

## Worm farming

By Clell Tompkins

Pure worm castings is a 100% organic fertilizer and is completely safe to all plants, animals, humans and our environment in any concentration. It is the richest natural fertilizer known to humans. Plant growth trials at Ohio State University have shown that as little as 5% (by volume) produces "unique and remarkable plant growth responses." The recommended rate is 10-20%. Unlike animal dung and artificial fertilizer it is absorbed easily and immediately by plants and will not burn. It also enhances the ability of your soil to retain water and even inhibits bacterial and fungal diseases. It will improve soil structure and aeration dramatically. It consists of thousands of durable torpedo-shaped pellets that resist compaction, creating a spongy quality to the material.

### ***Reasons to worm farm:***

- Produce free, all-natural fertilizer/soil amendment for gardens, house plants, or lawns
- Best fertilizer known to humans
- Get healthier plants without the use of chemical fertilizers
- Increase disease resistance in plants
- Avoid paper and plant wastes from filling up landfill
- Grow your own fishing worms

### ***Make your own natural fertilizer/Soil Amendment***

Earthworm castings contain 5 to 11 times more nitrogen, phosphorus, and potassium VS normal soil

In addition, the cooperation between the worms and microbes produce humic acid and plant growth hormones. The humic acid binds to minerals and nutrients in the soil. It protects them from being degraded by the UV rays and/or washed out of the soil. The acid "holds" them in the soil in a form which can be readily absorbed by the plants. And lastly, the plant growth hormones cause earlier germination, larger crop yields, and much deeper root development. It is these combined effects that keep gardeners using the worm castings in their gardens.

They can get bigger fruit and vegetables without adding any chemical fertilizer! Chemical fertilizers can be helpful to plants, but they have negative impacts in long run. First, the chemicals can burn your plant if too much is used. But more importantly, they kill off the thousands of microorganisms and earthworms that are naturally found in the soil. This leads to poor soil quality. By using vermicompost as a soil additive, the plant gets the nutrients it needs, rich humus to hold in moisture, and the soil's health improves (increased microbe population).

Below is a chart showing the improved conditions when adding vermicompost to normal soil. Note the high carbon, nitrogen, phosphorus, potassium, calcium, zinc and magnesium.

**Table 1.** Chemical properties of sheep-manure vermicompost and soil.

Medium	pH	EC (mScm <sup>-1</sup> )	C (%)	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Vermicompost	7.7	7	15	1.3	1.3	1	580	250	170	31
Soil	7.94	1.38	1.07	0.09	0.001	0.032	12	10	3	1.5

**Table 1. Shows chemical comparison between vermicompost and soil (taken from "Influence of vermicompost on soil chemical and physical properties in tomato field")**

Most people think compost is compost...but this is not true. There was a study performed comparing traditional compost (from a heap) to vermicompost (using worms). Again, you can see that the chemical makeup of the soil is better. The above mentioned elements are higher in quantity and even the pH has become more neutral. In addition the vermicompost nutrients are in a form that is easier for the plants to absorb (ex: nitrates).

In addition, vermicompost may have up to a 1000 times higher microbial population than normal compost. Compost piles break down materials using bacteria that thrive in high temperatures. These high temperatures kill off some of the microbes. But with vermicompost, waste is broken down aerobically at moderate temperatures. This permits a much wider spectrum of microorganisms to

develop in the final product. It is these microbes that can convert nutrients in the soil to a form that is more readily absorbed by plants (Edwards, 1999).

Also, vermicompost can be generated in 1/3 the time as regular compost. This means that you can produce more compost for your garden in the same amount of time. And it improves the plant's ability on many different levels including: seed germination, seed/plant growth, and higher productivity by plants ie. fruits and vegetables (Arancon, 2004). This study recommended vermicompost make up between 10-40% of the plant's soil.

