Composting
Earthworm Castings as Plant Growth Media

— Written By Rhonda Sherman and last updated by Brandon Hopper

Researchers worldwide have demonstrated that earthworm castings (vermicompost) have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. This paper describes the effects of vermicompost on plant growth. The following is based upon the paper “The Potential of Earthworm Composts as Plant Growth Media,” by Clive Edwards and Ian Burrows in Earthworms in Waste and Environmental Management (edited by Clive Edwards and Edward Neuhauser).

In 1980, Edwards and Burrows and their associates launched an extensive research program in England to examine earthworms, their castings, and their effect on plant growth. Because the physical structure of the plant growth media produced from organic wastes depends on the original material, an assortment of animal, vegetable and industrial wastes were tested as feedstock, including swine, chicken, duck, turkey, cattle, potato, brewery, paper, and mushroom wastes. Plants included in the tests were (a) several varieties of ornamental shrubs; (b) vegetables such as aubergine, cabbage, capsicum, cucumber, lettuce, radish, and tomato; and (c) bedding plants such as alyssum, antirrhinum, aster, campanula, calceolaria, cineraria, coleus, French marigold, plumose asparagus, polyanthus, salvia, and sweet pea.

The resulting nutrient content of vermicompost from animal waste feedstocks was compared to that of a commercial plant growth medium (Levington compost) which had inorganic nutrients added. The following nutrients were analyzed: nitrogen, phosphorus, potassium, calcium, magnesium, and manganese. The nutrient content was much higher in the vermicomposts for most elements except magnesium (a magnesium sulphate can be used to rectify this deficiency). The researchers noted that many of the nutrients in
waste materials (including nitrogen, potassium, phosphorus, calcium and magnesium), when processed by earthworms, are changed into forms more readily taken up by plants.

Although plants prefer a growth medium on the acid side of neutral (6.0 pH), organic wastes and earthworm castings are usually more alkaline (>7.0 pH). Therefore, Edwards and Burrows recommend that castings be mixed with an acid medium such as peat.

The wide range of plants tested were successfully grown in both undiluted wastes or several mixes including 3:1 or 1:1 ratios of vermicompost to peat, Kettering loam, or pine bark. Plant growth was reported to be better with vermicompost than when recommended commercial growing media was used, and seeds germinated faster for most plant species grown in vermicompost.

Seedling emergence of tomatoes, cabbage, and radish was much better in vermicompost than in thermophilically-composted animal wastes, and as good and usually better in vermicompost than in a commercial medium. In addition, early growth of ornamentals’ seedlings was as good or better in vermicompost/peat mixtures than in the commercial plant growth medium.

After the seedlings were transplanted into pots, the ornamentals grew better in vermicompost/peat mixtures than in the commercial growth medium. Plants that grew particularly well in the vermicompost mixture were aubergines, dahlias, coleus, capsicum, and polyanthus. In addition, several ornamentals (especially salvias, chrysanthemums, and petunias) planted in vermicompost mixtures flowered much earlier (the authors noted that this was possibly due to a hormonal effect).

Three types of ornamental plants grew better when a 50/50 mixture of swine and cattle vermicompost were diluted at several different levels with a commercial plant growth medium. Even 5 percent vermicompost in the vermicompost/commercial mixture had a profound effect on plant growth. Dilutions of the different mixtures grew better plants than 100 percent vermicompost, which tended to dry out quicker than the mixtures.

Although vermicompost produced from paper waste feedstock was lower in nutrients than that from animal wastes, it still had a positive effect on seedling germination and growth. Edwards and Burrows noted that the paper waste vermicompost was one of the best feedstocks tested, and they did not experience difficulties in processing or generating a standardized material.
The researchers concluded that vermicompost mixed with peat or other materials makes superb plant growth media; consequently, it has significant commercial potential. Vermicompost needs standardized production to ensure sufficient nutrient status, therefore uniform sources of organic feedstock must be available. Furthermore, vermicompost needs pH adjustment, and possibly sterilization to reduce pathogen problems and kill insects. If the goal is to reach a large market, mechanization of the production and packaging is in order, and the wholesale cost should be competitive with that of existing products.

