Chapter 4
Vermicomposting

The term vermicomposting means the use of earthworms (Plate 9) for composting organic residues. Earthworms can consume practically all kinds of organic matter and they can eat their own body weight per day, e.g. 1 kg of worms can consume 1 kg of residues every day. The excreta (castings) of the worms are rich in nitrate, available forms of P, K, Ca and Mg. The passage of soil through earthworms promotes the growth of bacteria and actinomycetes. Actinomycetes thrive in the presence of worms and their content in worm casts is more than six times that in the original soil.

Types of worms

A moist compost heap of 2.4 m by 1.2 m and 0.6 m high can support a population of more than 50 000 worms. The introduction of worms into a compost heap has been found to mix the materials, aerate the heap and hasten decomposition. Turning the heaps is not necessary where earthworms are present to do the mixing and aeration. The ideal environment for the worms is a shallow pit and the right sort of worm is necessary. *Lumbricus rubellus* (red worm) and *Eisenia foetida* are thermo-tolerant and so particularly useful. Field worms (*Allolobophora caliginosa*) and night crawlers (*Lumbricus terrestris*) attack organic matter from below but the latter do not thrive during active composting, being killed more easily than the others at high temperature.

European night crawlers *(Dendrabaena veneta* or *Eisenia hortensis)* are produced commercially and have been used successfully in most climates. These night crawlers grow to about 10–20 cm. The African night crawler (*Eudrilus eugeniae*), is a large, tropical worm species. It tolerates higher temperatures than *Eisenia foetida* does, provided there is ample humidity. However, it has a narrow temperature tolerance range, and it cannot survive at temperatures below 7 °C. Vermicomposting is in use in many countries. Experiences from selected countries are described as case studies.

Plate 9
Close-up of worm culture
[FAO/17449/ODOUL]

Case studies

Vermicomposting in the Philippines

The worms used in this study (FAO, 1980) were *Lumbricus rubellus* and/or *Perionyx excavator*. The worms were reared and multiplied from a commercially-obtained breeder stock in shallow wooden boxes stored in a shed. The boxes were approximately 45 cm × 60 cm × 20 cm and had drainage holes; they were stored on shelves in rows and tiers.

The bedding material comprised miscellaneous organic residues such as sawdust, cereal straw, rice husks, bagasse and cardboard, and was well moistened with water. The wet mixture was stored for about one month, being covered with a damp sack to minimize evaporation, and was mixed thoroughly several times. When fermentation was complete, chicken manure and green matter, such as ipil ipil leaves or water hyacinth, were added. The material was placed in the boxes. It was sufficiently loose for the worms to burrow and it was able to retain moisture. The proportions of the different materials varied according to the nature of the material, but the aim was to achieve a final protein content of about 15 percent. A pH value as near neutral as possible was necessary and the boxes were kept at temperatures between 20 and 27 °C (at higher temperatures, the worms aestivate; at lower temperatures, they hibernate).

Although the worms were able to eat the bedding material, the worms were fed regularly at this stage: every kilogram of worms received 1 kg of feed every 24 hours. For each 0.1 m^2 of surface area, 100 g of breeder worms were added to the boxes. The feedstuffs included chicken manure, ipil ipil, and vegetable wastes. At one farm, water hyacinth was grown specifically and used fresh (chopped up) as the sole source of feed. Some form of protection was required against predators (birds, ants, leeches, rats, frogs and centipedes).

Composting procedure

A series of pits (the number depending on the space available) were dug approximately 3 m × 4 m × 1 m deep, with sloping sides. Bamboo poles were laid in a parallel row on the pit floor and covered with a lattice of wood strips. This provided the necessary drainage as the worms could not have survived in a waterlogged environment.

The pits were lined with old feedstuff sacks to prevent the worms from escaping into the surrounding soil and yet permit drainage of excess water. The pits were then filled with rural organic residues such as straw and other crop residues, animal manure, green weeds, and leaves. The filled pits were covered loosely with soil and kept moist for a week or so. One or two spots on the heap were then well watered and worms from the breeding boxes were place on top. The worms burrowed down immediately into the damp soil.

