 20:1 or lower. Earthworm helps lower C/N ratio of fresh organic matter during respiration. To assess the role of earthworm in lowering the C/N ratio, the consumption of the carbon must be measured, and this can be done approximately, by measuring the respiration. Both the disadvantage of laboratory studies is that they do not always reflect the actual situation.

**Preparation and maintenance of base culture:**

 Base or mother or seed culture is the material which is stepwise multiplied for large scale culture for utilization in various form of vermitechnology. This has to be carefully maintained and check for health of live individuals and condition of feed which should not have any chemical i.e. lethal to worms. This means procurement point of organic waste should also be checked for seepage and contamination of feed. For initial multiplication best feed substrate is cow dung manure which is more or less in advance stage of decomposition spread it on ground to see if there is any parasite. The material is then given pre-treatment. This should be then stock on any of the scheme and proceed for multiplication of culture for vermicomposting.

**Feeds for earthworm:**

 Earthworms are consumer of decomposing organic matter. So variety of matters as earthworm feed can be used. However, efficiency and survival would depend upon various points that have already been discussed at length in preceding pages. Broadly under mentioned combinations are good for most species of earth worms used in vermiculture and vermicomposting. However, exact proportions may have to be adjusted with little pre- testing.

1. Old cow dung (Minimum 7 days)
2. Cow dung or mixed dung + Rice polish in the ratio of 10:3
3. Cow dung or mixed dung + Wheat bran in the ratio of 10:3
4. Cow dung or mixed dung + Vegetable waste in the ratio of 10:3
5. Cow dung or mixed dung + Agricultural waste in the ratio of 10:3
6. Cow dung or mixed dung + Kitchen waste in the ratio of 10:3etc,.

Any of the above materials can be taken up. These are thoroughly mixed with upturning with a spade to mix. Heap are watered and kept in shade for partial digestion for 2-3 weeks. Then it is beaten to break lumps, i.e., to make it some powdery and used as feed for earthworm.

**Preparation of vermin-beds:**

 Vermiculture bed or worm bed (3cm) can be prepared by placing after saw dust or husk or coir waste or sugarcane trash in the bottom of the tank/container. A layer of fine sand (3cm) should be spread over the culture bed followed by a layer of garden soil (3cm) and all layers must be moistened with water. If available, shredded paper or cardboard makes excellent bedding particularly when combined with typical on-farm organic resources such as straw and hay. Organic producer however must be careful to ensure that such materials are not restricted under the organic certification standards. Paper or cardboard fibre collected in municipal waste programs cannot be approved for certification purposes. There may be cases, however, where fibre resources from specific generators could be sourced and approved. Another material in this category is paper mill sludge, which has the high absorbency and small particle size that so well compliments the high C: N ratios and good bulking properties of straw, bark, wood shavings. The sludge must be approved if the user has organic certification.

 In general, it should be noted by the reader that the selection of bedding materials is the key to successful vermiculture or vermicomposting. Worms can be enormously productive (and reproductive) if conditions are good; however, their efficiency drops off rapidly when their basic needs are not met. Good bedding mixtures are as essential element in meeting those needs. They provide protection from extreme in temperature, the necessary levels and consistency of moisture, and an adequate supply of oxygen. The most difficult criterion to meet adequately is usually absorption, as most straw and even hay are not good at holding moisture. This can be easily addressed by mixing some aged or composted cattle or sheep manure with the straw.

 Mixing beddings need not be onerous process; it can be done by hand with pitchfork/dung fork (small operation), with a tractor bucket (large operations) or, if one is available, with an agricultural feed mixture.

**Layers in the beds/ fillings of vermin-beds:**

Leaves/waste materials : 25-30 cm

Partially digested dung : 5-8 cm

Earthworms/ Cocoons : 0.5-1 cm.

Partially digested dung : 8-10 cm thickness

Bedding materials : 8-10 cm thickness

**Care and release of earthworm:**

 Basically, worm care consists of providing the wigglers with the proper environment, checking them occasionally, and- other than that- leaving them alone daily care is unnecessary. Earthworms are released on the surface of the prepared substrate when the vermin-bed is ready for composting. Generally 1000-1500 numbers of earthworms is sufficient for one meter square (1M.sq.).

