Extension Bulletin No : 81

A Guide to Vermicomposting-Production Process and Socio Economic Aspects

Compiled and Edited by:

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Division of Natural Resource Management
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Preface

Indiscriminate use and dependency on chemical fertilizers and pesticides are the leading causes for environmental pollution globally, which results in decline in crop productivity while deterioration of soil health and secondary consequences on environmental pollution. Besides polluting the natural resources, the food consumption by human beings is also intoxicated through bio-magnification due to this overindulgence of agri-chemicals. As a result, organic source of plant nutrition for sustaining the soil health and environment while without any peril to existing crop productivity has been gaining momentum. Vermicompost is one such component which provides essential plant nutrients for supporting organic agriculture while improving the soil health without any threat to the ecosystem functioning.

Meghalaya being bestowed with vast resources of raw materials for composting such as weed biomass, animals waste, farm residues, and forests litter falls, has immense scope for organic agriculture. The state being rooted in a rich organic farming tradition, the Central Government wants this tradition to be nurtured further, so that Meghalaya can be branded as a **"100 percent organic farming State alike another Northeastern states of Sikkim".** According to a source, the Meghalaya government is mulling to convert 2 Lakh hectares of land into organic farmland by 2020. Expansion of organic farming tradition will reduce the use of inorganic / chemical fertilizers, which will also increase the carbon sink for reduction of green-house gas emissions into the atmosphere. Among the organic inputs which are used to maintain the soil fertility at desired level, vermicompost is one of the key inputs getting popular on account of its higher nutrient contents while exploring locally available cheap farm bio-wastes. Vermicompost is stable, fine granular organic manure, which enriches soil quality by improving its physical, chemical and biological properties. It is becoming popular as a major component of organic farming system in many places including Northeastern States of India. We made an attempt to enrich the farmers' of NE India about vermicomposting production technology and its socio economic befits through imparting a hand-on exercise training programme under TSP. The information shared during course of training programme with the farmers regarding vermicomposting has been documented in the form of an extension bulletin entitled ***"A Guide to vermicomposting-production process and socio economic aspects"*** for further dissemination and future use to various stakeholders including farmers of the region. The authors believe that it will serve as resource book for the farmers and extension workers involved in promoting the production of vermicompost from organic waste in this region.

The authors are thankful to the director, ICAR Research Complex for NEH Region, Umiam for providing necessary facilities under TSP. We gracefully acknowledged Nodal officer, Tribal Sub Plan, all the coordinators actively involved in the programme, research fellows, technical and field staff for making the publication a success.

Authors

Section 1: Introduction

Composting is one of the feasible means for converting bio-degradable solid wastes into beneficial organic soil amendments for supporting environment friendly agricultural production system. Many beneficial organisms and microorganisms act as chemical decomposer in the process of formation of stable organic end-products (compost) during composting. Among them, decomposers like earthworms play significant role in stimulating the process of composting, enhancing nutrient value while fastening the process of stable organic end-product formation. This process of involvement of earthworms in preparing enriched compost is called vermicomposting. It is one of the simplest methods to recycle agricultural wastes and to produce quality compost. Earthworm acts physically an aerator, crusher and mixer, chemically a degrader and biologically a stimulator in the process of decomposition. Earthworms consume biomass (decaying organic matter) and excrete it in a digested form called as worm casts or worm manure. Worm casts are popularly called as black gold. They are rich in essential plant nutrients, plant growth promoting substances, beneficial soil micro flora and having properties of inhibiting pathogenic microbes. As a result, the organic end-products produced by the use of earthworms i.e. vermicompost also inherits most of the beneficial properties (to soil health and crop productivity) of black gold. Vermicompost acts as an organic soil amendment- improves three dimensional soil health's (physical, chemical & biological properties). On application of vermicompost, it enhances the soil quality by improving its physicochemical and biological properties. The earthworm's underground burrows modify soil hydro-thermal and aeration regimes by making the soil more porous thus, allowing free movement of air, infiltration of water into deeper soil layers for better profile moisture recharge and root water uptake processes. Vermicompost is becoming popular as one the major components of the organic farming system because of its high nutritive value in addition to an important organic soil amendment.

Terms related to vermicomposting

i) **Vermiculture:** Vermiculture is the scientific method of breeding and raising earthworms under controlled conditions (mostly hydrothermal regimes).

ii) **Vermitechnology:** Vermitechnology means the combination of vermiculture and vermicomposting.

Preparation of vermicompost - at a glance

Vermicompost is obtained by turning organic debris and residues to compost using earthworms. Earthworms can feed on many types of organic waste like agricultural waste, forest litters, kitchen waste, etc. The organic wastes after entering the earthworms' alimentary canal undergo some chemical changes rendering it odourless and neutral. Vermicompost production unit can be set up in any land which is not under any economic use but shady and free from water stagnation. The site should also be nearer to a water resource. Vermicomposting production unit may be set up in cement or brick tank, wooden boxes, plastic bins, silpaulin bags of varying dimensions (preferable size of 10′ x 4′ x 2′), a basket, a bucket and even in soil pits. A quality vermicompost can be produced by using the suitable earthworm (350 - 360

worms per m3 of bed volume); bedding material that will provide the worms a relatively stable habitat and feeding with good worm food. Utmost care should be taken to maintain adequate moisture (about 60% water content by weight), aeration, and temperature (28 - 35^0 C) during the composting period.

Application of vermicompost in different crops

Fig1. Bio-resource flow of vermicompost

Section 2: Requirements for vermicomposting

a. Basic raw material

Any types of biodegradable wastes like crop residues, weed biomass, vegetable waste, leaf litter, hotel refuse, waste from agro-industries and biodegradable portion of urban and rural wastes can be used as basic raw materials for vermicomposting. A mixture of leguminous and non-leguminous crop residues enriches the quality of vermicompost.

b. Selection of suitable earthworm

Only surface dwelling earthworms should be used for vermicomposting.

c. Starter: cow dung, biogas slurry, or urine of cattle

During the beginning of the process of composting, cow dung can be used as feeding material in order to breed sufficient numbers of earthworms. On attaining desired number of worm population, subsequently other sources of organic wastes can be provided to maintain the population of earthworms.

d. Site Selection

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.

e. Containers for vermicompost production

A cement tub may be constructed to a height of 2½ feet and a breadth of 3 feet. The length may be fixed to any level depending upon the size of the room. The bottom of the tub is made sloppy to drain the excess water from vermicompost unit. A small sump is necessary to collect the drain water.

