Vermicompost
high-grade fertiliser
for improved soil fertility
Crucial to organic agriculture

The use of compost can make a crucial contribution to the maintenance and improvement of soil fertility. Composting is an ancient method of organic fertilisation used in agriculture and gardening: in south-east Asia, for example, soil fertility has been maintained in this way for the past six thousand years. Worm compost (also known as vermicompost, from “vermis”, the Latin for “worm”) is an especially high-grade and nutrient-rich fertiliser. This black substrate is what remains of organic matter after being broken down by micro-organisms, and especially by worms. Many tea and coffee growers keep small herds of cattle for extra income and use the dung produced as feed substrate for worm composting. The valuable and nutrient-rich worm compost is then employed as a fertiliser on the tea and coffee plantations, thereby achieving sustained increases in harvest yields (just one example of how recycling management is possible in a very confined space).

Preparation of the source material (wild sunflowers) for the worm compost (Idulgashinna Tea Estate, Stassen Natural Foods, Sri Lanka)
Wide-spread use in the tropics and sub-tropics

In (sub-) tropical countries in which the soil’s water- and nutrient-retention capacity is usually only very limited, this method of composting takes on great significance. The vast majority of naturally occurring earthworms are indigenous to the tropics. Major vermicompost centres can be found, for example, in Cuba and India. Many of the Naturland member farms in Asia and Latin America have been using worm humus for years. They try out and develop their own procedures, adapting them to local conditions and the organisation of their particular operation.

Flexible method

Vermiculture can be practised anywhere, even on a small scale, and easily be integrated into any agricultural system. For example, the waste from the crops currently being produced and processed (e. g. coffee pulp, or cuttings from shade trees in tea gardens) can easily be integrated into the worm compost as a co-substrate. Vegetable waste has a more complex structure and a higher C/N ratio than cattle slurry. Besides this, micro-organisms can pre-digest it, thereby ensuring good aeration. Worm humus is a fertiliser suitable for all types of crops.

Rapid conversion

The humus can be harvested within as little as 2 – 5 months after start-up. However, the conversion period and the worms’ rate of reproduction always depend on the source material used, the worms’ living conditions (humidity, temperature) and how well the composting is managed.

What exactly is vermicompost?

Worm compost is one of the highest-grade and most nutrient-rich natural fertilisers in the world. Its soil conditioning properties and plant-strengthening effect encourage the growth and yield of the plants.

Characteristics:

- similar to the soil found in deciduous woodlands and mixed forests
- black, odourless and crumbly substrate
- balanced nutritional composition for plants
- it contains an above-average number of micro-organisms which revitalise the soil
- loose yet stable soil structure (clay-humus complexes)
- absolutely free from all types of synthetic chemical additives
Crumbly worm compost substrate (SPOSEL, Chiapas, Mexico)

Conversion processes:

- accelerated conversion of organic waste matter by micro-organisms (bacteria, fungi) and by compost worms
- the worms coat the organic material with their mucous excretions which contain micro-organisms (bacteria, fungi etc.) --> microbial predecomposition
- the worms convert the pre-fermented composting material into worm humus, along with mineral substances
- worm humus is high in micro-organisms, enzymes and nutrients --> ideal supplier of nutrients bonded in clay-humus complexes, good plant availability
- cold composting (at temperatures below 50°C)
Compost worms coat organic material with mucous (Ambootia Tea Group, Happy Valley Tea Estate in Darjeeling, India).

**Plant nutritionists – encouragement of soil fertility**

- worm humus acts as an “appetiser” for plants, increasing their capacity to absorb water and nutrients
- earthworm humus contains the essential nutrients of nitrogen (N), phosphor (P) and potash (K) in much larger quantities than are present in the soil or in comparable compost. This makes it richer than mature manure or garden compost
- during the course of composting, the ratio shifts in favour of N (The C/N ratio of mature compost should be below 20. The higher the proportion of nitrogen in compost (primarily organically bonded nitrate and ammonium), the better, this complex process is performed by the worm in its gastrointestinal tract.)
Nutritional composition of vermicompost and conventional compost
Source: Practical on Vermicompost, Dr. D. K. Shahi