**Maintenance of vermicompost bed:**

Preparations of vermicomposting beds after necessary pre-tests and selection of suitable species is done. This is in fact one of the most important aspects in whole programme. Steps for the described six schemes are as under:

 1. Available container is to be selected, and cleaned for removing unwanted chemicals or other materials if any present. At bottom of 2 to 3 inches thick layer of any biodegradable matter is laid. Over this layer, 2 to 3” thick layer of partly digested and powdered cow dung is put. The whole material in bedding is sufficiently moistened (up to 40% moisture) and then live earthworms are gently released over it. A box of 1 m X 1 m X 0.5 m high can hold around 1000 – 1500 worms which require about 30 to 40 kg of whole organic matter. On top any of the earthworm feed matter is put in 7 to 9 inches thick and watered. Feed layer should be put in when previous layer disappears, i.e., converted into vermicompost. (in fact vermin-compost should be periodically removed from top). Finally on top a moist gunny bag is spread.

2. Dung and other feed materials are thoroughly mixed, watered and is subjected to partial digestion for 2 to 3 weeks in layer of 30 cm thick. On this earth worm are released

3. In container bottom, a 2 cm thick layer of fine sand is laid. Over these 2-3 inches thick layer of saw-dust is laid which is covered with a thin layer of garden soil. Thickness of each layer can be 2 to 3 inches. Whole is watered and earthworm are released. The material is then covered with a moist gunny bag. This process for vermicomposting is slow as sawdust takes time to partly decompose. However, can be useful for areas where sawdust is available. Responses of various sawdust have not yet been studied and comprise interesting lines of researches.

4. In case suitable container is not available, vermicomposting can be done on grounds. For this ground is levelled, over this, soil free of stones, glass or any form of chemical contaminants is plastered and a manageable size platform is made. Depending about availability of space and compostable organic waste , the size of platform is made .It could be 3 feet wide and 20 -50 feet long .over the platform a feed layer (9”) partly digested feed is spread . After watering, live earthworm is introduced .Finally more layer of Pre-tested waste matter can also be heaped. The whole is covered with a hessian cloth. If platforms are already under thatched roof shade, heaps can also be covered with broad leaves locally available. These however, have to be periodically replaced as they are decomposed and eaten up by worms.

5. In another variations, heaps in semi-circle can be made in same manner as in previous one. Composting can be done. Only advantage is that sufficiently moist dung does not spread in plastering with organic waste and cow dung has been done well

6. Rectangular or circular pits of dimension per requirement can be made and vermicomposting process can be taken up by any of the described methods .In this, however, packing or layering of the material has to be loose and not compacted. To certain extend common earthworm, *Metaphire posthuma* can also be used in this type of composting.

 **Vermicomposting efficiency:**

 In general a bed of 1m X 1 m X 0.3 m requires 30 to 40 kg of bedding and feed material. This can support 1000 – 1500 earthworms which would multiply and compost the matter from upper layers. So the upper layers of organic matter should be periodically replenished. Many experts opined that from top layer, accumulating cast should be periodically removed as it reduces worm activity or reproduction. Whole organic gradually get decomposed with exhilaration by worm activities and matter is converted into Vermicompost. Vermicompost is reported to contain 5 times more Nitrogen, 7 times more phosphorus, 11 times more potassium, 2 times more magnesium and calcium. This is in a form that is readily assimiable to plants.

 It has already been discussed that decomposition of organic waste depends upon several factors. Earthworm activity like burrowing, feeding and defecating (Casting) exhilarate process of decomposition. So larger the number of earthworms present in an appropriate medium and conditions , faster would be vermicomposting .This initially, i.e., immediately after introducing of worms ,first lot of Vermicompost is ready within 60- 70 days. Gradually with bacterial decomposition leading to breaking of larger masses and increase in number of worms , Vermicompost is ready in 30- 40 days only .According to available extrapolative estimates , 1 kg of earthworm (i.e., nearly 1000 adults *Eugenia species* worms)would produce 10 kg cast in 60 to 70 days.

**Precaution during the process:**

 The following precaution should be taken during vermicomposting.