References


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Vermicomposting

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Introduction
Yard and food waste make up a major component of solid waste in most cities and towns throughout the United States. Although much of this organic waste can be recycled in the backyard using traditional aerobic backyard composting techniques, these techniques are not appropriate for apartment dwellers and are often inconvenient, particularly during bad weather in the winter.¹

Vermicomposting, or composting with earthworms, is an excellent technique for recycling food waste in the apartment as well as composting yard waste in the backyard. Worm bins located near a hot water heater in the garage during the winter will save many a trip through the snow to the backyard compost bin. Letting worms recycle your food waste also saves your back because you don’t have to turn over the compost to keep it aerated.

Types of Earthworms
The most common types of earthworms used for vermicomposting are brandling worms (Eisenia fetida) and redworms or red wigglers (Lumbricus rubellus). Often found in aged manure piles, they generally have alternating red and buff-colored stripes. They are not to be confused with the common garden or field earthworm (Allolobophora caliginosa and other species).

Although the garden earthworm occasionally feeds on the bottom of a compost pile, they prefer ordinary soil (Figure 1). An acre of land can have as many as 500,000 earthworms, which can recycle as much as 5 tons of soil or more per year.

Redworms and brandling worms, however, prefer the compost or manure environment. Recycled organic wastes are passed through the gut of the earthworm and are excreted as castings, or worm manure, an organic material rich in nutrients that looks like fine-textured soil.

What is Vermicomposting?
Vermicompost contains not only worm castings but also bedding materials and organic wastes in various stages of decomposition. It also contains worms in various stages of development and other microorganisms associated with the composting process.

Earthworm castings in the home garden often contain 5 to 11 times more nitrogen, phosphorous, and potassium than the surrounding soil. Secretions in the intestinal tracts of earthworms, along with soil passing through the earthworms, make nutrients more concentrated and available for plant uptake, including micronutrients.

Redworms in vermicompost act in a similar fashion, breaking down food wastes and other organic residues into nutrient-rich compost. Nutrients in vermicompost are often much higher than traditional garden compost (see Table 1).

Finished vermicompost should have a rich, earthy smell if properly processed by worms. Vermicompost can be used in potting soil mixes for house plants and

¹County Program Director, Hidalgo County Extension Office, New Mexico State University.
²For more information on composting, see NMSU Extension Guide H-110, Backyard Composting (http://aces.nmsu.edu/pubs/_h/H110.PDF).

To find more resources for your business, home, or family, visit the College of Agricultural, Consumer and Environmental Sciences on the World Wide Web at aces.nmsu.edu
Table 1. Chemical Characteristics of Garden Compost and Vermicompost

<table>
<thead>
<tr>
<th>Parameter*</th>
<th>Garden Compost†</th>
<th>Vermicompost†</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.80</td>
<td>6.80</td>
</tr>
<tr>
<td>EC (millhos/cm)**</td>
<td>3.60</td>
<td>11.70</td>
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<tr>
<td>Total Kjeldahl nitrogen (%)***</td>
<td>0.80</td>
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<tr>
<td>Nitrate nitrogen (ppm)****</td>
<td>156.50</td>
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<tr>
<td>Phosphorus (%)</td>
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<td>Potassium (%)</td>
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<tr>
<td>Calcium (%)</td>
<td>2.27</td>
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<td>Sodium (%)</td>
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<tr>
<td>Magnesium (%)</td>
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<td>Iron (ppm)</td>
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<td>Zinc (ppm)</td>
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<td>Manganese (ppm)</td>
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<td>Copper (ppm)</td>
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<tr>
<td>Boron (ppm)</td>
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<td>34</td>
</tr>
<tr>
<td>Aluminum (ppm)</td>
<td>7,580</td>
<td>7,012</td>
</tr>
</tbody>
</table>

†Albuquerque sample  
‡Tijeras sample  
*Units: ppm = parts per million; millhos/cm = millimhos per centimeter  
**EC = electrical conductivity in millhos/cm, a measure of the relative salinity of soil or the amount of soluble salts it contains  
***Kjeldahl nitrogen = a measure of the total percentage of nitrogen in the sample, including that in the organic matter.  
****Nitrate nitrogen = nitrogen in the sample that is immediately available for plant uptake by the roots.