If hard floor is used, hollow blocks/bricks may be arranged in a compartment to a height of one foot, breadth of 3 feet and length to a desired level to have quick harvest. In this method, moisture assessment will be very easy. Vermicompost can also be prepared in wooden boxes, plastic buckets, silpaulin bag or in any containers with a hole at the bottom for draining excess water.

Fig 1. Cement pit

Source:ivri.nic.in/services/kvk/Download/SuccessStory2.pdf

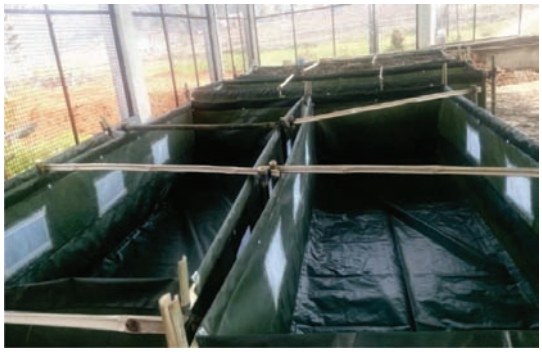


Fig 2. Silpaulin Bags at ICAR-RC-NEHR Soil Science Experimental field

Fig 3. Plastic bucket with holes at bottom

Source:https://gregthecrazyfishguy.wordpress.com

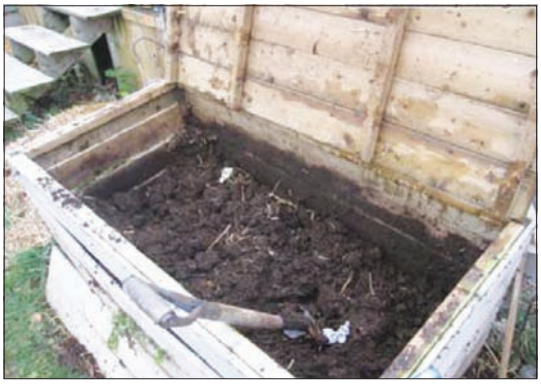


Fig 4. Wooden Box

Source: https://www.redwormcomposting.com

f. Thatched roof/vermished

A thatched roof or vermished may be provided to protect the process from direct sunlight and rain.

Fig 5. Vermibed (@ Rs 30,000 per piece) adopted from Indiamart.com

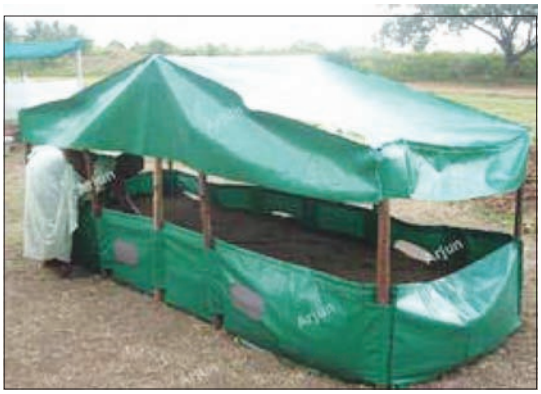


Fig 6. Vermibed with optional roof adopted from Indiamart.com

Fig 7. Vermicompost unit at Soil Science Experimental field, ICAR-RC-NEHR, Umiam

Fig 8. Vermibed with thatched roof Indiamart.com

Section 3: Role of earthworm in vermicomposting

a. A brief description of earthworm

Earthworms belong to phylum Annelida of the animal kingdom. They are long and cylindrical in shape while vary in size with large number of grooves. There are about 3000 species of earthworms identified in the world while in India alone; more than 300 of them are found which are adapted to a range of environment. Being hermaphrodite in nature, two mature earthworms are required to propagate. The clitellum is transformed into hard, girdle-like capsule called cocoon at the time of egg laying. Only a few of the shed cocoons (ranges from 1 to 5) survive and hatch. The juveniles and again the formation of cocoons take a period of 50-60 days cycle. Normally, the average life span of earthworms varies with species, ranging from 1 to 10 years.

b. Suitable earthworm for vermicomposting

The surface feeder earthworms, Epigeics are important for vermicomposting. The Epigeics used for vermicomposting are such as Eisenia foetida, Eudrilus eugeniae (both are exotic worms) and Perionyx excavatusis (native to India). Epi-anecic feeds on leaf litter and upper layers of soil. The indigenous Epi-anecic, Lampito mauritii is active in the in-situ decomposition of organic wastes and residues in soil.

Both epigeics and epi-anecics groups of earthworms are slender, shorter in length and red to dark brown in colour. They are very active in reproduction process and efficient in the recycling of organic materials as well. Among many available earthworm species, Eisenia foetida and Eudrilus eugeniae are the most popular ones in vermicomposting, mostly because of their ability to convert wide range of bio-degradable wastes into black gold while adapting to outstretched temperature ranges (0 - 40◦ C). However, the optimum temperature for most of the earthworm species in vermicomposting ranges from 20-30◦C.

Fig 1. African earthworm *(Eudrillus euginiae)*

Fig 2. Tiger worm or red wrinkle *(Eisenia foetina)*

Fig 3. Asian worms *(Perinonyx ecavatus)*

Source: adopted from http://agritech.tnau.ac.in/org_farm/orgfarm_vermicompost.html

Important characteristics of red earthworm *(Eisenia foetida)*

1. Body length 3-10 cm
2. Body weight 0.4-0.6 g
3. Maturity 50-55 days
4. Conversion rate 2.0 q/1500 worms/2 months
5. Cocoon production 1 in every 3 days
6. Incubation of cocoon 20-23days

Fig 4. Eisenia foetida cocoons

Sorce:http://www.hillagric.ac.in/edu/coa/agronomy/lect/agron-3610/Lecture-10-BINM-Vermicompost.pdf

c. How does earthworm facilitate vermicomposting?

