International Journal of Advanced Biotechnology and Research
ISSN 0976-2612, Online ISSN 2278–599X,
Vol5, Issue2, 2014, pp 85-92
http://www.bipublication.com

A STUDY ONRECYCLING ORGANIC WASTES THROUGH VERMICOMPOSTING

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[Received-08/03/2014, Accepted-28/03/2014]

ABSTRACT

Agriculture is facing a challenge to develop strategies for sustainability that can conserve non-renewable natural resources, such as soil and enhance the use of renewable resourcessuch as organic wastes.Earthworms are considered as the friends of farmers. Vermicompost obtained with the help of them has many benefits to soil, plants and in all to the environment. In the present study the nutrient status and microbiological enumeration of vermicompost was studied. The vermicompost was prepared from kitchen waste material obtained from the canteen of R.K.T.
College, Ulhasnagar, Dist. Thane, MS, India. Vermicompost was prepared using Eiseniafetida. Compost and plain soil were kept as controls throughout the study. Vermicomposting uses earthworms to turn organic wastes into very high quality compost. This is probably the best way of composting kitchen wastes. Adding small amounts of wet kitchen scraps to a large compost pile in the garden day by day can disrupt the decomposition process so that the compost is never really done. But it works just fine with vermicomposting.

Keywords—Chemical fertilizers, destructive to soils vermicompost protective, chemical fertilizers, decrease natural soil fertility · composts · a slow-release organic fertilizer · build up and improve soil fertility, earthworms vermicompost promote growth and protect plants, vermicompost richer in nkp and micronutrients and several times powerful growthpromoter over conventional composts

I. INTRODUCTION

Earthworm's vermicompost is proving to be highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective' farm input (increasing the physical, chemical &biological properties of soil, restoring & improving its natural fertility) against the 'destructive' chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NKP (nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25%), micronutrients, beneficial Soil microbes and also contain 'plant growth hormones & enzymes'. It is scientifically proving as 'miracle growth promoter & also plant protector' from pests and diseases. Vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in shorter time, the vermicompost does. Vermicompost contains plant hormones like Auxin and gibberellins and enzymes which believed to stimulate plant growth and discourage plant pathogens. It improves the fertility and water holding capacity of the soil. It also enriches the soil with useful microorganisms which add different enzymes like phosphatases and celluloses to the soil. Vermicompost enhances germination, plant growth and thus overall crop yield [14]Vermicompost was prepared from farm garbage from different combinations of materials and its nutrient status was studied. *Eisenia fetida, Eudrilus eugeniae, Peronyx excavatus* were used for the production of vermicompost. There was about 74 -96 percent, 20-24 percent, 43-153 percent increase in N,P,K respectively and a great reduction in C/N ratio about 59-69 percent and in electrical conductivity about 32.6 percent had been observed [15]. In the other study vermicompost was prepared from kitchen waste using *Eisenia fetida* and then vermicompost was chemically analyzed. There was increase in Nitrogen, phosphorus and potassium content while decrease in organic carbon, C/N and C/P ratio as compare to control. In compare to control treatment vermibed with E. fetida showed 1.07, 109.4, 13.2 and 24.7% more increase in carbon, total nitrogen, potassium and phosphorus, respectively [16]. Similar kind of study was carried out on crop residue along with cattle dung [17]. Decomposition of leaf litter using *Eisenia fetida* was studied along with nutrient status of vermicompost [18]. Nutrient status of vermicompost from vegetable waste and cow dung by using three different species (*Eisenia foetida, Eudrilus eugeniae and Perionyx excavates)* of earthworms has been reported in 2010. The results showed a high increase in nitrogen, potassium and high decrease in organic carbon, C/N and C/P ratios .There was maximum (117.39%) increased found in nitrogen content , while minimum (9.13%). The maximum (110%) increased found in potassium content of experiment while minimum (51.61%) increase observed in experiment [19].

II. VERMICOMPOST AND PLANTS

Vermicompost consists mostly of worm casts (poop) plus some decayed organic matter. In ideal conditions worms can eat at least their own weight of organic matter in a day. In fact it seems they don't actually eat it -- they consume it, sure enough, but what they derive their nourishment from is all the micro-organisms that are really eating it. And yet -- mystery! -- Their casts contain eight times as many micro-organisms as their feed! And these are the micro-organisms that best favor healthy plant growth. And the casts don't contain any disease pathogens -- pathogenic bacteria are reliably killed in the worms' gut. This is one of the great benefits of vermicomposting.

Worm casts also contain five times more nitrogen, seven times more phosphorus, and 11 times more potassium than ordinary soil, the main minerals needed for plant growth, but the large numbers of beneficial soil micro-organisms in worm casts have at least as much to do with it. The casts are also rich in humic acids, which condition the soil, have a perfect pH balance, and contain plant growth factors similar to those found in seaweed.