**Table 1. Chemical characteristics of garden compost and vermicompost, 1994.**

Parameter*	Garden compost <sup>1</sup>	Vermicompost <sup>2</sup>
pH	7.80	6.80
EC (mmhos/cm)**	3.60	11.70
Total Kjeldahl nitrogen(%)***	0.80	1.94
Nitrate nitrogen (ppm)****	156.50	902.20
Phosphorous (%)	0.35	0.47
Potassium (%)	0.48	0.70
Calcium (%)	2.27	4.40
Sodium (%)	< .01	0.02
Magnesium (%)	0.57	0.46
Iron (ppm)	11690.00	7563.00
Zinc (ppm)	128.00	278.00
Manganese (ppm)	414.00	475.00
Copper (ppm)	17.00	27.00
Boron (ppm)	25.00	34.00
Aluminum (ppm)	7380.00	7012.00

<sup>1</sup>Albuquerque sample

<sup>2</sup>Tijeras sample

\*Units- **ppm**=parts per million      **mmhos/cm**=millimhos per centimeter

\*\* EC = electrical conductivity is a measure (millimhos per centimeter) of the relative salinity of soil or the amount of soluble salts it contains.

\*\*\* Kjeldahl nitrogen = is a measure of the total percentage of nitrogen in the sample including that in the organic matter.

\*\*\*\* Nitrate nitrogen = that nitrogen in the sample that is immediately available for plant uptake by the roots.

Table 2 shows comparison between normal compost and vermicompost.

One final benefit I will touch upon is that in many different studies, vermicomposts was found to help increase a plant's resistance to disease. The theory is that all the microbes present compete for the nutrients in the soil and make it harder for the harmful microbes to survive. By having a diverse population of microbes in the soil, diseases and harmful microbes have a harder time surviving. Wineries on the west coast use vermicompost to help prevent loss of grape vines to disease. They continue to have remarkable results. And in some cases, it has been found to repel pesky mites... but this is an area still being investigated.

So the question is now why not use vermicompost? I can't answer that one

Discover an easy way to turn your table scraps into a rich organic fertilizer without having to make a compost pile and adding all the greens, browns, etc. It's easy, inexpensive and compact. Your food scraps can be turned into rich, plant-nourishing compost and organic fertilizer that is probably one of the richest fertilizers known to man. It's an excellent addition to any sustainable home, garden, or permaculture farm. Worms are an excellent choice for small scale composting, such as in your home garden or kitchen. This system of composting is also called the "vermicompost system" or the "worm bin."

### Why do this?

It's really amazing. Worms change food scraps into a rich, organic, usable material that helps fertilize your gardens and indoor house plants better than any other material most likely. It's an organic compost/fertilizer that is superior to other forms of compost. The worms' mucous plays a special role in slowing the release of nutrients from the compost. Their mucous is deposited with their droppings (called "**castings**") and helps *bind nutrients into the compost* so that they are not easily washed away by watering or rain.

### Worm composting systems

There are many ways to start a worm composting system. You can purchase a pre-made kit or make your own. Worm bins use smaller varieties of worms that feed close to the surface for decomposition. These are not the typical earth worms. The types of small worms used in worm composting systems include *red wigglers* and *manure worms*.

### **Here is how you how to turn 18 gal tot bins into a composting system with red wigglers.**

One way is simply using a single chambered bin. These can be as large as a shipping crate or as small as a shoebox. But one of the biggest challenges of a single chamber bin is separating the worms from the finished vermicompost. Also, the single chambered bin can often become too wet. This is because as the worms process food scraps, excess fluid is created. ***This fluid is often times mistakenly called "worm tea". But this "leakage" can be toxic. More about this later.***

Another system is a multi-tiered worm bin. The tiers often consist of several totes or trays nested on top of each other with small holes drilled into the bottoms (except for the bottom tote/tray which is used to collect the leakage. I like using the multi-tiered because the worms sort themselves away from the completed vermicompost or worm castings.

Worms like to feed close to the surface, so in the multi-tiered system that is where we place the food scraps for them to eat. Start by placing food scraps in the middle bin. As you continue to feed over a number of weeks, the bin begins to fill. When it is full, you stop feeding in the middle bin and begin feeding in the top bin instead. When the worms finish processing food scraps in the middle bin, they will naturally move upwards through the small holes into the top bin. By the time they get to the top bin the middle bin will be finished compost with very little worms to be sorted out. It leaves you with a nice supply of worm castings to use as fertilizer.