Materials consumed by earthworms undergo physical breakdown in the gizzard resulting in particles of size <2 µ, thereby giving an enhanced surface area for microbial processing. This finally ground material is exposed to various enzymes such as protease, lipase, amylase, cellulase and chitinase secreted in lumen by the gut wall and associated microbes, which facilitates breaking down the complex biomolecules into simple compounds. Only 5-10% of the ingested material is absorbed into the tissues of worms for their growth and rest is excreted as cast.

d. Favourable conditions for earth worm culture in the composting material

- pH: Near neutral (range between 6.5 to 7.5)
- Moisture: 60-70% of the moisture (wt./wt.); below and above this range, mortality of worms taking place
- Aeration: 50% aeration from the total pore space
- Temperature: Range from 180 C to 350 C.

Section 4: Methods of vermicomposting

Vermicomposting is done by various methods. Among them, bed and pit methods are more common.

Fig 1. Bed method

Fig 2. Pit method

Source:http://www.hillagric.ac.in/edu/coa/agronomy/lect/agron-3610/Lecture-10-BINM-Vermicompost.pdf

a. **Bed method:** Composting is done on the pucca / kachcha floor by making a bed (dimension: 6 x 2 x 2 feet) of organic mixture. This method is easy to maintain and to practice.

Stepwise procedure:

1. Processing involves collection of wastes, shredding, mechanical separation of the metal, glass and ceramics and storage of organic wastes.
2. Pre-digestion of organic waste for twenty days by heaping or dumping the material along with cattle dung slurry. This process partially digests the material and fit for earthworm consumption.
3. Preparation of earthworm bed. A concrete base is required to put the waste for vermicompost preparation. Loose soil will allow the worms to go into the soil and also while watering; all the dissolvable nutrients go into the soil along with water.
4. A layer of 15-20 cm of chopped dried leaves/grasses should be kept as bedding material at the bottom of the bed.
5. Beds of partially decomposed material of size 6x2x2 feet should be made. Each bed should contain 1.5-2.0 q of raw material and the number of beds can be increased as per raw material availability and requirement.
6. Red earthworm (350 -360 worms per m3 of bed volume) should be released in the upper layer of the bed.
7. Water should be sprinkled with can immediately after the release of worms.

Fig 3. Preparation of Cow dung slurry

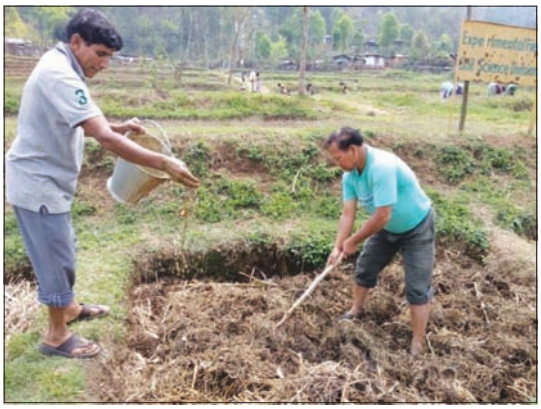


Fig 4. Mixing the organic waste with cowdung slurry

Fig 5. Watering the vermibeds

Fig 6. Vermibeds covered with gunny bags

Source: http://www.krishisewa.com/mobile/articles/soil-fertility/305-vermicompost-production-practices.html

8. Beds should be kept moist by sprinkling of water (daily) and by covering with gunny bags/polythene.
9. Bed should be turned once after 30 days for maintaining aeration and for proper decomposition.
10. Compost gets ready in 45-50 days.
11. The weight of the finished product is about 75% of the raw materials used.

b. Pit method: Composting is done in the cemented pits, wooden boxes, plastic buckets, silpaulin bag, baskets, etc. The unit is covered with thatch grass or any other locally available materials.

Stepwise procedure:

1. Pit size of dimensions 10´x 4´ x 2´ of either cement or vermibag is maintained. The length

and width can be increased or decreased depending upon the availability of material but not the depth because the earthworms' activity is confined to 2 feet depth only.

1st layer: bedding material of 1" thick with soft leaves

2nd layer: 9" thick organic residue layer finely chaffed material

3rd layer: dried cattle dung + water equal mixture of 2" layer.

The layer is continued until the pile is filled up.

2. On 25 days old unit, 795-820 worms are introduced into the pit (350 -360 worms per m3 of bed volume) without disturbing the pit.
3. Proper moisture and temperature is maintained by frequent watering, turnings and subsequent staking.
4. The turnover of the compost is 75% (If the total material accommodated in the pit is 1000 kg; the out turn will be 750 kg).
5. The filled materials are watered and turned at regular interval.

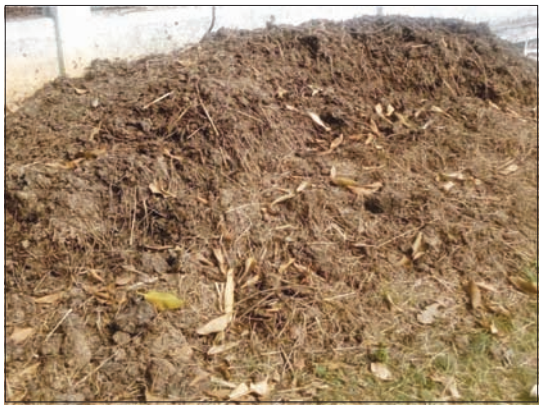


Fig 7. 20 days old dried cowdung

Fig 8. Preparation of raw material

Fig 9. Filling up the vermibag

Fig 10. Spreading of cow dung layer

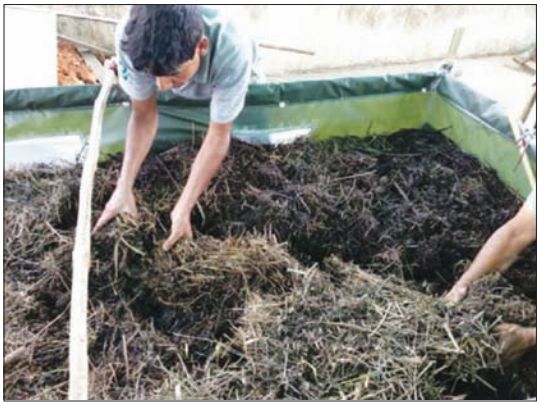


Fig 11. Turning the compost material

Fig 12. Watering the vermicompost unit

c. Recomposting and In-situ vermicomposting

Recomposting is done in the same pit or bed following the same steps as described in the above mentioned pit/bed methods.