* The species of earthworms, *Eisenia foetida, Eudrilus eugeniae* and *Perionyx excavatus* are ideal for the preparation of vermicompost. Most Indian species are not suitable for the purpose
* Only plant-based materials such as grass, leaves or vegetables peelings should be utilized in preparing vermicompost.
* Materials of animals organic such as egg shell, meat, bone, chicken droppings, etc. are not suitable for vermicompost.
* *Gliricidia* lopping, Tobacco leaves, onion, garlic, chilli etc. of kitchen waste are not suitable for rearing earthworm.
* The earthworm should be protected against birds, termites, ants and rats.
* Adequate moisture should be maintained during the process. Either stagnant water or lack of moisture could kill the earthworms.
* After completion of the process, vermicompost should be removed from the bed at regular interval and replace by fresh waste materials.
* Worms generally stay in the bin, but many try to leave the bin when fist introduce, or often after a rain storm when outside humidity is high. Maintaining adequate condition in the worm bin and putting a light over the bin when first introducing worms should eliminate this problem.

**Harvesting of vermicompost:**

Vermicompost is ready for harvest when it contains few to no scrapes of uneaten food or bedding and top layers appears somewhat dark brown, granular as if used dry tea leaves have been spread over the layer. Watering should be then be stopped for 5-7 days and gently compost should be scrapped from top layers. This should then be left undisturbed for 6-24 hrs. If there were any adult worms present these would move down or away from the heap materials.

There are several methods of harvesting from small scale system to commercial system of harvesting. The pyramid method of harvesting worm compost is commonly used in small-scale vermiculture, and is considered the simplest method for single layer bins. In this process, compost is separated into large lumps, which is placed back into composting for further breakdown, and lighter compost, with which the rest of the process continues. This lighter mix is placed into small piles on a trap under the sunlight. The worms instinctively burrow to the bottom of the pile. After a few minutes, the top of the pyramid is removed repeatedly, until the worms are again visible. This repeats until the mound is composed mostly of worms. While harvesting, it is also a good idea to try to pick out as many eggs/cocoons as possible and return them to the bin. Eggs are small, lemon-shaped yellowish objects that can usually be seen pretty easily with the naked eye and picked out.

 Fresh feed materials should be placed immediately after removing the compost on the worm bed. The culture bed will contain other stages of worms’ life cycle, cocoons juvenile as an adults. The bedding materials will also be eaten by the worms and should be discarded after 6 months and fresh bed should be laid. Collected vermicompost is air dried in shade before packing in convenient size.

**Sorting of earthworm:**

 Sorting of earthworm is done after every four months by gathering 6 foot square sheet of heavy plastic, a light source, A plastic dishpan for the worms, a garbage can or heavy duty plastic bag to hold the vermicompost, and some fresh bedding. Spread the plastic sheet on the floor or on large table, and overturn the entire contents of the worm bin onto it. Make about nine cone pile shape out of this material. You should see worm all over the place, but if the light is bright enough, they will quickly move away from it toward the centre of each mound.

After a few minutes, the top of the mound is removed repeatedly, until the worms are again visible. This repeats until the mound is composed mostly of worms. Eventually, the creatures will congregate in mass at the bottom of each pile. Put them in the dishpan, clean off any castings or compost and weight the worms and segregate them into cocoons, young worm and matured earthworm and use them according to your own needs. During the sorting procedure, you will encounter many earth-living creatures you had not noticed before, including springtails, white “pot worm” or enchytraeids, sow bugs, mites and even a centipede or two. Except for the centipede, which may attack worms, most of these organisms help in the process of converting your organic waste to compost.

**Transportation of live earthworm:**

 With gradual development and functioning of vermicomposting beds or tanks a stage is attained when surplus numbers of earthworms’ area produced. These can be sold to other vermiculturist and for various other usages like areas ranging from export potentials to local demands have already been indicated. In such situations transportation of live earthworm arises.

 Transportation of live earthworms is very simple and easy. Cocoons are to be handpicked with brush and collected in some container having same feed material with some moisture. Feed material should be approximately ½ gm per cocoon for every 24 hours of transportation journey period. Cocoons can be gently packed in any clean perforated container, *viz.* Softly put in muslin bag and which is put in any other plastic jar having perforated lid for aeration. Final postal packing or air freight packing should also be performed.

 Live earthworms are also similarly packed with moist feed substrate in any plastic jar with perforated lid. Feed substrate quantity should be roughly 105 gm per individual per 24 hours of transportation journey. Container space should be roughly ½ sq. Inch per individuals. 1 litre capacity jar is sufficient for approximately 200-500 live earthworms for short journeys. For local transportation, live earthworms with feed substrates can be put in clean empty bags and transported.