A simple and inexpensive bin system can be made using plastic totes stacked into each other. Since these are already made to fit one into another, they make it easy to make a multi-tiered worm composting system. Below is a typical setup using 18 gal gas plastic containers.



1. The bottom tray catches the leakage - no holes in it.
2. The middle tray has 1/8" holes about 3" apart in all directions over the entire bottom of the bin for drainage yet these holes shouldn't let the worms or the bedding fall thru.
  - a. It should also have one row of 1/4" holes just below the top rim around the sides spaced about 6" apart. This allows air movement into the bin
  - b. More about what goes in the middle bin a little later.**
3. The top tray is a duplicate of the middle tray but will have a lid. The lid will have no holes in it.

Make sure all the bins are the same size, so they fit into each other. There is nothing magic about the sizes. The larger the size, the more worms you can have. Any size around the 18 gal container size should work fine and is the best size.

### **How to setup the bins**

Bedding: the middle bin

You can use good soil, compost, or coconut core (purchased as ground up coconut shell compressed into a brick)

I prefer the coconut core brick. It is the most recommended bedding for worm farming.

Coconut bricks when placed in water expands probably 10 times in volume. You want it to be damp. Not soggy. When compressed with your hands, it should stay in a reasonable shape as squeezed into but not water squeezed out.

Place this coconut compost in the middle bin filling the bin to about 3 inches. Add your worms. 1,000 or approximately 1 lb. Next put about 6 - 8" of shredded paper (fluffy, not compacted).

Shredded Paper:

Use news paper and cardboard. **DO NOT USE ANY SHINNY PAPER.** Worms don't like it.

Use a spray bottle or flower watering can to lightly dampen the shredded paper so that it somewhat sticks together but not even close to being soggy.

Give the worms 1 day to get comfortable in their new home before you put in your food scraps or other organic wastes.

Use any and all types of food scraps:

Including coffee grounds and egg shells - preferable egg shells finely chopped up

**EXCEPT DO NOT USE:**

- Meat
- Citrus
- Dairy products
- Onions
- Oils

The more chopped up the food the faster the worms can digest it; however, even if it is not cut up into smaller pcs, between it decaying and the worms digesting it, it will still work. The more chopped up the faster the castings are generated. Open a hole in the shredded paper and place the food in shredded paper at the top of the coconut bedding then cover it back over with the shredded paper. This keeps it from smelling and keeps the fruit flies from finding it.

The worms will generate their own dampening so you will no longer need to add water, EXCEPT when you add new shredded paper. Add more shredded paper as the worms begin to make castings all over the shredded paper.

The shredding will become more compact as the worms begin to work in it and begin to digest it as well. This is when more shredded paper should be added.

Make sure you follow the list of do's and don'ts below!

**Do's and Don'ts**

The following are two lists of things that you should practice to maximize the health and happiness of your worms.

**DO**

- Use red wigglers - they are the most efficient to generate castings
- The ideal balance of worms to food scraps per week ratio is **1 lb of worms to .5 lbs of food scraps (2:1 ratio)**. For an established bin, that is about the amount of food scraps from 2-3 people per week.

- Do pay attention to the smell of the worm bin. If it becomes smelly it is likely receiving too much material for the worms to break down quickly. This means you need to cut back on the amount of food for a short time.
- When in doubt, add more bedding
- Keep your system ideally at a temperature of between 59 and 77 degrees but the worms should survive between 40 and 90 degrees just fine. The better temperature the better production of castings.
- Relax, have fun and let the worms eat your garbage and do the work. Then come and collect the reward.

