Vermicomposting: Earthworms in Action

What is vermicomposting and how is it undertaken? Few of us think of earthworms as domesticated animals that produce useful products, but the efforts of Canon Savala of FORMAT show us how to make good use of this humble, but very important creature.

Vermicomposting is the processing of organic wastes using earthworms. Earthworms ingest and transform organic residues into high quality humic material. A useful procedure for vermicomposting at home or on small farms follows:

1. **Construct the bed.** Prepare a bed with a concrete, wood or plastic sheet bottom and construct walls 20 to 30 cm in height using wood, logs or stone.
2. **Add coarse material.** Place a 10 to 15 cm layer of coarse organic materials such as banana trash, maize stover, coffee husks and other crop residues on top of the chicken wire placed on the floor of the bed (right).
3. **Add fine material and water.** Place a 5 to 10 cm layer of manure on top of the coarse material. Cattle, pig, sheep or goat manure are suitable. Green manure, such as tree leaves or grass cuttings may be substituted. Moisten the organic materials prior to the introduction of the worms.
4. **Release worms.** Release the earthworms into the moist bed. Avoid handling individual worms, rather place small handfuls of material rich in earthworms (clusters) into "holes" spaced about 0.5 m apart.
5. **Cover the bed.** Cover the bed with banana leaves or dark polythene plastic. Inspect the bed regularly during composting for moisture and the presence of predators, particularly ants. Add new layers of banana leaves occasionally as the worms consume older leaves.
6. **Feed the bed.** Organic materials may be applied to the bed regularly as additional layers or in discrete locations. A common practice is to periodically apply additional organic wastes by burying them in different positions within the bed. Vermicompost is ready after three to six months.
7. **Recover worms and compost.** When the vermicompost is ready, worms are harvested and compost processed. Collected worms may also be fed to fish and poultry. Spread vermicompost in the sun to collect remaining pockets of worms by hand as it dries (below).

In this way, earthworms are useful in organic waste recycling. A typical nutrient content of the compost is 1.9% nitrogen, 0.3% phosphorus and 2.7% potassium. Screened vermicompost serves as an excellent potting media. After vermicomposting, the worms may also be recovered for use as fishing bait or poultry feed. Keep in mind that vermicomposting requires the use of specialized worms that feed on plant litter, known as epigeics. More information on vermicomposting is available in the book "Organic Resource Management in Kenya". Earthworms provide an excellent source of protein that could even be consumed by humans but current food preferences tend to discourage this practice. *Worm burger anyone?*

Chapter 11

Using Earthworms to Make Vermicompost

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Epigeic earthworms do not inhabit the soil rather they live in and consume surface litter. These worms are domesticated and, when fed plant and animal wastes, they produce vermicompost, a process that has many advantages over conventional composting. This technology serves both social and environmental goals of sustainable agriculture and is widely employed in India, Australia, New Zealand, Cuba and Italy (Ceccanti and Masciandaro, 1999), but seldom in Africa. Epigeic earthworms do not burrow into the soil and are therefore more easily contained within vermicomposting systems than other types of earthworms.

Epigeic earthworms can be raised at several levels of production, from backyard bins to large-scale composting of agricultural, municipal and industrial biosolids (Appelhof *et al*., 1996). Epigeic earthworms fragment organic matter and provide microenvironments for the establishment of decomposing microorganisms. During vermicomposting, earthworms prefer mixtures of feed rather than a single type. Therefore, vermicomposting can be utilized to decompose mixtures of agricultural, urban or industrial organic wastes (Masciandaro *et al.*, 2000). Vermicomposts from these wastes promote growth of crops when added to the soil and compare favorably with greenhouse potting mixtures for production of seedlings and flowering plants (Edwards, 1988). There is need, however, to bridge the gap between controlled vermicomposting within the laboratory and the broader field utilization of vermicomposts in organic resource management. This chapter describes the commonly used terminologies and organisms in vermicomposting and includes step-by-step guidelines on establishing a vermicomposting unit suitable for processing agricultural and domestic wastes.