**Pests and diseases of vermicompost:** 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 diseases known as “sour crop” caused by environmental conditions.

**Common problems and their solution:** The most common problem is the unpleasant odours caused by lack of oxygen in the compost due to overloading of food waste, and when the bin contents become wet. The solution is to stop adding food waste until the worms and microorganisms have broken down then initial feed and to gently stir up the entire contents to promote aeration. The drainage holes may be checked for blocking. If the drainage is insufficient addition holes can be drilled.

 Worms have been known to crawl out of the bedding if conditions are not favourable for them. If this migration is not triggered by moisture content of the soil, then the bedding may be acidic. Avoid adding citrus peels and other acidic foods to the bedding as these might reduce the pH of the bedding soil. One can overcome acidic medium by adding a little garden lime and cutting down on acidic wastes.

***Points to remember:***

* Vermicomposting is a low cost technology of producing compost with the help of earthworms under optimum conditions by feeding biodegradable materials.
* Pits used for vermicomposting should be 1m deep, 1.5m wide and a desirable length.
* Heap method is better than pit method.
* Tank size of 1m width, 4.5m length and 0.6m height is suitable for easy handling and uniform vermicomposting.
* Cement rings of 90cm diameter and 30cm height placed above the ground can also be used for vermicomposting.
* A shady upland area is suitable for establishing vermibeds.
* Bedding material is the lower most feed layer of the earthworms consisting of banana stem peels, grasses, husks, coconut leaves, sugarcane trash *etc*.
* Feeding material consists of animal dung (minimum of 7 days), cow dung + sheep dung + pig dung mixed at equal proportions, and cow/mixed dung + rice polish (10:3)
* Moisture content of the composting should be maintained at 30-40% by sprinkling water at regular intervals for 30 days.
* The various layers present in a vermibed comprises of leaves/waste materials (25-30cm), partially digested dung (5-8cm), earthworms/cocoons (0.5-1cm), partially digested dung (8-10cm) and bedding material (8-10cm) thickness. Finally on the top a moist gunny bag is spread.
* Generally, 1000-1500 no. of earthworms are released for 1 m sq. Area.
* Earthworm activity like burrowing, feding and casting exhilarate the process of decomposition.
* Vermicompost is ready to harvest after 30-40 days when it contains no scrapes of uneaten food and top layer appears somewhat dark brown.
* Live earthworms and cocoons are handpicked and packed in plastic jars with perforated lids with sufficient substrate.

**VERMI-WASH**

**Definition:** Vermi-wash is liquid manure obtained from earthworm used in vermicomposting and is used as foliar spray. It contains plant growth hormones like auxin and cytokinin apart from nitrogen, phosphorus, potash and micronutrients. A container (concrete/plastic) with small hole at the base can be used for the purpose. A based layer of gravel/broken pieces of bricks are placed in the bottom of the container to the height of 10 - 15 cm above which another layer of coarse sand is placed (10 cm). Normal process of vermicomposting can be practiced in the container using earthworms. For continuous supply of vermi-wash, a pot with some holes in the bottom can be used so that the water trickles down continuously to the vermi-wash container. About 4 to5 litre water every day may be used in the pot. After about 10 days vermi-wash starts forming in the container. Vermi -wash can be diluted with water and sprayed in the evening hours.

**Uses of vermi-wash:**

Vermi-wash can be a strong fertilizer its strength is intimated by the deepness of the colour. It will range in colour from black to very weak brown. As explained above, the colour (strength) of vermin- wash is regulated by the amount of water applied in relation to the amount of vermicompost which is been made by the worms. As a general rule it should be diluted at about one part vermin-wash to nine parts water (vermi-wash: water @ 1:9 ratio) before it is applied as either a foliar spray to plants leaves. It can be drenched ‘neat’ to the soil, as long as it does not touch the plant stems.

Do not apply foliar spray to plants in the same week as fruit or vegetable is to be harvested, to ensure the fruit is clean when harvested. Always wash fruits and vegetable before use. During harvest in and any other time, vermin-wash can be drenched in the soil. Never apply a foliar spray during the heat of the day as this will scorch the leaves of the plant. Apply once or twice per week during periods of active plant growth. One knapsack (15 ltr.) will covered about 60 meter square of crop in the ground. Vermiwash can be stored in sealed containers if it not need for the garden.