In-situ vermicomposting can be done by direct field application of vermicompost at 5 t/ha followed by application of cow dung (2.5 cm thick layer) and then a layer of available farm waste about 15 cm thick. Watering should be done at an interval of 15 days.

Fig 13. In-situ vermicomposting

(http://www.hillagric.ac.in/edu/coa/agronomy/lectagron-3610/Lecture-10-BINM-Vermicompost.pdf)

Section 5: Handling and harvesting of vermicompost

Handling and harvesting of earthworm and vermicompost is an easy task, but it needs little attention, otherwise it may disturb the earthworm activity and also may delay the process of vermicomposting. Vermicomposting is a 5 phase process, needs care at each and every stages to get a quality vermicompost for fetching remuneration on a sustainable basis. The commonly faced problems, management options, different phases of vermicomposting, and precaution to be taken care during different phases of composting are listed below.

a. Commonly faced problem in vermicomposting

Vermicomposting is more sensitive than other composting methods and may induce to the following problems:

- Extreme weather condition: Vermicompost is susceptible to extreme weather conditions such as frost, heavy rainfall, drought and overheating.
- Putrefication: Anaerobic conditions (due to compaction and lack of oxygen) can quickly lead to putrefication.
- Predators: ants, birds, lizards may disturb the activity of earthworm.

b. Five Phases of vermicomposting

Collection of waste materials

↓

Pre-digestion

↓

Earthworm bed preparation and composting

↓

Harvesting of vermicompost & Earthworm

↓

Packing and storing of vermicompost

c. Precautions to be taken during the five phases:

i) Collection of waste material: The collected waste material should be processed for shredding, mechanical separation of the metal, glass and ceramics and should be stored in a proper place.

ii) Pre-digestion: Pre-digestion of organic waste should be done for at least 20-25days 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.

iii) 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. The five basic necessities are listed below:

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

❖ **Bedding:**

Bedding is any material that provides the worms a relatively stable habitat. This habitat must have the following characteristics:

i) High absorbency

Earthworms breathe through their skins and therefore, must have a moist environment of living. Worm dies if their skin dries out. The bedding material must be able to absorb and retain water fairly enough if the worms are to be thrived.

ii) Good bulking potential

The flow of air is reduced or eliminated if the material is too dense to begin with, or packs too tightly. There should be proper aeration as worms require oxygen to live, just as we do. A variety of factors, including the range of particle size and shape, texture, strength and rigidity of the materials affect the overall porosity of the bedding.

iii) Low protein and/or nitrogen content (High Carbon: Nitrogen ratio)

Bedding material with high Carbon: Nitrogen ratio is desirable as high protein/nitrogen levels can result in rapid degradation, heating creates an inhospitable environment for the worm. Heating can occur safely in the food layers of the vermicomposting system, but not in the bedding.

❖ **Vermiculture bed**

Vermiculture bed or worm bed (3 cm) can be prepared by placing saw dust, straw, coir waste, sugarcane trash etc. at the bottom of tub/container. A layer of fine sand of 3 cm thick should be spread over the culture bed followed by a layer of garden soil (3 cm). All layers must be moistened with water. In case of bed method, the floor of the unit should be compacted to prevent earthworms' migration into the soil.

Table 1. List of some of the commonly used vermicompost bedding materials

Bedding Material	Absorbency	Bulking Potential	C:N Ratio
Peat Moss	Good	Medium	58
Corn Silage	Medium-Good	Medium	38 - 43
Hay – general	Poor	Medium	15 - 32
Straw – general	Poor	Medium-Good	48 - 150
Straw – oat	Poor	Medium	48 - 98
Straw – wheat	Poor	Medium-Good	100 - 150
Paper from municipal waste stream	Medium-Good	Medium	127 - 178
Newspaper	Good	Medium	170
Bark – hardwoods	Poor	Good	116 - 436
Bark – softwoods	Poor	Good	131 - 1285
Corrugated cardboard	Good	Medium	563
Lumber mill waste – chipped	Poor	Good	170
Sawdust	Poor-Medium	Poor-Medium	142 - 750
Paper fibre sludge	Medium-Good	Medium	250
Paper mill sludge	Good	Medium	54
Shrub trimmings	Poor	Good	53
Hardwood chips, shavings	Poor	Good	451 - 819
Softwood chips, shavings	Poor	Good	212 - 1313
Leaves (dry, loose)	Poor-Medium	Poor-Medium	40 - 80
Corn stalks	Poor	Good	60 - 73
Corn cobs	Poor-Medium	Good	56 - 123

Source: http:// agritech.tnau.ac.in/org_farm/orgfarm_vermicompost.html

❖ **Food Source**

Under ideal conditions earthworms are able to consume in excess of their body weight each day, although in general they consume ½ of their body weight per day. They feed on anything organic that is, of plant or animal origin, manures are the most commonly used worm feedstock. Dairy and beef manures are generally considered as the best natural food for Eisenia foetida, with the possible exception of rabbit manure. The former, being more often available in large quantities, is the feed most often used.