Earthworms are hermaphrodites, which means they have both male and female sex organs, but they require another earthworm to mate. The wide band (citrilum) that surrounds a mature breeding earthworm secretes mucus (albumin) after mating. Sperm from another worm is stored in sacs. As the mucus slides over the worm, it encases the sperm and eggs inside. After slipping free from the worm, both ends seal, forming a lemon-shaped cocoon approximately 1/8 inch long. Two or more baby worms will hatch from one end of the cocoon in approximately 3 weeks. Baby worms are whitish to almost transparent and are 1/2 to 1 inch long. Redworms take 4 to 6 weeks to become sexually mature.

How to Construct a Worm Bin

Bins can be made of wood or plastic, or from recycled containers like old bathtubs, barrels, or trunks. They also can be located inside or outside, depending on your preferences and circumstances.

Because red wigglers tend to be surface feeders, bins should be no more than 8 to 12 inches deep. Bedding and food wastes tend to pack down in deeper bins, forcing air out. The resulting anaerobic conditions can cause foul odors and death of the worms.

The length and width of the bin will depend on whether it will be stationary or portable. It also depends on the amount of food waste your family produces each week. A good rule of thumb is to provide one square foot of surface area per pound of waste in your bin.

Wooden bins have the advantage that they’re more absorbent and provide better insulation. Do not use redwood or other highly aromatic woods that may kill the worms. Plastic tends to keep the compost too moist. Plastic, however, tends to be less messy and easier to maintain. Be sure containers are well cleaned and have never stored pesticides or other chemicals. Drilling air/escape holes (1/4- to 1/2-inch diameter) in the bottom and sides of the bin will ensure good water drainage and air circulation. Place the bin on bricks or wooden blocks in a tray to catch excess water that drains from the bin. The resulting compost tea can be used as a liquid fertilizer around the home landscape.

Each bin should have a cover to conserve moisture and exclude light. Worms prefer darkness. Bins can be covered with a straw mulch or moist burlap to ensure darkness while providing good air ventilation. Outside bins may require a lid to exclude scavengers and other unwanted pests.

Outdoor bins should be insulated from the cold to protect the worms. One option is to dig a rectangular hole 12 inches deep and line the sides with wooden planks. The bottomless box can then be filled with appropriate bedding material, food wastes, and worms. Food wastes can be continually added as they accumulate. The

Anatomy of Earthworms

The earthworm has a long, rounded body with a pointed head and slightly flattened posterior. Rings that surround the moist, soft body allow the earthworm to twist and turn, especially since it has no backbone. With no true legs, bristles (setae) on the body move back and forth, allowing the earthworm to crawl.

The earthworm breathes through its skin. Food is ingested through the mouth into a stomach (crop). Later the food passes through the gizzard, where it is ground up by ingested stones. After passing through the intestine for digestion, what's left is eliminated.
pile should be kept damp and dark for optimal worm activity. During the winter, soil can be piled against the edges of the bin and straw can be placed on top to protect the worms from cold weather. Do not add food waste to outdoor bins during the winter because this could expose the worms to freezing weather.

There are many very good commercially available composting worm bins on the market today (Figure 2). These bins are specifically designed to keep the worms happy and healthy while decreasing smell. They are an attractive option for use in the home, classroom, or office. Store-bought bins are easy to set up, maintain, and harvest.

**Bedding Materials**

Bedding for bins can be made from shredded newspapers (non-glossy), computer paper, or cardboard; shredded leaves, straw, hay, or dead plants, sawdust, peat moss, or compost or aged (or composted) manure. Peat moss should be soaked for 24 hours in water, then lightly wrung out to ensure it is sufficiently moist. Grass clippings should be allowed to age before use because they may decompose too quickly, causing the compost to heat up. Bedding materials high in cellulose are best because they help aerate the bin so the worms can breathe. Varying the bedding material provides a richer source of nutrients. Some soil or sand can be added to help provide grit for the worms’ digestive systems. Allow the bedding material to sit for several days to make sure it doesn’t heat up, and allow to cool before adding worms.

The bedding material should be thoroughly moistened (about the consistency of a damp sponge) before adding the worms. Fill the bin three-quarters full of moist bedding, lifting it gently afterwards to create air space for the worms to breathe and to control odors.