<table>
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<th>nutrients</th>
<th>vermicompost</th>
<th>conventional compost</th>
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<tr>
<td>N</td>
<td>1.9%</td>
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<td>C/N</td>
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<tr>
<td>P (%)</td>
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<td>40</td>
</tr>
<tr>
<td>Mn (ppm)</td>
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Soil conditioning and plant strengthening effect

- improvement of soil structure (better bonding and storage of nutrients and water)
- acceleration of regeneration of depleted and infertile soils (from permanent crops, pesticides, artificial fertilisers)
- growth of healthy, pest-resistant plants
- encouragement of root growth
- minimisation and defence against pests (phytopathogenic fungi, aphids) and soil-borne pathogens

Minimisation of solid waste with low toxicity and containing heavy metals

The worms are capable of accelerating the processing of waste. This means they can be used to detoxify soils contaminated with solid waste, pesticides or heavy metals from industrial or agricultural waste. The worms do this by storing these substances in their tissue. Worm enzymes and microbes in the worm humus can also degrade toxic substances. Although worms have proven to be highly resistant, the toxicity level should not be too high. To avoid these accumulated pollutants being passed on, the worm should be removed from the system after it has done its job, for when the “contaminated” worm dies, everything will be released back into the soil. If the worm is used as a source of protein-rich fodder, then, for example, the heavy metals will accumulate in the food chain.
Which species of earthworms?

Special species of earthworms have been bred since about 1930 for use in worm composting. Of the over 3,000 species of earthworms, special compost worms (mainly Eisenia fetida) are used in vermiculture.

Eisenia fetida – hard workers

The most frequently used species of compost worm is the red wiggler (Eisenia fetida), which is naturally predisposed towards high rates of conversion and reproduction. Eisenia fetida (formerly foetida) grow to a length of 6 – 13 cm on average. They are reddish in colour, with yellowish rings, making them easy to distinguish from other species. In threatening situations they exude a foul-smelling mucous, which is the reason for the name of this species: “fetida” means stinky.

Transformation of the organic material:

- between half and the whole of the equivalent of its body mass a day (depending on conditions: climate, food supply)
- under perfect conditions: 3,500 worms (approx. 1 kg) devour 1 kg kitchen waste a day
- 200 - 300 worms can convert a volume of 1 m² and 20 cm depth into worm humus within 60 days
- of 100% source material, 15% is what remains in the form of worm compost

Compost worms (SPOSEL, Chiapas, Mexico)
Reproduction:
The good living conditions in the compost make the development cycle of Eisenia fetida the shortest of all earthworms, with a correspondingly high rate of reproduction: the young worms hatch 3 weeks after the eggs are laid and are sexually mature within another 9 weeks.

Under perfect conditions:
- the worm population doubles every 3 months (4 generations a year)
- 500 - 600 offspring per worm per year

Further uses:
In some instances, earthworms are used to feed fish or poultry. In Mexico, the banana worm bread is also baked.

Eudrilus eugeniae – less well known
The less well known *Eudrilus eugeniae* is used in the tropics. It is also known by the name of *African Nightcrawler* ("African" or "ANC" for short) and is used, for example, in Naturland’s operations in India.
Feed
Compost worms, which have a huge appetite, feed on almost anything from vegetable or animal sources. However, Eisenia fetida is particularly partial to cattle excrement. For this reason, cattle manure is the most commonly used source material for worm composting. However, green and nutrient-rich vegetable waste is often also composted, matter which rots only slowly on conventional compost heaps. Generally speaking, a wide range of source materials is suitable as worm fodder. However, the waste used should, for preference, be from organic agricultural sources. As a basic principle it can be said that, the finer the material offered to these energetic workers (worms, microbes, microorganisms), the faster its conversion. Since worms are creatures of habit, the composition of the compost should remain fairly constant throughout the composting period. If the material added to the compost heap is too coarse, this cannot be degraded properly. The worms then have to get used to new fodder.

Tree cuttings are shredded for use in worm compost (TPI, Seeyok Tea Estate in Darjeeling, India).
Wild sunflowers are shredded for use in worm compost (Idulgashinna Tea Estate, Stassen Natural Foods, Sri Lanka).

