Vermicomposting:
Worms Around the World Making Black Gold

This “how to” guide on worm composting has been adapted from agricultural research and experiences at the University of Washington-Bothell, Washington State, USA, in an African Conservation and Sustainability Course, Spring quarter 2007. The adaptation considered cultural differences, climate/rainfall, crop output, worm species, economic resources and agricultural uses of the earth worm castings. This research was compiled at the request of Village Volunteers of Seattle, Washington to be used as a conservation resource on their database. This compilation is the result of many worm farmers’ research and personal experiences, which were modified to be used in Ghana, but could be tailored to any demographic region/country of the world.

Introduction

Vermicompost (also called worm compost, vermicast, worm castings, worm humus or worm manure) is the base-product of the breakdown of natural material by earthworms. Vermicompost is a nutrient-rich, organic fertilizer, and soil conditioner. The process of making vermicompost is called vermicomposting. Vermicompost contains not only worm castings, but also bedding materials and organic wastes at a mixture of stages of decomposition. It also contains worms at different stages of growth and other microorganisms associated with the process. Earthworms’ castings in the home garden usually contain 5 to 10 times more additional nitrogen, phosphorous, and potassium than the adjacent soil (Composting 101). Secretions in the intestinal tracts of the worms, along with soil passing through the worms, make the nutrients needed by plants more concentrated and available for plant uptake (IOBB)

Using a worm box, pile, pit, bin, or windrow helps expand and develop many skills needed to enhance sustainability of farming activities. In essence, worms work as natural bioreactors. The technique generates organic fertilizers, permits harmless disposal of certain organic wastes and decreases the requirement for landfill.
Vermicompsting can be performed all year-round, providing that environmental conditions remain within acceptable limits. For improved efficiency, care should be taken to ensure that organic feedstock and environmental circumstances allow worms to reproduce productively and tolerate climatic fluctuations. Given appropriate conditions, vermicomposting appears to offer a relatively uncomplicated solution to the management of compostable organic wastes.

Section Sources:

Composting 101:
http://www.composting101.com/worms-cut-waste-article.html
Feeding:
http://www.compostsantacruzcounty.org/Home_Composting/Worm_Composting/worm_feeding.htm
IOBB:
http://www.iobbnet.org/drupal/node/view/609

Wikipedia : http://en.wikipedia.org/wiki/Earthworm

General Considerations
What worms need to create and sustain optimal vermicomposting conditions.

Five Rudimentary Conditions to Successful Vermicomposting

1. Living Environment
2. Food Source
3. Moisture
4. Aeration
5. Protection from Temperature Extremes

1. Living Environment or Bedding is any material that provides the worms with a relatively stable habitat. This habitat must have the following characteristics:

- **High absorbency:** Worms breathe through their skins and therefore must have a moist environment in which to live. If a worm's skin dries out, it dies. The bedding must be able to absorb and retain water fairly well if the worms are to thrive.
- **Good bulking capability:** If the material is too dense to begin with, or packs too firmly, then the flow of air is reduced. Worms require oxygen to live, just as we do. Different materials affect the overall porosity of the bedding through a variety of factors, including the range of particle size and shape, the texture, and the strength and rigidity of its structure.
- **Low protein and/or nitrogen content (high Carbon: Nitrogen ratio):** Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid disrepair and its associated heating, creating harsh, often fatal, conditions. Heating can transpire safely in the food layers of the vermiculture or vermicomposting system, but not in the bedding.

2. Worm Food: Compost worms are big eaters. Under model conditions, they are able to devour in excess of their body weight each day, although the general rule is 1/2 of their body weight per day. They will eat almost everything organic (that is, of plant or animal origin), but they definitely prefer some foods to others.

Do Feed Worms:

- Vegetable scraps: crop waste
- Tree and Bush leaves, and grasses
- Fruit scraps and peels (mold/rot is fine)
- Moldy Bread and grains
- Used Tea leaves
- Non-greasy food leftovers
- Coffee grounds
- Crushed egg shells
- Most moist paper products
- Manures (must pre compost)

Don't Feed Worms:

- Don't overfeed citrus—should be no more than 1/5 of worm food
- Meats, fish
- Greasy foods

- Dairy products
- Twigs and branches
- Dog/cat feces

3. Moisture: Worms breathe through their skins; moisture content in the bedding of less than 50% is dangerous to the creatures. With the exception of extreme heat or cold, nothing will kill worms faster than a lack of adequate moisture. The bedding used must be able to hold sufficient moisture if the worms are to have a livable environment.

The ideal moisture-content range for materials in conventional composting systems is 45-60% (Rink et al, 1992). In contrast, the ideal moisture-content range for vermicomposting or vermiculture processes is 70-90%. The average worm weight increases with moisture content (among other variables).