Table 2. List of commonly used earthworm food with their advantages and disadvantages

Food	Advantages	Disadvantages
Cattle manure	Good nutrition, worms required little adaptation to it	Presence of weed seeds makes pre-composting necessary
Poultry manure	Good nutrition, results in a high-value product due to high N content	Require pre-composition due to high protein levels, used in small quantities
Sheep/Goat manure	Good nutrition	Require pre-composting (weed seeds); packing due to small particle size, extra bulky materials may be required
Hog manure	Good nutrition; produces excellent vermicompost	Usually in liquid form, must be dewatered or used with large quantities of bedding material with high absorbent capacity
Rabbit manure	Second highest N content to poultry manure, good nutrition; contains vitamins & minerals; ideal earth-worm feed	Must be leached prior to use due to high urine content; can overheat if used in large quantities; usually not available in plenty
Fresh food scraps (e.g., peels, kitchen waste, leftovers, commercial food processing wastes)	Excellent nutrition, good moisture content	High N content can result in overheating; meat & high-fat wastes can create anaerobic conditions and foul odors, attract pests, should be included only after pre-composting
Pre-composted food wastes	Good nutrition; partial decomposition makes easy and fast digestion by worms; meat and other greasy wastes are included; less tendency to overheat	Less nutrition than fresh food wastes.

Bio-solids (human waste)	Excellent nutrition and excellent product; activated or non-activated sludge, septic sludge; possibility of waste management revenues	Odour during application to beds; possibility of pathogen survival if process not completed
Seaweed	Good nutrition; results in excellent product, contain micronutrients and beneficial microbes	Salt must be rinsed off prior to use, as it is detrimental to worms; availability restricted to certain regions
Legume hays	Good feed and bedding due to high N content	Low moisture levels in comparison to other feeds, requires more input and monitoring
Corrugated cardboard (including waxed)	Excellent nutrition (glue used to hold layers together contain high-protein); worms like this material	Shredded (waxed variety) and/or soaked (non-waxed) prior to feeding
Fish, poultry offal; blood wastes; animal mortalities	High N content; problematic wastes can be turned into high-quality compost	Pre-composting required until the completion of thermophilic stage

Source: http:// agritech.tnau.ac.in/org_farm/orgfarm_vermicompost.html

- Horse dung, due to the risk of Tetanus virus, lethal to human beings is not advisable to be used as feeding material for earthworms.
- Paddy husk, marigold and pine needles should not be used as feeding materials for earthworms.

❖ **COMPOSTING**

1. Precautions to be taken while filling the vermicomposting unit:

i) The vermicompost heap should not be overloaded, in order to avoid high temperature that adversely affects earthworm's population.

ii) Organic materials free from stones, glass pieces, plastics, ceramic tubes, etc. should be used.

2. Precautions to be taken during the period of composting:

i) Temperature maintenance: Temperature should be maintained at 30o C by upturning and staking and regular sprinkling of water.

ii) Moisture maintenance - Moisture should be maintained at about 60% by proper drainage and aeration and by sprinkling of water.

iii) Avoid water stagnation: The pit should be a bit inclined toward the hole at the bottom of the pit or tube to drain out the excess water. Make sure to have a drainage channel around the heap to avoid stagnation of water.

iv) The compost materials should be turned upside down giving some day's gap without disturbing the basal layer.

*Manual method to check the moisture level: A handful of vermicompost is taken in palm, it should stick to the palm but water should not be leaked from within the fingers.

Fig 1. Squeeze a handful to determine humidity.

v) Protection from pest and diseases:

Flies are commonly attracted to the decomposing organic material. Other than this, the worms are not subjected to diseases caused by micro-organisms. A disease known as "sour crop" caused by environmental conditions and is subjected to predation by insects and certain animals.

To avoid the problems, selection of proper bedding material and composting material are must, and also have to maintain moisture and temperature in the composting unit.

Fig 2. covering compost pit with jute mate

vi) Technique to avoid predators

There are few predators like ants, birds and lizards; they damage or predate the earthworm. To avoid all these problems of predation, the pit or heap should be covered by gunny bags. Make sure that compost beds/heaps are not covered by plastic sheets/material since this can trap the heat and gases due to non-porous nature.

The most effective means of controlling ant is to increase the moisture level in bed, so that ants won't be able to tolerate anymore. The composting unit can also be converted into an Island surrounded by water.

4a.Bird

4b. Carpenter ants

Fig 3. A model of vermicompost pit surrounded by water channel

4c. Army ants

Fig 4. Predators of vermi-worm

vii) Protection from sunlight and rain: A thatched roof may be provided to protect the vermicomposting unit from direct sunlight and rain.

d. Assessing the maturity of vermicompost and harvesting

Black granular compost formation after 40-45 days at the surface of tank indicates the compost is ready for harvesting, which can be done by scrapping layer-wise from top of the tank. Watering should be stopped 5 days before the harvesting and compost should be collected from the top without disturbing the bottom layer.

Harvesting of vermicompost

In the tub method of composting, first harvesting can be done after 2 months and the castings formed on the top layer are collected periodically. The collection may be carried out once in a week, scooping the casting with hands and heaped it in a shady place. The harvesting of casting should be restricted to earthworm presence top layer. This periodical harvesting is necessary for free flow of air and retaining the quality of compost. Otherwise, when watering is done the finished compost gets compacted. In case of small bed vermicomposting method, periodical harvesting is not required. Since the height of the waste material heaped is around 1 foot, the produced vermicompost can be harvested at one time after the process is over.

e. Methods of earthworm harvesting:

1. Manual method

- Used by small scale growers.
- Involves hand sorting or picking the worm directly from compost by hand.

2. Screen method

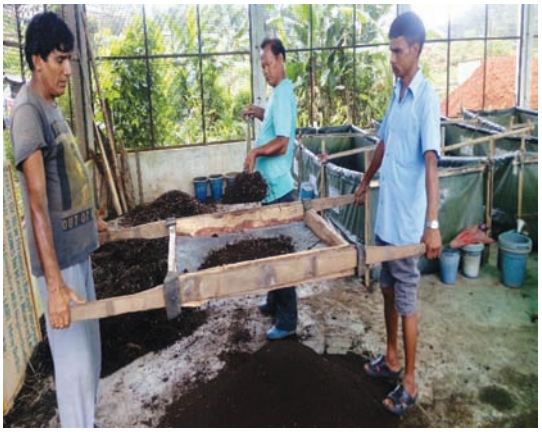
- A box is constructed with screen at bottom and compost along with earthworm spread above the box can be separated.