***Points to remember:***

* Vermiwash is the blackish/brownish liquid manure obtained as a by-product of vermicomposting which is rich in plant growth hormones and nutrients.
* Vermiwash is used as a foliar spray by diluting 1 part of verminwash to 6 parts of water.

**PACKAGING AND MARKETING**

**Packaging**

The harvested vermicompost should be well dried in shade and a few samples from each lot should be analysed for its nutrient content which are subsequently printed in the packs for information to the buyer. The vermicompost so dried are weighed from standard weighing balance and packed in 5kg, 10kg, 25kg or 50 kg bags and stitching is done at the same time.

**Marketing**

 Marketing of vermicompost is now a potential flourishing industry due to the growing awareness among the people about the ill effect of chemical fertilizers and the relative benefit of organic farming. In India the cost of vermicompost range between 2000-5000 per tonne. The retail market in urban areas is more promising with sale price of vermicompost, in neatly designed and printed packets fetching rates as high as Rs. 15/kg. Unfortunately, the sale of an earthworm such as not been very promising in India so far the desire for angling as a game is not as popular as it is in the west. However, worms like *E. foetida* and *E. eugenia* are sold by agencies in India market especially in Pune and Bangalore. Similarly *Amyanthas morrisi* is gaining immense popularity among the hill farmers of Kumaon and Garhwal region. The only reservation against commercial exploitation of this compost is that no yardstick has been established as yet to evaluate the quality of vermicompost produced. In India government agencies could be authorized with clearly defined parameters to evaluate and certify such organic manure, otherwise soil mix with dried dung mixtures will soon flood the market in the name of vermicompost.

**Points to remember**

* The shade dried vermicompost is weighed from standard weighing balance and packed in 5kg, 10kg, 25kg or 50 kg bags and stitching is done at the same time.
* In India the cost of vermicompost range between 2000-5000 per tonne.
* In India, earthworms are commercially sold by some agencies in Pune and Bangalore.

**ADVANTAGES OF VERMICOMPOSTING**

1. Huge quantities of domestic, agricultural and rural industrial organic wastes which are readily abundant can be recycled through vermicomposting for micro-entrepreneurship development as it has emerged as an efficient, eco friendly waste management system wherein earthworms are used as natural bio-reactor for cleaning up the environment.
2. Vermicompost rich in all essential plant nutrients is an important nutrient substitution with chemical fertilizer to meet the demand under organic farming in North Eastern Hill Region of India.
3. Vermicompost substitution with fertilizer input will reduce economic input, viz., by substituting certain percent of chemical fertilizer with the vermicompost reducing the economic on input.
4. Vermicompost can be produced nearest to the site of use resulting in many advantages.
5. Provides excellent effect on overall plant growth encourages the growth of new shoots/leaves and improves the quality and shelf life of the produce.
6. Vermicompost is free flowing, easy to apply, handle and store and does not have bad odour.
7. It improves soil structure, aeration and water holding capacity and prevents soil erosion.
8. Vermicompost is rich in beneficial micro-flora such as fixers, P- Solubilizers, cellulose decomposing micro-flora etc. in addition to improve soil environment.
9. Vermicompost contains earthworm cocoons and increases the population and activity of earthworm in the soil.
10. It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
11. Vermicompost is free from pathogens, toxic elements, weed seeds etc.
12. Vermicompost minimizes the incidence of pest and diseases.
13. It enhances the decomposition of organic matter in soil.
14. It contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.
15. Extra production with or without worms can be marketed for generating extra income.

**Nutrient content of vermicompost**

The level of nutrient in compost depends upon the source of the raw material and the species of earthworm. A fine worm cast is rich in N P K besides other nutrients. Nutrients in vermicompost are in readily available form and are released within a month of application.

**Nutrient analysis of vermicompost**

***Parameters Content***

pH ` 6.8

OC% 11.88

OM% 20.46

C/N 11.64

Available N (%) 0.50

Available P (%) 0.30

Available K (%) 0.24

Ca (%) 0.17

Mg (%) 0.06

***Points to remember:***

* Vermicompost is an eco-friendly organic fertilizer which provides excellent effect on overall plant growth encourages the growth of new shoots/leaves and improves the quality and shelf life of the produce.
* Vermicompost contains 0.50% N, 0.30% P and 0.24% K.

**HOW TO USE VERMICOMPOST**

 Vermicompost can be used for all crops: agricultural, horticultural, ornamental and vegetables at any stage of the crop.