Earthworms used in vermicomposting are not wild animals and must be protected before they perform properly. They are preyed upon by many species of reptiles, birds and mammals. Even some earthworms are carnivorous, feeding on other, smaller earthworms (Lavelle, 1983). Ants are particularly effective predators of earthworms. Vermicompost containers should be constructed with a concrete base or raised be raised above the ground and covered. The technologies available for proper vermicomposting include beds, windrows and container systems, and each system has a different design.
Containers and box systems are more labour-intensive since batches have to be moved in order to add more wastes or water. It is however, the best technology for backyard vermicomposting of garden and kitchen wastes (Figure 1). Low cost beds or windrows are the simplest technologies commonly used in vermicomposting. The bed size may vary but it must be freely drained and covered. The cover is only removed when water or new feed is added. The production of vermicompost requires from three to six months.

Figure 1. Raised wooden boxes for vermicomposting, open (left) and closed (right).

Techniques and Terminologies

Vermicompost. A humic substance produced through an accelerated composting process that, when applied to soil, results in improved chemical, physical and biological properties and better conditions for plant growth.

Vermicomposting. This is the use of earthworms to transform organic materials into rich, organic fertilizers. The growth of earthworms in organic wastes is termed *vermiculture* while the processing of wastes using earthworms is known as *vermicomposting* or
vermin-stabilization.

Figure 2.
Well cured vermicompost that is

ready for use in potting mixtures or horticultural crop production.

Box 1. Differences between composting and vermicomposting technologies	
Microorganisms decompose substrate	Microorganisms and earthworms combine their activities to transform the substrate
Takes a longer period to mature	Matures relatively faster than compost
Thermophilic stage must be attained	No thermophilic stage is required
Compost is coarser textured	Vermicomposts are finer textured
Risk of heavy metals in the compost	Heavy metals are removed and accumulated within worm bodies

Advantages of Vermicomposting

Vermicomposting is important in both smallhold and large scale agricultural production in several ways. Some of the reasons why farmers will choose to practice vermicomposting are summarized as follows:

- Vermicomposting is rapid and minimizes nutrient losses.
- Suitable earthworms are found throughout the world and the best worms are available through commercial channels.
- Suitable mixtures of organic feeds are widely available and the environmental range for vermicomposting is broad.
- Environmental conditions that affect the survival and distribution of earthworms, moisture, temperature, pH and aeration can be controlled within the vermicomposting bed.
- Vermicomposting processes organic material more rapidly than traditional composting yet the final products are very similar (Box 1).
- Farmers, especially smallhold farmers need inputs for crop production and vermicomosting offers an affordable source of organic fertilizer.

Vermicomposting Species

The tiger worm *(Eisenia foetida*). This is the most commonly used species in commercial vermiculture and waste reduction (Haimi and Huhta, 1990). The species colonizes many organic wastes and is active in a wide temperature and moisture ranges (Figure 3, right). The worms are tough, readily handled, and survive in mixed species cultures. It is closely related to *Eisenia andrii*, another useful vermicomposting species. The species is commonly used in the U.S., Europe and Australia under the name *Lumbricus rubellus.* This species is raised in Kenya by several flower farms in the Central Highlands and Rift Valley.

Figure 3. Earthworm species that are well-suited for vermicomposting of agricultural wastes: Kenyan pigmented worm (left) and tiger worm (right).

Kenyan highland forest pigmented earthworm. A not yet identified earthworm was recovered by the author from highland forest litter near Muguga, Kenya. This species performance is comparable to the well-known *Eisenia foetida* (Savala, 2003). It produces finer vermicomposts than *E. foetida* but the chemical composition is comparable (Figure 3, left).

African night crawler (*Eudrilus eugeniae*). This is a large prolific African worm that is cultured in the U.S.

and elsewhere. When large worms are produced under optimum conditions, they are ideal for use as fish bait and in protein processing. It is somewhat difficult to raise because of its intolerance to low temperature and handling. The use of *E. eugeniae* in outdoor vermiculture is limited to tropical and sub-tropical regions because it prefers warmer temperatures and cannot tolerate extended periods below 16^0C (Viljoen and Reinecke, 1992).

Perionyx excavatus. This is a species well adapted to vermicomposting in the tropics. The earthworm is extremely prolific and easy to handle and harvest but it cannot tolerate temperatures below 5^0C, making it more suited to the tropics.

Dendrobaena venata. A large worm with potential to be used in vermiculture and that can also inhabit soils. It has a slow growth rate (Edwards, 1988) and the least suitable species for rapid organic matter breakdown.

Polypheretima elongata. The species is suited for use in reduction of organic solids, municipal and slaughterhouse waste, human waste and poultry and dairy manure but it is not widely available. It is restricted to tropical regions, and may not survive temperate winters.