3. Cow Dung Ball

- A cow dung ball is placed into the bed and the ball is kept for about 24 hrs.
- The cow dung ball should be taken out on the next day and finding all the worms sticking to the ball.
- The worms can be separated out by placing the cow dung ball in a bucket full of water.
- The collected worms can be used for the next batch of composting.

Sieving may be done to separate earthworm and cocoon

Fig 5. Vermiworm at the maturity stage of the vermicompost



6a. For large scale vermicomposting

6b. For small scale vermicomposting

Fig 6. Different modes of sieving

Fig 7. Harvested vermicompost

f. Storing and packing of vermicompost

- The harvested vermicompost should be stored in dark and cool place and it should be protected from sunlight.
- It is more advisable to store the compost in open dark room rather than closed sector.
- The moisture level of prepared compost should be maintained, so packing should be done at the time of selling.
- The compost can be stored for one year without loss of quality, if moisture is maintained at 40 % level.

Section 6: Vermiwash

Vermiwash is a liquid that is collected after the passage of water through a column of worm action and is very useful as foliar spray.

a. Principles of vermiwash preparation

- Vermiwash can be produced by allowing water to percolate through the tunnels made by the earthworms on the substrate kept in a plastic barrel.
- Water is allowed to fall drop by drop from a pot hung above the barrel into the vermicomposting system.
- Vermiwash units can be set up either in barrels or in buckets or even in small earthen pots.

Alternate method of Vermiwash production:

Around 10 kg compost taken from a vermi-bed of high-density worms is put in a jute bag and dip slowly five times into a tub containing 10 liters of water. The water in the tub is ready to use as spray.

Note: Plastic bag should not be used.

b. Method of application of vermiwash

- Vermiwash alone or mixed with cow urine is also an excellent growth promoter.
- One litre of vermiwash or 0.5 litre of vermiwash + 0.5 litre of cow urines are diluted in 20 liters of water and can be used as foliar spray.

Section 7: Benefits of vermicompost

a. Nutrient content of vermicompost

The plant nutrient contents in vermicompost depend on the source of the raw materials and the earthworm species used for composting. A fine vermicompost is rich in macro-nutrients like nitrogen (N), phosphorus (P) and potash (K), and other secondary and micro-nutrients as well. Nutrients in vermicompost are present in readily available form and are released within a month of application.

Nutrient	Content
Organic carbon	9.15 to 17.98 %
Total nitrogen	1.5 to 2.10 %
Total phosphorus	1.0 to 1.50 %
Total potassium	0.60%
Ca and Mg	22.00 to 70.00 meq /100 g
Available S	128 to 548 ppm
Copper	100 ppm
Iron	1800 ppm
Zinc	50ppm

Nutrient content (N, P& K) is higher in vermicompost than rural composts.

Element	Vermicompost	Rural compost
N (%)	1.68	0.50 - 1.0
P (%)	1.06	0.40 – 0.80
K (%)	1.57	0.18 – 1.2

Source: Hazarika et al. (2006); Sharma (2002)

b. Application of vermicompost for different crops

Mode of vermicompost application depends upon the type of crop grown in the field/nursery. It is applied in the tree basin for fruit crops. It should be added in the pot mixture for potted ornamental plants and for raising seedlings. Vermicompost should be used as a component of integrated nutrient management system for better crop production.

Recommended quantity and time of application of vermicompost for different crops are list as follows:

Crop	Recommended quantity	Time of application
i. Field crop		
Rice	1 ton/acre	After transplanting
Sugarcane	1.5 ton/acre	Last ploughing
Chilli	1 ton/acre	Last ploughing
Groundnut	0.5 ton/acre	Last ploughing
Maize	1 ton/acre	Last ploughing
Turmeric	1 tone/acre	Last ploughing
ii. Fruit crop		
Grape	1 ton/acre	June-July
Citrus. Pomegranate, Guava	2 Kg per tree	At planting time and before flowering in 1-2 year old tree
Mango	2 kg per tree 5 kg per tree 10 kg per tree 20 kg per tree	At planting time 1-5 year old tree 6-9 year old tree Tree older than 10 years
iii. Vegetable crop		
Onion, Garlic, Potato, tomato, bhendi, brinjal, cabbage, cauliflower	1-1.5 ton/ acre	Last ploughing
iv. Tree		
Teak	3 kg per tree	At planting time
v. Flowers	100-200 g/sq ft	At planting time and before flowering

c. Soil health improvement and crop productivity enhancement

i) Vermicompost is simply the excreta of earthworms rich in plant nutrients, plant growth hormones and humus. It is used as an important source of organic matter to the soil as well as soil amendment for sustainable agricultural production. Its application may result in soil health improvement and crop productivity enhancement because of the following reasons:

ii) Vermicompost is rich in beneficial micro flora such as N-fixers, P-solubilizers, cellulose decomposing micro-flora, etc. which can improve soil environment.

iii) Vermicompost contains earthworm cocoons and increases the population and activity of earthworm in the soil.

iv) It prevents nutrient losses and increases the use efficiency of chemical fertilizers.

v) Vermicompost is free from pathogens, toxic elements, weed seeds, etc.

vi) Vermicompost minimizes the incidence of pests and diseases.

vii) It enhances the decomposition of organic matter in the soil.

viii) It contains valuable vitamins, enzymes and hormones like auxins, gibberellins, etc.

ix) Superiority of vermicompost over other synthetic growth media are more pronounced in plant nurseries:

- It can be used as rooting medium and for establishment of saplings in nurseries.
- Provides excellent effect on overall plant growth, encourages the growth of new shoots/leaves and improves the quality and shelf-life of the produce.

x) It improves taste, lusture and maintains the quality of the produce.

xi) Immobilized enzymes such as protease, lipase, amylase, cellulase and chitinase present in vermicompost keep on their function of biodegradation of agricultural residues in the soil so that further microbial attack is speeded up.

xii) It does not have foul odour unlike manures and decaying organic wastes.