## **DON'T**

- ***Don't put oils, dairy, citrus or meats into your worm bin, as they don't break down and they do attract pests***
- Don't put large amounts of coffee grounds in the worm composting system as it can make the environment too acidic for the worms. If you're a heavy coffee drinker, just place the grounds at the base of your acid-loving plants like roses, or blueberry bushes.
- ***Don't put your worm bin in the sun, as it will get too hot! Also, protect them from prolonged freezing temperatures.***
- Don't completely seal off your worm bin from the air, as they need to breathe

## **Worm Tea is NOT**

Worm tea is not the leakage coming out of your bottom bin. You will find many people, including worm farmers, who call this worm tea and a great fertilizer. **Research tells you it is NOT. It can be toxic to plants and should NOT be use on food plants.** Why is it toxic? You see the food you place in the worm bin for food decays and as it leaches out running down thru the worm bedding, it is run of through rotten food. Rotten food will make us sick. Therefore the runoff is toxic. Yes it does have worm secretion as well but it also contains that toxic matter. We don't want to put this on our food bearing plants.

You can use it on non-food plants but here is a test before you do.

When you pour the leakage into a container, smell it. If it smells bad, then it is toxic and don't even use it on your non-food plants. However, if it does not smell bad and smells earthy, then you can use it on your non-food plants but **NEVER USE IT ON FOOD BEARING PLANTS**

## **So what is worm tea?**

Worm tea is a mixture of worm castings and non-chlorine aerated water.

## **Why make and use worm tea?**

Worm tea is an excellent plant starter or a good material to start new soil out with. It's as rich as the worm castings but it will penetrate the soil and plants faster that the worm castings would do.

When you have used worm castings as a booster to your soil and the soil begins to build up from the castings, worm tea is not so important for the soil but can be good for spraying directly onto the foliage of the plant.

When you spray it directly onto the leaves and foliage of the plants, it will help protect from insects and the plant will draw it's richness into the plant this way as well.

## **How to make worm tea**

Materials needed

1. 5 gal bucket
2. A small fish tank aerator

3. Tubing long enough to reach from aerator to the bottom of the bucket
4. A tee that lets more than just one outlet put air into the bucket
5. Non-chlorine water - rain water or tap water that has set for 1 or more days
6. 3 double hand full's of worm castings
7. Optional: 1 table spoon of molasses - speeds up microbes. Most people think it is good.

## Process

1. Fill 5 gal bucket 3/4 way full of non-chlorine water
2. Hook up aerator and tubing and run into water to bottom of bucket
3. Turn on aerator so you see lots of bubbles
4. Put in 3 double hand full's of worm castings into the water
5. Stir to mix up worm castings with water as much as possible
6. Let set and aerate for 24 hours
7. Use immediately on plants as described earlier
- 8. Do not let the mixture set very long before using as the aeration will be eliminated**