Production of Vermicompost Using the Bed Technique

Step 1. Construct the bed. Prepare a bed with a concrete, wood or plastic sheet bottom and construct walls 20 to 30 cm in height using wood, logs or stone. Place a wooden board across the bottom and line with chicken wire for better handling and aeration (Figure 4).

Figure 4. A vermicomposting bed with rock walls and concrete floor (Step 1).

Step 2. Add coarse material. Place a 10 to 15 cm layer of coarse organic materials such as banana trash, maize stover, coffee husks and other crop residues on top of the chicken wire (Figure 5). The material must not contain poultry manure as the uric acid is harmful to worms. Composted poultry manure is, however, suitable as feed.

Figure 5. Many coarse-textured materials placed on the floor bed are suitable for vermicomposting (Step 2).

Step 3. Add fine material and water. Place a 5 to 10 cm layer of manure on top of the coarse material. Cattle, pig, sheep or goat manure are suitable. Green manure, such as tree leaves or grass cuttings may be substituted. Mix some of the fine material with the coarse layer. Mixtures of fine materials such as grass cuttings, bean threshing, maize or wheat bran and brewery waste are preferable. If the fine material is available in short supply, then use it to surround specific areas where earthworms are released. Moisten the organic materials prior to the introduction of the worms. Sufficient water should be applied so that no pockets of dried material remain. Wet materials such as banana trash and fresh manure need little watering while dried materials may require as much as 30 liters of water per m^2 of bed.

Step 4. Release worms. Release the earthworms into the moist bed. Avoid handling individual worms, rather place small handfuls of material rich in earthworms (clusters) into "holes" spaced about 0.5 m apart (Figure 6).

Figure 6. Clusters of earthworms are introduced into a well-watered composting bed (Step 4).

Step 5. Cover the bed. Cover the bed

with banana leaves (Figure 7) or dark polythene plastic. Inspect the bed regularly during composting for moisture and the presence of predators. Ants will usually leave the bed if the underlying chicken wire is violently and repeatedly shaken. Add new layers of banana leaves occasionally as the worms consume older leaves.

Figure 7. Fresh banana leaves used to cover the bed. Epigeic earthworms avoid light so beds should be covered (Step 5).

Step 6. Feed the bed. Organic materials may be applied to the bed regularly as additional layers or in discrete locations. A common practice is to periodically apply additional organic wastes by burying them in different positions within the bed. Vermicompost is ready after three to six months. Additional feeding prolongs the vermicomposting process but yields larger amounts of vermicompost. Withhold feed about three weeks before the vermicompost is collected to obtain a finer and more homogeneous and finished product.

Step 7. Recover worms and vermicompost. When the vermicompost is ready, worms are harvested and compost processed. Place a fine feed material on the bed prior to vermicompost harvesting to facilitate the collection of worms from subsequent “batches”. Wheat bran, brewers’ waste or fresh cattle manure are particularly good feeds that lure earthworms. Collected worms may also be fed to fish and poultry. Spread vermicompost in the sun to collect other pockets of worms by hand as the vermicompost dries.

Figure 8. Collecting earthworms that aggregate within the drying vermicompost for use as feed, bait or starter for the next batch of compost (Step 7).

Once worms are collected, the vermicomposting cycle may be repeated. The finished vermicompost is uniform, dark and fine textured. It is best used as the main ingredient in a seedling or potting medium after passing it through a 5 or 10 mm mesh. A typical nutrient content from a manure-based vermicompost using *E. foetida* is 1.9% N, 0.3% P and 2.7% K.

Conclusion

Earthworms are useful in organic waste recycling. If a large number of adult worms (200 to 300) are introduced into one square meter of a 20 cm-deep compost substrate, covered with fine material and optimum conditions provided, mature vermicompost can be produced within as little as 60 days. Vermicomposts have excellent chemical and physical properties that compare favorably to traditional composts. Furthermore, the diversity among epigeic earthworms enables them to be utilized across a wide range of environments and in processing many different organic materials. Earthworms transform wastes into valuable products and a clever resource manager can discover many advantages through this process.

Vermicomposts are best applied to higher-value crops as a source of plant nutrients. The material is also excellent as a major ingredient of potting mixtures and to raise seedlings for transplanting. After vermicomposting, the worms may also be recovered for use as fishing bait or feed for poultry and fish. Earthworms provide an excellent source of protein that could even be consumed by humans but current food preferences tend to discourage this practice. *Worm burger anyone?*

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