Case studies on the effect of vermicompost application on soil and crop productivity

Manivannan *et al.* (2009) found that application of vermicompost @ 5 tonnes /ha gave significantly higher result than the application of inorganic fertilizers @ 20:80:40 kg ha-1 in Frence bean *(Phaseolus vulgaris)* in terms of growth, yield (1.6 times) and quality (protein (1.05 times) and sugar (1.01 times) content in seed) of bean. Vermicompost application also improve the physical, chemical and biological properties of clay loam and sandy loam soils of Sivapuri, Chidambaram, Tamil Nadu.

Rajkhowa and his co worker (2017) reported that the integrated use of 50% RDF + VC 2.5 T ha-1 + lime 4 q ha-1, under the hilly ecosystem of NE India, resulted in significantly higher yield of green gram (10 q ha -1) and improved the soil organic carbon (2.5 %), bacteria and fungi population and available N, P2O5 and K2O compared to the sole application of recommended dose of fertilizer.

***Effect of nutrient management on soil nutrient status and microbial population**

Treatment	pH	Nutrient (kg ha^{-1})			Soil Organic carbon (%)	Bacterial population (CFU $X10^6$ g^{-1})	Fungal population (CFU $X10^6$ g^{-1})
		N	P_2O_5	K_20			
Recommended dose of fertilizer (RDF)	4.73	275.9	20.8	121.9	2.2	177	20.3
50% RDF + Vermicompost(2.5 t ha^{-1})	4.84	283.5	25.9	138.0	2.5	202.7	28.0
50% RDF + Lime (4 q ha^{-1})	4.80	228.8	19.5	130.0	2.3	184.7	22.7
50% RDF + Vermicompost(2.5 t ha^{-1}) + Lime (4 q ha^{-1})	4.95	290.6	27.2	151.0	2.5	264.7	44.7

Source: Rajkhowa *et al*. 2017

Choudhary and Suresh Kumar (2013) showed that application of vermicompost can increase the production potential of cowpea (*Vigna unguiculata* L., Walp.) in acid soil by improving water retention at field capacity (FC), permanent wilting point (PWP), bulk density (BD), pH, and availability of nitrogen (N), phosphorus (P), and potassium (K), thereby increasing growth and yield attributes of cow pea.

Rekha *et al.* (2018) recorded that C. *annum* treated with 50% vermicompost showed significant growth than the plant growth enhancers *viz*. Gibberellic acid (GA) and Indole acetic acid (IAA) treated plants. Significant improvement in all the parameters like length of shoot, length of inter node, number of leaves and number of branches was observed in plants at the end of 3^{rd}, 4^{th} and 5^{th} weeks of treatment. The findings clearly indicate that vermicompost can be exploited as a potent biofertilizer.

Chaudhuri *et al.* (2016) observed a significant (p\0.05) but gradual increase in density (up to 20 tons ha^{-1} $year^{-1}$) and biomass (up to 30 tons ha^{-1} year-1) of earthworms with the increasing amounts of vermicompost application in pineapple plantation. During the second year, average length and width of leaves, number of leaves per plant, plant girth, fruit weight, fruit yield and fruiting percentage were highest in plot where vermicompost were applied at 20 tons ha^{-1} $year^{-1}$ compared to other treated plots and control. The study revealed that pineapple yield was very much related to the particular concentration of vermicompost, beyond the level of which production declines and increase in vegetative growth, fruit weight and fruiting percentage of pineapple are strongly linked with the soil pH, available P, available K, clay content and the earthworm density of soils.

Section 8: Vermicompost: an additional source of income

A growing number of individuals and institutions are taking interest in the production of vermicompost utilising earthworm activity. The operational cost of production of vermicompost in a year works out to be around Rs. 4.2/Kg on an average, thus, it is quite profitable to sell the compost at Rs. 10/Kg. As vermicompost can be produced in any non-economic place with shade, high humidity and cool temperature, it has a near to nil opportunity cost and provide a great scope for earning extra income for the farm. Abandoned cattle shed or poultry shed or unused buildings can be used. It can also be produced in open area, by providing low cost thatched roof to protect the process from direct sunlight and rain.

A vermicomposting unit can be set up in any convenient scale according to the availability of resources.

i. Large scale vermicomposting - commercial vermicomposting facilities may require 0.5 – 0.6 acre to house 6-8 sheds, store house, manager office, water supply system, etc.

ii. Small scale vermicomposting - farmers can prepare in their own farms in small brick tank, cement tub, wooden boxes, plastic bins or any other containers (except metal) with a drain hole at the bottom.

Apart from the compost, which has a recovery of 75%, the unit will also have as by Products:

- Adult worms for sale
- Vermi-wash – rich in plant nutrients

One success story of an entrepreneur in Manipur:

Ningthoujam Kumar Mangang is a 56-years old philosophy graduate from Manipur who taught in a government high school. He now owns a 1 acre vermicomposting farm in Nongdum of Imphal East District which is 25 Kms away from his home. The farm now has more than 75 lakhs earthworms, which breeds within a span of one and half years, and produces nearly 360 metric tons of compost a year. He sells the product to governments agencies like ICAR, State Horticultural Department, KVKs and other farmers in the state. He also exports them to Mizoram and Meghalaya farms occasionally.

a. Financial aspect of a vermicomposting unit

Two types of cost are incurred in setting up and operationalizing a vermicomposting unit viz., capital cost: incurred on development of working shed or vermished, construction of vermi tank, and other tools and implements including sieves and operational cost: incurred on seed stock (earthworms), biodegradable wastes and labour cost.

The cost of production for a vermicomposting unit consisting of a single tank with a capacity of 1000 Kg and 75% compost recovery is worked out and presented in the subsequent table. The benefits and cost were also analysed.