In order to harvest the worms from the boxes, two-thirds of the box was emptied into a new box lined with banana leaf or old newspaper. The original box was then provided with fresh bedding material and those worms remaining multiplied again. The worms emptied from the box were picked out by hand for adding to the heap.

The compost pits were left for a period of two months; ideally such pits should be shaded from hot sunshine and kept moist. Within two months, about 10 kg of castings had been produced per kilogram of worms. The pits were then excavated to an extent of about two-thirds to three-quarters and the bulk of the worms removed by hand or by sieving. This left sufficient worms in the pit for further composting, and the pit was refilled with fresh organic residues. The compost was sun-dried and sieved to produce good quality material. A typical analysis was:

organic matter, 9.3 percent; N, 8.3 percent; P, 4.5 percent; K, 1.0 percent (water soluble); Ca, 0.4 percent; and Mg, 0.1 percent.

The excess worms harvested from the pits were then either used in other pits, sold to other farmers for the same purpose, used or sold as animal feed supplement, used or sold as fish food, or used in certain human food preparations.

Vermicomposting in Cuba

In Cuba, different methods are used for worm propagation and vermicomposting (Cracas, 2000).

Worm trough rows

The most common method uses cement troughs (60 cm × 180 cm) to raise worms and create worm compost. Because of the climate, they are watered by hand every day. In these beds, the only feedstock for the worms is manure. This manure is aged for about one week before being added to the trough. First, a layer of 7.5–10 cm of manure is placed in the empty trough, and then worms are added. As the worms consume the manure, more manure is layered on top, about every ten days, until the worm compost reaches to within about 5 cm of the top of the trough (about two months). Then the worms are separated from the compost and transferred to another trough.

Wind-rows

Another method of vermicomposting is wind-rows. Cow manure is piled about 90 cm across and 90 cm high. It is then seeded with worms. As the worms work their way through it, fresh manure is added to the end of the row, and the worms move forward. The rows are covered with fronds or palm leaves to keep them shaded and cool. Some of these rows have a drip system (a hose running alongside the row with holes in it) but most are watered by hand. Some of these rows are tens of metres in length. The compost is gathered from the opposite end once the worms have moved forward. It is then bagged and sold. Fresh manure, seeded with worms, begins the row and the process again. Some of the wind-rows have bricks running along their sides, but most are simply piles of manure without sides or protection. Manure is static composted for 30 days, then transferred to rows for worms to be added. After 90 days, the piles reach a height of about 90 cm. Wind-rows are also used to compost rice hulls and sugar cake (cake is what is left after sugar cane has been processed), but this too is mixed with animal manure. Food scraps are sometimes added to worm beds.

Vermiculture in India

This approach (Jambhhekar, 2002) uses the following materials: breeder worms, a wooden bed and organic wastes. The bed should be of the desired length and about 75 cm high × 120 cm wide. Worms should be applied for every part of waste. Other steps in the process are:

- Sieving and shredding – decomposition can be accelerated by shredding raw materials into small pieces.
- Blending – carbonaceous substances such as sawdust, paper and straw can be mixed with N-rich materials such as sewage sludge, biogas slurry and fish scraps to obtain a near

optimum C:N ratio. A varied mixture of substances produces good quality compost, rich in macronutrients and micronutrients.

- Half digestion – the raw materials should be kept in piles and the temperature allowed to reach 50–55 °C. The piles should remain at this temperature for seven to ten days.
- Maintaining moisture, temperature and pH – the optimum moisture level for maintaining aerobic conditions is 40–45 percent. Proper moisture and aeration can be maintained by mixing fibrous with N-rich materials. The temperature of the piles should be 28–30 °C. Higher or lower temperatures reduce the activity of microflora and earthworms. The height of the bed can help control the rise in temperature. The pH of the raw material should not exceed 6.5–7.

The compost is ready after about one month. It is black, granular, lightweight and humus-rich. In order to facilitate the separating of the worms from the compost, watering should cease two to three days before emptying the beds. This forces about 80 percent of the worms to the bottom of the bed. The remaining worms can be removed by hand. The vermicompost is then ready for application.