**Source material for the fodder:**

- **animal excrement from:**
  - cattle
  - horses
  - sheep
  - pigs
  - poultry
  - goats
  - hares
  - donkeys

- **vegetable waste:**
  - hay
  - grass, silage (retains moisture)
  - weeds
  - leaves
  - foliage, for example from tea or coffee trees (chopped small)
  - cereals
  - coffee pulp
  - bean pods
  - banana and orange peelings

- forest soil, ash
- pre-composted kitchen waste
- fish remains, seaweed
Nutritional balance in feed:

The nitrogen content should not be too high, because otherwise the activity of the micro-organisms increases greatly, thus raising the temperature in the substrate. The worms then try to escape, and those which are not fast enough die. Fresh cattle manure should not be fed to them either; it must be pre-fermented. It must be moistened in a separate bed, built on a slight slope. If 2 – 3 drops appear when it is squeezed, the manure can be added to the worm bed.

Feeding process:

- at regular intervals of 10 – 30 days
- manually or automatically

Various worm composting methods

There are various methods of making worm compost: tray stacks, windrows, compost heaps and bins, complete recycling systems, containers and box systems. Sometimes a simple wooden chest is sufficient. Most worm composting methods are relatively simple and require little effort.

Size of the worm compost heap

Most compost heaps are 1 – 2 m wide, 30 – 50 cm high, and can be as long as desired. Since Eisenia fetida is an epigeic species, i.e. a surface dweller which works in the upper layers of the soil, the compost should not be over 60 cm deep.

Location of worm compost heaps

The compost heaps can be distributed between rows of trees, or housed in shelters.
Plant for production of worm compost (Tea Promoters India, Seeyok, Darjeeling, India)

Compost bed 50 m long laid out between avocado trees (avocado project ABIOEM in Uruapan, Michoacan, Mexico)
Storage container for the vermi-wash between avocado trees (avocado project ABIOEM in Uruapan, Michoacan, Mexico)

**Climate**

The *Eisenia fetida* is very tolerant of temperatures between 0 - 30°C and is therefore well suited to locations in the open air. To ensure that the earthworm bed does not get too hot, shade trees or a roof should protect it from direct sunshine. Fresh manure must first be prefermented. The humus should not be too moist since it can otherwise lead to an infection of the female reproduction organs. (Test by squeezing it. No more than 5 drops of liquid should come out of a handful.) In order to obtain constantly high rates of yield and reproduction, the following general conditions should be maintained by making adjustments to the processes:

- temperature 20°C - 25°C (ideally)
- humidity 80%
- sufficient oxygen (loose soil, to guarantee aerobic conditions)
- pH-value 7.5 – 8.0 (ideal), 5.0 - 8.4 (tolerance value) --> Acidic pH-value can be compensated by adding calcium carbonate
Squeeze a handful to determine humidity (SPOSEL, Chiapas, Mexico).

The worms’ activity is monitored by specially trained workers (Ambootia Tea Group, Happy Valley Tea Estate in Darjeeling, India).
Construction of a worm farm

Stage 1: Bedding
To create a perfect climate, a “worm bed” is made by using coarse materials such as shredded twigs, coconut fibre, mulch or wood shavings/sawdust as a basis, varying according to what is available locally. All the components should have been produced organically.

Properties of the worm bed:
- protection from extreme fluctuations in temperature
- guarantees well-balanced humidity and aeration

Stage 2: Feed
The next step is to cover the worm bed with a layer of feed matter consisting of vegetable waste and manure.

Stage 3: Introducing the worms
The worms are added to the compost heap in batches.

Stage 4: Watering the worm compost
The amount of water needed depends on the climate (temperature, evaporation).

Stage 5: Cover the compost heap
In order to protect the worm population from predators such as birds, rats, snakes, cockroaches and ants, but also from heavy rains, the compost heap needs to be covered. Here, the most suitable materials are:
- banana leaves
- polyethylene foil
- wood
- bamboo
- bricks
- corrugated sheeting
- palm leaves

Stage 6: Monitoring the worm compost
The compost heap should be checked once a week.
Covering with locally available plastic sheeting (Idulgashinna Tea Estate, Stassen Natural Foods, Sri Lanka)

Regular inspection of the composting process (SPOSEL, Chiapas, Mexico)
**Harvesting the vermicompost**

The compost can be harvested in about 2 – 5 months. There are various ways to go about it:

If the compost heap takes the form of a windrow, the source material is introduced to one end of the windrow and added to continuously. Care should be taken that the new material added is in contact with the old substrate. The compost worms move over to the fresh substrate and continue conversion there. The older material can then be harvested and, if necessary, left to mature.