Benefits

- It is assumed that there will be around 2-3 cycles of production in the first year and 5 – 6 cycles in the subsequent years with a duration of each cycle at around 65-70 days.
- Benefits include the income from sale of vermicompost (@Rs 10 per Kg) and adult worms (@ Re 1 per worm) and vermiwash (@Rs 50 per Litre)

Costs

- Vermicomposting could be taken up commercially on any scale starting from 10 MT per annum (TPA) to 1000 TPA and above.
- For a small scale single tank production, the total capital cost of Rs. 3300 is required first time with a subsequent operational cost of Rs. 605

Table 1. Per Kg cost of production per cycle in a year

Sl. No.	Particulars	Cost of vermicompost production				
		Units	Quantity	Value (Rs.)		
				1st cycle	2nd cycle onwards	3rd Cycle
1	Operational costs					
	I. Material costs			4300		
	• Agricultural wastes and cow dung	Kg	1000	300	300	300
	• Earthworms	Nos.	4000	4000	-	
	II. Labour costs	Rs.		250	250	250
	• Pit filling	MD	0.25	50		
	• Worm separation	MD	0.25	50		
	• Watering	MD	0.25	50		
	• Collection of wastes	MD	0.25	50		
	• Sieving	MD	0.25	50		
	III. Interest on working capital	Rs.		455	55	55
	IV. Total operational cost (I + II + III)	Rs.		**5005**	**605**	**605**

2	Capital cost					
	• Land rent	Rs.			-	-
	• Working shed	Rs.		200	-	-
	• Vermi tank	Rs.		3000	-	-
	• Tools and implements	Rs.		100	-	-
	V. Total capital cost			**3300**	-	-
	VI. Total production costs (IV + V)			8305	605	605
	• Total vermicompost production	Kg	**750**	7500	7500	7500
	• Cost of production per Kg	Rs.		11.07	0.8	0.8

Cost and benefits of a vermicompost unit of dimension 10′x4′x2′ annually

Sl No.	Cost	Amount (Rs.)
1	Total capital cost (Fixed cost)	3300
2	Total operational cost	6215
3	Total cost	**9515**
	Benefit	
4a	Sale of vermicompost (@ Rs. 10 per Kg)	22500
4b	Sale of worms (@ Re. 1 per worm)	500
4c	Total benefit	**23000**
5	Net benefit	13,485

Inference from the financial aspects

On an average in a year, 2.25 tonnes of vermicompost can be produced from a vermi tank of dimension 10X4X2 feet square, assuming three numbers of harvest in a year. The cost of producing one kg of vermicompost in a year on an average is Rs 4.2. If the cost of the product is Rs 10 per Kg, then a profit of Rs 13,485 can be earned annually, considering at least 500 adult worms can be sold.

Note: Market risk

Low demand in the market: It is advisable to price it competitively. It will help the producer to get good profit even if the price goes low, since the cost of production is quite low.

Section 9: Potential funding sources for adoption of vermicompost unit at farmers' field

The population of the NER has quadrupled to 40 million during the past half century leading to the increase in food demand. The agricultural productivity of NER is low and uncertain due to vulnerability to flood, drought, soil erosion and heavy siltation. The existing level of productivity should be improved and sustained so as to meet the increasing food demand of the region while at the same time; the environmental sustainability should also be maintained. Approaches for boosting the agricultural productivity includes improving water use efficiency, improving the soil nutrient status and availability, increase the accessibility to formal agricultural credit, accessibility to quality seeds, etc. Vermicomposting is a process of converting waste/raw organic material into high nutrient content organic manure. Application of vermicompost to the crops also increases the water use efficiency, nutrient use efficiency, quality of grains output and there by productivity of crops. Presently the demand of vermicompost has been increased in the north east regions due to many programmes on organic production undertaken by different government agencies. The government of India and some of the state government are giving financial supporting to the farmers for the production of quality composts from various organic residues through training and through some schemes. This section will give an overview of different schemes that will support for stating a vermicomposting unit.

a. Government initiatives for the establishment of vermicomposting unit

i. Paramparagat Krishi Vikas Yojana (PKVY)

- Launched in 2015 with the aim for supporting and promoting organic farming. Funding pattern - 60:40 by the Central and State Governments in Mainland India while the share is 90:10 for North East India.

Approach

- Time frame for implementation is 3 years in a cluster basis.
- In a cluster, 65% is allocated for small and marginal farmers and 30% specifically for women.
- Assistances are provided to the cluster member at a minimal charges of Rs. 5000/unit.

ii. National Mission for Sustainable Agriculture (NMSA)

- It is one of the eight missions under National Action Plan on Climate Change (NAPCC).
- It focuses on enhancing agricultural productivity especially in rain-fed areas with a focus on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

Approach

- For vermicomposting unit: The mission incurs 50% of the cost subject to a limit Rs. 5000/- per ha and Rs. 10,000/- per beneficiary.

iii. MGNREGA

- MGNREGA has expanded its operation for the improvement of agriculture and allied services over the years.

Establishment of vermicompost production unit under the scheme has been initiated.

Unit cost of 1 unit is Rs. 9000/- with labour and material ratio of 25:75.

iv. Mission for Integrated Development of Horticulture (MIDH)

- It was launched for the holistic development of horticulture sector in the country during XII plan from 1st April, 2014.

It is the integration of the ongoing schemes of National Horticulture Mission, Horticulture Mission for North East & Himalayan States, National Bamboo Mission, National Horticulture Board, Coconut Development Board and Central Institute for Horticulture, Nagaland.

- For a vermicompost unit of size 30′× 8′×2.5′, assistance is provided up-to 50% of the total cost subject to a maximum of Rs. 50,000/- per beneficiary.
- For smaller unit: Size 12′× 4′×2′ up to 50% assistance of cost up to Rs. 8000/-.

Note: The farmers can also get the financial support for establishing the vermicompost unit from NGOs or by forming the self-help group, consisting 15 or 20 members. Centralized bank like Cental Bank of India also offers loans to meet the investment credit or working capital requirement of farmer/s and or corporates for setting up and running Vermicompost Units through schemes like Cent Vermicompost Scheme.

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