Some entrepreneurs have made modifications, e.g. making the floor leakproof, and providing a covered shade in order to ensure temperature regulation and protection against accumulation of excessive water in the rainy season. Although this adds to the cost, the improved efficiency of vermicomposting and faster rate of growth of earthworms more than offsets this additional cost.

The excess water, which may be leached along with the earthworms extracts, is also collected from the concrete flooring and recirculated. This ensures high N content in the finished product and also better quality because of the preserved worm extracts. The steps in this process are:

- Cattle dung is collected from cow shelters.
- The dung is kept for about 7–10 days to let it cool.
- Beds/rows of dung and crop residues/leaves, etc. are made about 1 m wide, 75 cm high and with a distance of 75 cm between two rows.
- In the beds/rows, crop waste such as leaves, straw etc. is layered alternatively with the dung to thus make a height of about 75 cm. The beds are kept as such for 4–5 days to cool.
- Water is sprinkled to let the compostable matter cool down.
- Earthworms are put on the top of the manure row/bed. About 1 kg worms in a metre-long manure row are inoculated.
- It is left undisturbed for 2–3 days after covering with banana leaves. Covering with jute bags or sacks is not recommended as it heats the manure bed.
- The bed is opened after 2–3 days. The upper portion of about 10 cm of manure is loosened with the help of a suitable hand tool.
- The bed is covered again. The worms feed on an upper bed of about 10 cm. This portion becomes vermicasted in about 7–10 days.
- This portion (vermicasted manure) is removed and collected near the bed. Another upper portion of 10 cm is loosened and covered again with the leaves.
- Moisture is maintained in the bed by regular sprinkling of water.
- The loosened portion of the manure is vermicasted in another 7–10 days and is removed again.

- Thus, in about 40 days, about 60 cm of the bed is converted into vermicompost and is collected on 3–4 occasions.
- The remaining bed of about 10 cm in height contains earthworm mixed manure.
- Fresh manure mixture/organic residues, etc. are again put on the residual bed containing earthworms of about 10 cm and the composting process is restarted.
- The manure collected from the bed is freed of worms through sieving. Uncomposted or foreign matter is also removed in this way.
- The screened manure is bagged and used or sold as required.

Enhancing vermicompost production

Vermicompost production using epigeic compost worms such as *Eisenia foetida*, *Lumbricus rubellus* and *Eudrilus eugeniae* can be enhanced effectively by supplementing the organic wastes used for vermicomposting with cow urine . Undiluted urine can be used for moistening organic wastes during the preliminary composting period (before the addition of worms.). After the initiation of worm activity, urine can be diluted with an equal quantity of water. No problems have been observed with daily use of diluted cow urine for moistening the vermicomposting bed. This simple technique can yield vermicompost with a higher N content. Moreover, worms have been found to become very active and vermicompost can be harvested at least 10 days early.

Integrating traditional composting and vermicomposting

Problems associated with traditional thermophilic composting relate to: long duration of the process, frequent turning of the material, material size reduction to enhance the surface area, loss of nutrients during the prolonged process, and the heterogeneous resultant product. However, the main advantage of thermophilic composting is that the temperatures reached during the process are high enough for an adequate pathogen kill.

In vermicomposting, the earthworms take over both the roles of turning and maintaining the material in an aerobic condition, thereby reducing the need for mechanical operations. In addition, the product (vermicompost) is homogenous. However, the major drawback of the vermicomposting process is that the temperature is not high enough for an acceptable pathogen kill. Whereas in traditional thermophilic composting the temperatures exceed 70 °C, the vermicomposting processes must be maintained at less than 35 °C.

A study has examined the possibility of integrating traditional thermophilic composting and vermicomposting (Ndegwa and Thompson, 2001). The work involved combining pertinent attributes from each of the two processes to enhance the overall process and improve the product qualities. The two approaches investigated in the study related to: (i) pre-composting followed by vermicomposting; and (ii) pre-vermicomposting followed by composting. The duration of each of the combined operations viz. composting and vermicomposting was four weeks. A comparison was made with vermicomposting alone (duration: 56 days). The results indicated that the combination of the two processes shortened the stabilization time and improved product quality. Furthermore, the resultant product was more stable and consistent, had less potential impact on the environment, and met pathogen reduction requirements.