4. Aeration: Worms are oxygen breathers and cannot live an-aerobically (defined as the absence of oxygen). When factors such as high levels of grease in the feedstock or excessive moisture combined with poor aeration conspire to cut off oxygen supplies, areas of the worm bed, or even the entire system, can become anaerobic. This will kill the worms very quickly. Not only are the worms deprived of oxygen, they are also killed by toxic substances (e.g., ammonia) created by different sets of microbes that bloom under these conditions. This is one of the main reasons for not including meat or other greasy wastes in worm feedstock unless they have been pre-composted to break down the oils and fats. Although composting worms' oxygen requirements are essential, however, they are also comparatively moderate.

5. Temperature Control: Controlling temperature to within the worms' tolerance is crucial to both vermicomposting and vermiculture processes. This does not mean, however, that heated buildings or cooling systems are required.

- **High temperatures.** Compost worms can survive temperatures in the mid-30s but prefer a range in the 20s (oC). Above 35oC will cause the worms to leave the area. If they cannot leave, they will quickly die. In general, warmer temperatures (above 20oC) stimulate reproduction.
- **Low temperatures.** It is generally considered necessary to keep the temperatures above 10 oC (minimum) and preferably 15 o C for vermicomposting efficiency and above 15 oC (minimum) and preferably 20 oC for productive vermiculture operations.

Section Sources:

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Case Study

Note: this section is intended to show from an actual geographic location how the 5 essentials listed could be successfully used in worm composting. This methodology can be applied to most locations through critical reasoning, researching and adaptation (trial and error/success), except where extreme weather conditions prevail.

Location

Atorkor is a village in the Keta District of Ghana. Atorkor is located in the south-eastern part of Ghana on the Atlantic Coast.

Temperature

Atorkor village is located in the littoral anomalous zone of Ghana, and thus the village experiences high temperatures year round. The hottest months are February and March, just before the main rainy season, while the coolest months are between June and August. Atorkor experiences relatively high temperatures throughout the year and is humid, but the annual rain cycle is the most limiting factor for vegetation and animal life. Annual rainfall is typically <900 mm. Natural vegetation consists of shrubs.

Accra, Ghana: General Climate Conditions

Month	Average Sunlight (hours)	Temperature Average Min	Temperature Average Max	Temperature Record Min	Temperature Record Max	Discomfort from heat and humidity	Relative humidity am	Relative humidity pm	Average Precipitation (mm)	Wet Days (+0.25 mm)
Jan	7	23	31	15	34	High	95	61	15	1
Feb	8	24	31	17	38	High	96	61	33	2
March	7	24	31	20	38	High	95	63	56	4
April	7	24	31	19	34	High	96	65	81	6
May	7	24	31	21	35	High	96	68	142	9
June	5	23	29	20	33	High	97	74	178	10
July	5	23	27	19	32	Medium	97	76	46	4
Aug	5	22	27	18	32	Medium	97	77	15	3
Sept	6	23	27	20	32	Medium	96	72	36	4
Oct	7	23	29	19	32	High	97	71	64	6

Worms

- Worms Suitable: (Ghana Worm Species: Anecic and Endogeic) I recommend the **African Night Crawler (*Eudrilus eugeniae*).** This species likes to live about 3 feet below the surface, which is optimal for this climate.
- Six families of earthworms in Ghana, Ocnerodrilidae, Biwadrilidae, Enchytraeidae and Moniligastridae, were identified from collected specimens. All are acceptable vermicomposters, but stick with the African Night Crawler. In the Accra area, moist soils, especially **behind bathhouses and along streams**, are recognized as earthworm habitats (Mainoo, 2006). Vegetable farmers are aware that the absence of earthworms in their soils is a consequence of frequent pesticide sprayings (ARA)

Materials (Building and Food)
The best suggestion for creating vermidigesters would be to construct them from cement, but they can be built from other available materials.

- Plywood**,** nails and sheet plastic
- Burlap bags
- Black plastic
- The region possesses a narrow range of materials; wood, metal, cement and laterite (red tropical soil), from which Vermidigesters can be constructed. Cement vermidigesters (well ventilated) are more appropriate for long term Vermicomposting. Fresh wood is expensive whereas scrap wood is of inferior quality especially after termite action. Wood vermidigesters also rot and eventually fall apart, a consequence of high moisture content and insect action. In addition, there is an extremely resourceful scrap market in the Accra area where materials for Vermidigester construction can be sought at low rates. The city's scattered small scale capital goods markets (welders, carpenters and masons) are also a reliable source of expertise for Vermidigester design and assembly.
- Food materials: Besides recommendations from general considerations section, crop waste is a great source of food. Ghana produces **pineapple, corn and maze**: all waste from these types of crops is an excellent worm food. No stems, branches or twigs, use just good leafy plant material.

Agriculture: Ghana
Vermicompost product as a soil improvement option is one optimal and natural way to develop Ghana's agricultural output, and recover soil conditions.