* For general field crops: Around 2–3 t ha-1 vermicompost is used by mixing with seed at the time of sowing or by row application when the seedlings are 12–15 cm in height. Normal irrigation is followed.
* For fruit trees: The amount of vermicompost ranges from 5 to 10 kg per tree depending on the age of the plant. For efficient application, a ring (15–18 cm deep) is made around the plant. A thin layer of dry cow dung and bone meal is spread along with 2–5 kg of vermicompost and water is sprayed on the surface after covering with soil.
* For vegetables: For raising seedlings to be transplanted, vermicompost at 1 t ha-1 is applied in the nursery bed. This results in healthy and vigorous seedlings. But for transplants, vermicompost at the rate of 400–500 g per plant is applied initially at the time of planting and 45 days after planting (before irrigation).
* For flowers: Vermicompost is applied at 750–1000 kg ha-1.
* For vegetable and flower crops vermicompost is applied around the base of the plant. It is then covered with soil and watered regularly.

**Advantage of applying vermicompost:**

* It is rich in plat nutrients, provides almost all the essential nutrient elements.
* Provides excellent effect on overall plant growth, encourages new shoots and leaves.
* Improves soil structure, aeration, water holding capacity and prevents soil erosion.
* Prevents nutrient losses and increases the use efficiency of chemical fertilizers.
* Minimized the incidence of pest and diseases in crops.
* Vermi-composting is free flowing, easy to handle, store and application and does not have bad odour and side effect.

**CONCLUSION**

 Vermi-culture in general are beneficial to agriculture. Vermiculture movement is going on in India with multiple objective of community waste management, highly economical way of crop production, which replaced the costly chemical fertilizers, and poverty eradication programmes in village. Vermicomposting to a non professional simply means making of compost by worms by utilizing innate behaviour. Vermicomposting process improves soil aeration and there by promotes the survival and dispersal of the useful bacterium within such system, which is slowly becoming clear day by day. Vermicompost could be preparing from the kitchen waste, farm waste, market waste, even from bio degradable city waste. The most effective uses of earthworm are organic waste management and supplement of readily available plant.

 Much emphasis has been put on increase use of organic manures globally for enhancing soil health and quality produce. As Chemical fertilizers are produce from “Vanishing Resources” of earth. Farmers urgently need a sustainable alternative, which is both economical and productive while also maintaining soil health and fertility. The new concept is “Ecological Agriculture”, which is by definition different from “Organic farming” that was focus mainly on production of chemical free foods. Ecological agriculture emphasises on total protection of food, farm and human ecosystems while improving soil fertility and development of secondary source of income for the farmers. UN has also endorsed it. Vermiculture has provides the best answer for ecological agriculture, which is synonymous with “sustainable agriculture”. Thereby it may be concluded that through vermi-culture technology,the production of vermicompost from available bio-watse vis-a-vis their large scale production has immense potentiality.

**ECONOMICS OF THE VERMICULTURE UNIT**

The size of the unit depends upon the availability of raw material and financial capability. The establishment and production cost of the small unit of 1 m x 1 m x 0.6 m (WxLxH) with bamboo thatched shed is estimated as follows under Dimapur condition:

**Estimate (Approx.):**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S. No.** | **Materials** | **Quantity** | **Cost (Rs.)** | **Cost (Rs)** |
|  | **Roofing cost** |  | **First year** | **Second year** |
| 1. | Bamboos of different quality | 10 x Rs 150 | 1,500 | - |
| 2. | Binding materials |  | 400 | - |
| 3. | Thatched grass | 50 bundles x Rs 15 | 750 | - |
| 4. | **Beds construction- Two beds of 3m x 1m x1m size beds** |
| Bricks | 200 x Rs 10 | 2,000 | - |
| Sand (Deopani) | 50 cft x Rs 40 | 2,000 | - |
| Cement | 3 bags x Rs 450 | 1,350 | - |
| Transportation and Miscellaneous costs |  | 1,000 | - |
| Labour charges |  | 2,000 | - |
| 5. | Earthworms @ 2000/m2 for 2 x 3m2  | 2,000 x 1 Rupee | 2,000 | - |
| 6. | Feeding material (locally available) and labour charges (Lump sum) |  | 4,000 | 4,000 |
| 7. | Bags, sieve, basins etc. |  | 1,000 | - |
| **Total expenditure** | **17,800** | **4,000** |
| **Production** |
| 8. | Vermicompost: Minimum production of 200 kg/m2/3-4 months (3-4 harvest / year)  | 600 kg @ Rs 30 / kg | 18000 | 18000 |
| 9. | Earthworms- Minimum four multiplications / yr (doubling the worms in every two months)(2000 worms are required/6m2 for maintenance)36000 worms will be available for sale @ Rs. 1000/- per 1000 worms | 8,000 x 1 | 8,000 | 8,000 |
|  | **Gross return** |  | **26000** | **26000** |
|  | **Net return (Gross Return- Expenditure)** |  | **8200** | **22000** |