## Facts about worms

- Earthworms have no lungs, but they do breathe oxygen. They exchange oxygen through their moist skin. If an earthworm's skin dries out, it will suffocate and die.
- Earthworms are 90 percent water and have no bones. Instead their structure is provided by a "hydrostatic skeleton," coelmic fluid (fluid within the body cavity) held under pressure and surrounded by muscles.
- Earthworms have five hearts, although they are not four-chambered hearts like ours. Instead, they are five pairs of enlarged blood vessels with valves that prevent the blood from backing up. Like human blood, earthworm blood has iron-rich hemoglobin as its base and is red in color.
- Red worms are hermaphrodite. Having two sex organs, you can already breed them even if you only have two worms on hand. Breeding for them is better under a temperature of 59 - 68 degree F.
- Red worms cannot see. You may be wondering how they can detect light as they are afraid of it. Well, Red Wiggler worms have light sensor which makes it easy for them to sense when they are exposed into such. However, they can live with red light.
- Earthworms have no ears, but they can feel vibrations in the ground. This helps them sense predators moving toward them through the soil. Earthworms have bristles, called setae, along the bottom of their bodies which help them move. These bristles can be pulled in like a cat's claws.
- Earthworms live where there is food, moisture, oxygen and a favorable temperature. If they don't have these things, they will go somewhere else. Keep this in mind when building and maintaining your worm bin.
- You also have to know that this kind of composting worm does not have teeth. This is the very reason why you have to cut their food into pieces and why you have to shred their bedding. It would be hard on their part to feed on big and organic materials.
- Another truth about Red Wiggler worms is that they breathe through their skin that is why their environment should always be moist. Air is also important because they are still aerobic organisms.
- Red worms can make worm composting effective as long as their needs are all met. As said, they do not thrive on too hot or too cold areas. Thus, a temperature of 40-90 degrees Fahrenheit should always be maintained. The acidity level on the other hand should be kept at 6.0-6.5 as too much acidity may kill the worms.
- As with foods, Red Wiggler worms can eat half or as much as their body weight. You can give them a little lesser than what they need but never overfed them. Red Wiggler worm fact shows that a pound of worms can process an estimated amount of ¼-1/2 lb. wastes every day.
- Worm composting (also known as vermicomposting) involves the breakdown of organic wastes via the joint action of worms and microorganisms (although there are often other critters that lend a hand)
- Regular (soil and garden) earthworms cannot be used for worm composting. They will die if added to an indoor worm bin.
- Composting worms are specialized surface dwellers (not burrowers), typically living in very rich organic matter such as manure, compost heaps or leaf litter
- Most common variety used is *Eisenia fetida* (also spelled 'foetida'), although it's larger cousin, *Eisenia hortensis* (a.k.a. the 'European Nightcrawler') is commonly used as well (more commonly to be sold as bait worms)
- Common names for *E. fetida* include: red worm, red wiggler, brandling worm, manure worm, tiger worm
- You won't likely find this species on your property (unless you live on a farm, or happen to introduce them into your compost heap).
- It is widely believed that a composting worm can process the equivalent of it's own weight in waste each day. Under highly optimum conditions (not likely to be attained with a small home system) red worms have been found to process multiple times their own weight! This is very much dependent on the foodstock and how well managed the system is.

- A reasonable guideline to follow is 1/4-1/2 total worm weight in waste per day. So if you have a pound of worms, they should be able to process roughly 1/4-1/2 lb of food waste per day. Keep in mind however that you may need to feed them less during the first couple months since they usually require a period of acclimation when added to a new system.
- Red worms technically graze on the microbial community that colonizes waste materials – not really the waste itself (although they certainly ingest some of the rotting waste in the process). Some research has indicated that protozoans are the primary food source, while there is also evidence that fungi and other microbes are consumed as well.
- There have been a number of research studies indicating that vermicomposting can significantly reduce levels of pathogens in waste materials, such as biosolids.
- Red worms love (and can tolerate) very high levels of moisture content (80-90%), but they also require oxygen so it's important to find the right balance
- One lb of composting worms is estimated to consist of approximately 1000 individuals, and can cost anywhere from \$15 to \$40 USD
- Surface area far more important than depth when it comes to worm bins (ie tubs work much better than buckets)
- Regular light is harmful to worms but red light is not
- Red worm eggs look like tiny straw-coloured lemons
- Baby worms look like very small versions of the adults (but have less red pigment)
- Adding crushed egg shells (or other calcium sources) can help stimulate worm reproduction

### **DON'T DO IT!**

Contrary to folklore, if a worm is cut in half, the halves do not regenerate.

If a tiny part of the worm is cut off, it can heal and eventually grow back. However, this ability to regenerate is limited to a few segments from the tail end and even fewer segments from the head end. If you cut a worm in half, you'll kill it.

### **Leachate vs. Worm Compost Tea**

Keeping the distinction between these terms is actually quite important.

Definitions

**Leachate** - The liquid run off (or seepage) that settles in or below the vermicompost or worm castings. Check for accumulated leachate in your vermicomposter frequently (when you feed, or weekly).

**Worm tea** - The end result of suspending worm castings in highly oxygenated water (brewing).

### **Leachate**

Leachate can contain phytotoxins (toxins that can harm plants and humans). Some of these toxins are created by bacteria. Every worm bin has good and bad microbes. This is ok of course, as long as the good ones outnumber the bad ones. Some leachate can contain harmful pathogens because it has not been processed through the worms intestinal tract. It should not be used on edible garden plants.