Agriculture: accounts for about 50% of GDP (including fishing and forestry); the major cash crop is cocoa; other principal crops - rice, coffee, cassava, pineapple, peanuts, corn, shea nuts timber; normally self-sufficient in food production.

ARA (Agriculture and Rural Development Association): Agriculture is Ghana's future. It supplies 40 per cent of the gross domestic product but at present it is operating at only 20 per cent of its potential. This is the sector, the government and aid donors agree, that has to be a major focus of investment, especially to develop appreciable livelihoods for the rural folks.

Recommendations: Ghana (5 rudimentary conditions of vermicomposting in Atorkor Village Ghana analysis)

Worms
There are several great species of worms in Ghana, but I recommend the African Night Crawler. African Night Crawlers should be easily accessible behind bath houses, or along rivers and creeks by digging down.

Living Environment
For bedding consider availability of crop wastes such as corn silage, pineapple plant matter, shrub/tree leaves and waste paper products appear as the best options in this category. Where to vermicompost: I recommend one of two choices depending on availability of building supplies. First and most economical would be pit vermicomposting. For small (family size) usages dig a pit that is 3ft. deep, 6ft long and 3ft. wide. Line the pit with thick plastic, burlap sacks, wood or any materials that are not biodegradable, that will keep the worms contained and will help to keep pest out. Next the pit must be covered, to protect it external environment (heat, animals and pests). If temperatures are extremely high, consider the depth of the pit. Second option would be to build a composting bin made out of wood or preferably cement

because of heat, when making a bin consider a small amount of drainage, and a location that is cool and out of direct sunlight.

Food Source
Using manures helps increase the castings nitrogen level, but don't over use it.
Use a blend of food waste (no dairy, shells, or grease), leaf materials, crop waste and pre-compost any matter that is high in protein and nitrogen like meats.
(Always consider the food for the worms may attract other animals and pests).

Moisture
Caution: this is a concern in any region with high temperatures. Moisture content must stay about 50%, so consider wetting down your pit/bin regularly. If suitable drinking water is in sort supply, use any source of water (rain, lake, river or drainage), except salt water. Remember these are worms, and they are very resilient.

Aeration
As you collect food waste or other forms of worm foods, I recommend aeration when you feed, which could be once or twice a week. Aerate by using a pitch fork, rake or stick and turn the bedding in your pit/bin two or three times. This loosens the bedding, aerates the worms, and mixes in the food.

Protection from Temperature Extremes
In Ghana's case I recommend a deeper pit for warmer temperatures. If using a bin, consider a cooler place that is shaded from direct sun light and always monitor moisture conditions in your pit/bin.

Final Thoughts: The two concerns I have in Ghana is temperature and building supplies. So building a deeper pit should alleviate these concerns. Remember to use methods of trial and error/success. If any of the local circumstances that are questionable are not covered in this manual, use small amounts and let the worms tell you if it's right or wrong. Good luck and always ask for help!

Section Sources:
ARA (Agriculture and Rural Development Association) http://www.ara-ghana.de/

Homepage Ghana: http://www.ghanaweb.com/GhanaHomePage/economy/statistics.php
http://www.ghanadistricts.com/districts/?r=3&_=50&sa=1915

Mainoo, N. (2006). Ecological approaches to vermicomposting for peri-urban market gardens and household farms in Accra, Ghana: Evaluating indigenous knowledge frameworks as a tool. Ph.D.Dissertation Bioresource Dept. University of McGill.

Appendix

Definitions:

Vermicomposting is the process of turning organic debris into worm castings.

Castings are just a fancy word for earthworm excretions.
Earthworms are often grouped according to their function in the soil.

Anecic worms are usually larger worms that build permanent burrows in the soil and come to the surface to pull leave bits and other food to their burrows.

Epigeic worms living in decayed organic matter, not in soil.

Endogeic worms that rarely come to the surface. They live near the roots of plants feeding on decaying roots, fungi and bacteria.

Lumbricus terrestris, the night crawler is a large Anecic worm with a flattened tail that is great for your soil, but will not survive in a closed bin.

Eisenia fetida the red wiggler or red worm is a small Epigeic worm. They thrive in compost bins, and some may have yellow bands.

Aporrectodea catiginosa often called the grey worm, or southern worm, live near roots.

Internet Sources:

Community Composting Network: The Growing Heap
www.communitycompost.org/index.php/publications/thegrowingheap
Honduras Vermiculture
www.sweetmarias.com/honduras2003.html
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www.fadr.msu.ru/rodale/agsieve/invol7.html
The New Farm (Worldwide)
www.rodaleinstitute.org/200309/Connett
Worms.com (Aussie Guide to Changing Vermiculture)
http://www.worms.com/pages.php?pageid=8

International Contacts

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Earthworm research in South Africa

"It is a marvelous reflection that the whole---expanse has passed, and will again pass, every few years through the bodies of worms. The plough is one of the most ancient and most valuable of man's inventions; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed, by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures."
- Charles Darwin (1881)