If the worm bed is constructed in layers, this should consist of several trays. The bottom tray (collecting pan) serves as a reservoir for the liquid seepage. The bottom of the working trays designed to hold the compost material should have holes or slits in them large enough for the worms to pass through. They are placed on the collecting pan. The first working tray is now filled with the source material: at the bottom comes a layer of coarse material (e. g. wood shavings), and on top of this a layer of finer material (leaves and manure). As soon as most of the material has been converted to compost, the next working tray is placed on top of it, so that the bottom of this tray is in contact with the material below, and filled with fresh material. Once the worms have migrated up into the new tray, the worm compost can be removed from the lower tray. If the compost bed is on a slight incline and not filled completely, then the finished compost is sieved into the upper part. Alternatively, the upper humus layer can be removed carefully by hand, and the worms then retreat downwards.

In most cases the farms and co-operatives use the worm compost for their own fields and gardens, but there are plants which sell the worm humus.

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**Earthworm bed made of concrete, on a slight incline. The humus in the upper part is ready.**

(Paluch’én, Chiapas, Mexico)
Storage of vermicompost

The worm humus is slightly moistened and then stored in sacks in the shade. The humus is stored for up to one month before being applied to the soil.

Spreading the vermicompost

The vermicompost is usually spread when it is moist. Once the “finished” compost has been worked into the soil, it serves not only as a nutrient carrier or fertiliser, but also helps to keep the soil loose and improves its water storage capacity.

- The compost is usually spread one to three times a year.
- 10 litres of worm humus can supply about 100 litres of soil with all the nutrients and soil biota which plants require.
The liquid variety: vermiwash

The seepage (vermiwash) drained from the worm bed is especially valued, and is used in diluted form as foliar spray. This concentrated liquid fertiliser contains valuable amino and silicic acids.

A method to prepare vermiwash:
If vermicompost, when finished, is diluted with water, this becomes the liquid “vermiwash” (“humus liquido”). A decoction is made of one part vermicompost to ten or twenty parts water, and left to stand for between 15 and 24 hours. There are then two procedures to choose from: either an air pump is used to pump air into the concoction throughout this period, or no air is pumped in (a method which, however, since anaerobic, is suspected of producing substances harmful to plants).
Liquid vermiwash created by rainfall is drained into collecting vessels (ABIOEM Uruapan, Michoacan, Mexico).

Worm beds with bottles to capture the vermiwash, roofed over because of the heavy monsoon rains (Am-bootia Tea Group, Moodakotee Tea Estate in Darjeeling, India)
Application of vermiwash:
The vermiwash is either poured onto the soil or sprayed on the leaves. This strengthens the epidermis of the leaves and reduces damage by aphids and penetrating fungal spores. It is also possible to use vermiwash in drip irrigation or other standard methods of irrigation, thereby considerably reducing the amount of work required.

Management

Vermiculture: more sensitive than other composting methods

- Vermicompost is susceptible to extreme weather conditions such as frost, heavy rainfall, drought and overheating.
- Anaerobic conditions (due to compaction) can quickly lead to putrefaction and lack of oxygen.
- Every stage, from construction to feeding and irrigation, must be precisely controlled and monitored.

Trained workers assume responsibility for the worm compost (Ambootia Tea Group, Moodakotee Tea Estate in Darjeeling, India).
Great potential for large and small organic farms alike

Vermicompost is a high-grade, nutrient-rich plant fertiliser which at the same time improves the structure of the soil and its water- and nutrient-storage capacity. Farms in Mexico, for example, were able to increase their coffee yields from 6 to 8 quintals (qq). The worms are an one-off investment and, if treated properly, will continue to propagate. Nevertheless, the procedure is labour intensive and time consuming and requires fastidious management. It is therefore necessary to see that newcomers are trained properly. In order to impart the expertise and knowledge necessary for success in the sensitive science of vermicomposting, co-operatives and communities hold regular workshops on the topic of soil enhancement, during which they hand out “worm starter packages”. For example, 60 smallholders are given 60 kg of earthworms, which they then continue to breed.

Worm compost propagation for the worm starter package given to smallholders ("PDS Organic Spices", Kerala, India)
Sources

Literature:


Starck, G.: Wurmkompost - Was ist das eigentlich? In: Garten Organisch 2/91


Photos:

Naturland