**Adding the Worms**

Under optimal conditions, redworms can eat their own weight in food scraps and bedding in one day. On the average, however, it takes approximately 2 pounds of earthworms (approximately 2,000 breeders) to recycle a pound of food waste in 24 hours. The same quantity of worms requires about 4 cubic feet of bin to process the food waste and bedding (1 cubic foot of worm bin per 500 worms).

Composting worms can be purchased from your local garden center or online. Worms will come in the mail usually within a week of ordering and ready to go to work. Some dealers sell worms as pit-run worms, which consist of worms of all ages and sizes. Add worms to the top of the moist bedding when they arrive. The worms will disappear into the bedding within a few minutes.

**Adding Food Waste**

Earthworms eat all kinds of food and yard wastes, including coffee grounds, tea bags, vegetable and fruit waste, pulverized egg shells, grass clippings, manure, and sewage sludge. Avoid bones, dairy products, and meats that may attract pests, and garlic, onions, and spicy foods. Limited amounts of citrus can be added, but too much can make the compost too acidic. The compost should be kept at a pH of 6.5 if possible, with upper and lower limits at 7.0 and 6.0, respectively. Overly acidic compost can be corrected by adding crushed eggshells.

Avoid adding chemicals (including insecticides), metals, plastics, glass, soaps, pet manures, and oleanders or other poisonous plants, or plants sprayed with insecticides to the worm bin.

Food wastes should be added to the bin by pulling back the bedding material and burying it. Be sure to cover it well to avoid attracting flies and other pests. Successive loads of waste should be buried at different locations in the bin to keep the food wastes from accumulating. Grinding or blending the food waste in a food processor speeds the composting time considerably.
Controlling Temperature and Moisture in the Bin

Redworms can survive a wide range of temperatures (40–80°F), but they reproduce and process food waste at an optimal bedding temperature range of 55–77°F. The worms should never be allowed to freeze. Bins kept outside may have to be insulated with straw in the winter to keep the worms from freezing. Portable bins can be kept by a hot water heater in the garage during the winter to keep them warm.

The bin contents should be kept moist but not soaked. Do not allow rainfall to run off a roof into the bin. This could cause the worms to drown. A straw covering may be needed in exposed sites to keep the bin from drying out during hot summer weather.

Maintaining the Bin

Food scraps can be continually added to the bin for up to 2 to 3 months, or until you notice the bedding material disappear. When the bedding disappears, harvest the worms and finished compost, then refill the bins with new bedding material.

Overloading the bin with food wastes can result in foul odors. If you notice these odors, stop adding the waste until the worms have a chance to catch up. Overly moist food waste and bedding also cause odors. To relieve this problem, fluff up the bedding to add air and check the drainage holes. As a general rule of thumb, keep the bedding material moist, but never soggy. Make sure the food waste is buried properly in the bedding. Exposed food wastes can attract fruit flies, house flies, and other pests. Keeping the bin covered with straw or moist burlap also deters these pests.

Garden centipedes can be a problem in the worm bin, especially outside. These predators should be destroyed. Overly wet beds also can attract the earthworm nite, which may cause the worms to stop eating.

Harvesting the Compost and Worms

There are three basic ways to separate the worms from the finished compost. One way involves moving the finished compost and worms over to one side of the bin and adding new bedding material and food waste to the other side. Worms in the finished compost should move over to the new bedding with the fresh food waste. The finished compost can then be removed.

A second way to remove the worms is to build a small harvester frame of 2 × 4s with a 3/16-inch mesh bottom. Place the worm compost on the frame and sift the worms out. Larger pieces of compost can be returned to a new batch of bedding and worms.

The compost also can be placed in small piles on a tarp in the sun (or under bright lights inside). Because worms don’t like light, they will wiggle to the bottoms of the piles. After waiting 10 minutes, remove the upper inch or more of finished compost from each pile until you run into the worms. Allow the worms to again wiggle to the bottom of the pile and repeat the process. Combine what’s left of the small piles into one big pile and again repeat the process. You should eventually end up with a pile of finished compost and a ball of worms. The worms can be added back to a new bin of bedding and food waste. Larger worms also can be used as bait for fishing.

References