During decomposition, waste releases liquid from the cell structure. This liquid or leachate seeps down through the worm composter into the collection area. The leachate should be drained regularly and if you are getting more than 2-4 ounces of liquid in a week, the composter is probably too wet! We recommend leaving your spigot open with a container underneath to catch the leachate to avoid having it build up in your system. Just keep an eye on it to make sure your container doesn't overflow!

While leachate can have value as a liquid fertilizer it should be treated with caution. For every story extolling the benefits of using leachate there is one lamenting the problems from having used it. If you decide you want to use the leachate we recommend taking some extra steps.

1. DO NOT use it if it smells bad! Pour it out on an area where it cannot harm living plants like a roadway or driveway.
2. Dilute it ten parts water to one part leachate (10:1)
3. Aerate it with an air pump if available.
4. Use it outdoors on shrubs, ornamentals or flowering plants only. DO NOT use on plants you intend to eat.

### **Worm Tea**

Worm compost tea is known mostly for its ability to boost microbiological activity in soil by adding bacteria, fungi, acinomyces, and protozoa to the soil. It is brewed by either soaking a porous bag full of worm castings in water or simply dumping the castings into a container of clean chemical free water. Molasses (a food source) is then added to the water as a catalyst to stimulate growth of the microbes. Then last, an air pumping system is installed to increase an aerobic (oxygenated) environment for the inoculation of the microorganisms

Worm tea is beneficial in so many ways. The microbes delivered in worm tea help plants by out-competing anaerobic and other pathogenic organisms and by occupying infection sites on plants' root and leaf surfaces.

The purpose behind creating worm tea is to speed up the growth rate of microbes such as bacteria, fungi, protozoa, and nematodes, and to multiply their numbers exponentially. One reason for applying the tea to your plants is that it is absorbed more rapidly by the plant than castings, which are released over time.

When you spray or pour the tea on the soil not only are you feeding the plant, but you increase the number of beneficial microbes in the soil, thus crowding out the bad. It has been proven that the tea, along with the castings, can significantly increase plant growth, as well as crop yields, in the short term (a season) and especially the long term over a period of seasons.

Along with these great benefits come a boost in the plant's own immune system to be able to resist parasites like the infamous aphid, tomato cyst eelworm, and root knot nematodes. Plants produce certain hormones (like the jasmonic hormone) that insects find distasteful so they are repelled. Worm tea also helps a plant to resist diseases such as Pythium and Rhizoctonia.

When worm tea is sprayed on leaves and foliage, the bad disease-causing microbes are again outnumbered and cannot populate to the levels of taking over a single plant. The tea also aids the plant in creating the "cuticle", a waxy layer on top of the epidermis, or plant skin. This waxy surface protects the leaves from severe elements and reduces attacks by certain harmful microorganisms and insects.

Making an organic compost tea involves several important steps

1. choosing the right compost,
2. choosing the right nutrients and
3. brewing and applying tea correctly. Our instructions here are only meant to give you some background to tea making.

The compost used in making tea is like the starter you use in making yoghurt, or bread. The compost inoculates the tea with organisms. Thus, you want the compost you begin with to have a good diversity of beneficial organisms!

Plants differ in their soil preferences. Some need a bacterial-dominated soil, others want a fungal-dominated soil, and still others like a soil that's somewhere in between.

To make an organic compost with more fungi, mix in larger amounts of cardboard, paper, sawdust, wood shavings and heavy stalk plant material as you prepare the compost. For bacterial dominance, use food waste and green plant waste. Whatever compost you use, be sure it is finished, well-stabilized compost, and that it's fairly fresh.

Always use only **dechlorinated** water, rainwater, pond or distilled water.

Brewing nutrients also influence the finished tea. To encourage the development of fungi in the tea, mix two parts humic acids, two parts yucca, saponin or aloe vera and one part fish hydrolyzate or other proteins into the water. For bacterial dominance, you'll feed one liquid ounce black strap molasses per gallon of tea and an equal amount of cold-water kelp. For the molasses, you can also substitute brown sugar, honey or maple syrup if you like.