**GENERAL FIRST AID PRECAUTIONS IN VERMICOMPOSTING**

 In case of pesticides poisoning and injuries from sharp objects, a physicians should be called immediately. Awaiting the physician’s arrival, apply the following first-aid.

**Swallowed poison:**

* Make the patient to vomit immediately. To induce vomiting, give the patient 1 teaspoonful of common salt in a glass of warm water and repeat giving until the vomit fluid is clear. Tickle the throat with finger or insert the blunt end of spoon in the throat down gently to help induce vomiting when the stomach is full of fluid.
* In case the patient is already vomiting, give him only a large amount of warm water instead of salt in warm water.
* Do not try to induce vomiting if the patient is in coma.

**Inhaled Poison:**

* Carry the patient to fresh air, open all doors and windows.
* Loosen all tight clothing’s
* Apply artificial respiration if breathing is stopped or is not regular. Avoid vigorous application of pressure to the chest.
* Keep the patient as quite as possible
* Cover the patient with blanket, if chilling.
* If the patient is convulsing, lay him in bed in dark room.
* Avoid any jarring noise.
* Do not give alcohol in any form.

**Skin Contamination:**

* Wash the skin with warm water and soap immediately
* Repeatedly cleanse the skin thoroughly with water.

**Eye Contamination:**

* Hold the eye lids open.
* Wash the eyes gently with stream of running water immediately. A delay of even a few seconds greatly increases the extent of injuries.
* Continue washing until physician arrives.
* Do not use chemicals. They may increase the injuries.

**Injuries from Sharp Object:**

* If the cuts is sever and you cannot get immediate help begin this treatment
* Rinse the cut or wound with water and apply pressure with sterile gauze, a bandage or a clean cloth
* If blood soaks through the bandage, placed another bandage over the first and keep applying pressure.
* Raise the injured body part to slow bleeding
* When bleeding stop, cover the wound with new, clean bandage.
* Do not apply tourniquet.

**Seek Medical Care If:**

* The cut is deep or its edges are widely separated
* The cuts continues to ooze and bleed even after applying pressure
* The injury was caused by burn, electrical injury or nail etc.

**References**

Bhatnagar, R.K. and Palta, R.K. (1996). Earthworm, vermiculture and vermicomposting. Kalyani Publishers. ISBN 81-7096-993-X.

Bouwman, H. and Reinecke, A. J (1991). A defined medium for study of growth and reproduction of earthworm *Eisenia foetida* (Oligochata). *Biol. Fertility of soils*. **10** (4):285-289.

Divya, U.K. (2001). Relevance of vermiculture in sustainable agriculture. *World.* 9-12.

Edward, C. A. and Loafty, J. R. (1977). Biology of earthworms, 2nd edn. Champan and Hall, London, pp : 333.

Gunasekaran, S. and Desai, U. (2000). Spectral studies on Vermicompost .*Asian J. Physics*, **9** (2), 510 - 1.

Kikon, Z.K. and Sarma, S.K. (2002). Study on the production of vermicompost from different biowastes. M.Sc. (Agri.) Thesis, School of Agricultural Science and Rural Development Nagaland University, Medziphema Campus, Nagaland.

Singh, M and Jacob, P (1998). Deep in earth. *Wastelands News*. August-October **(59)**.

Singh, R and Kumar, N (2000). Vermiculture paving the way for prosperity in hill. *Indian Farmer’s digest*. **33** (2):36 - 40.

Vilijeon and Reinecke (1992). The temperature requirements of the epigeic earthworm species *Eudrilus eugeniae* (Oligochaeta) -Labortory study. *Soil Boil Biochem*. **24** (12): 1354 - 1350.