III. WORMS

These are not the usual big burrowing earthworms that live in garden soil. Called red worms, tiger worms, brandlings, angle worms, manure worms, or red wrigglers, they occupy a different ecological niche, living near the surface where there are high concentrations of organic matter, such as on pastures or in leaf mould, or under compost piles. Two breeds are used in vermicomposting: *Eisenia foetida* or *Lumbricus* *rubellas*. Many garden centres now supply them, and in most countries they can be bought by mail order from worm farms. Some sellers advertise special high-performance breeds or specially developed hybrids, but don't believe them -- they'll be one of these two breeds. There's no such thing as a hybrid worm.

Types of earthworms

Earthworms are invertebrates. There are nearly 3600 types of earthworms in the world and they are mainly divided into two types: (1) burrowing; and (2) non-burrowing. The burrowing types *Pertimaelongata* and *Pertima asiatica* live deep in the soil. On the other hand, the non-burrowing types *Eisenia fetida* and *Eudrilus eugenae* live in the upper layer of soil surface. The burrowing types are pale, 20 to 30 cm long and live for 15 years. The non-burrowing types are red or purple and 10 to 15cm long but their life span is only 28 months. The non-burrowing earthworms eat 10% soil and 90% organic waste materials; these convert the organic waste into vermicompost faster than the burrowing earthworms. They can tolerate temperatures ranging from 0 to 40°C but the regeneration capacity is more at 25 to 30°C and 40–45%moisture level in the pile. The burrowing type of earthworms comes onto the soil surface only at night. These make holes in the soil up to a depth of 3.5 m and produce 5.6 kg casts by ingesting 90% soil and10% organic waste.

You'll need 1,000 worms (1 lb) to start a worm box, maybe twice that if you want to process your garden wastes too -- they breed very fast in the right conditions, but starting with more will give the system a good start.

Temperature changes during the process

Change in temperature was observed during the process of vermicomposting (from 5 to 65 days) with different farm residues (*Parthenium* and grass). In the beginning of the process, i.e., up to 15 days, the temperature was high (32 to 33°C) in both *Parthenium* and grass substrates when compared to outside temperature (26 to 30°C). Later, there was a gradual decrease in temperature, which reached a minimum of about 24°C. However, higher temperature was recorded in *Parthenium* compost (decline from 32.8 to 27.5°C) than in grass compost (decline from 31.5 to 26.8°C) during the whole period of digestion process. Generally more heat was evolved from control treatment (without earthworms) than the vermicompost treatments (with earthworms). From these studies, it was suggested that the most suitable period for releasing the earthworms into organic residues would be between 15 and 20 days after heaping of the organic residues when the temperature is about 25°C.

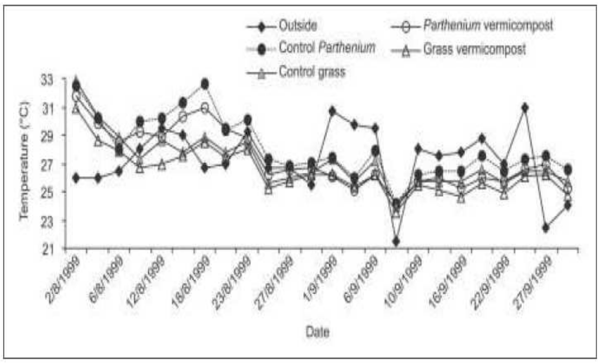

Figure 1. Temperature changes during biodigestion.

Breeding: Worm populations double each month. In ideal conditions they can reproduce much faster than that: 1 lb. of worms can increase to 1,000 lbs (one million worms) in a year, but in working conditions 1 lb will produce a surplus of 35 lbs in a year, because hatchlings and capsules (cocoons or eggs) are usually lost when the vermicompost is harvested.

Mature red worms make two or three capsules a week, each producing two or three hatchlings after about three weeks. The hatchlings are tiny white threads about half an inch long, but they grow fast, reaching sexual maturity in four to six weeks and making their own capsules. Three months later they're grandparents. This rapid breeding rate means the worm population easily adjusts to conditions in the wormbox according to the feed supply and the proportion of worm casts to feed and bedding -- their casts are slightly toxic to them, and as the box gets "full" they'll either leave, if there's any where for them to go, or they'll die off. This is an important consideration -- if you only want the vermicompost for the garden it doesn't much matter if the worms die off, as long as you've kept some aside to set a new box going.

It also makes it easier to harvest the castings, and you'll have a higher proportion of pure castings. But if you want to produce excess worms as well, to extend your worm system, for sale as fishing bait, or to feed to poultry or fish (they really thrive on worm feed), you'll need to separate them from the vermicompost before the proportion of castings gets too high.

Worm boxes:

This section mainly applies to using worms to compost kitchen wastes. For garden wastes, the same basic principles apply, with a few cautions. There's a good range of specialized worm composting units that you can buy: Can-O-Worms, Worm Factory, Worm-a-way, Eliminator, Worm-A-Roo, Tiger Wormery and others.

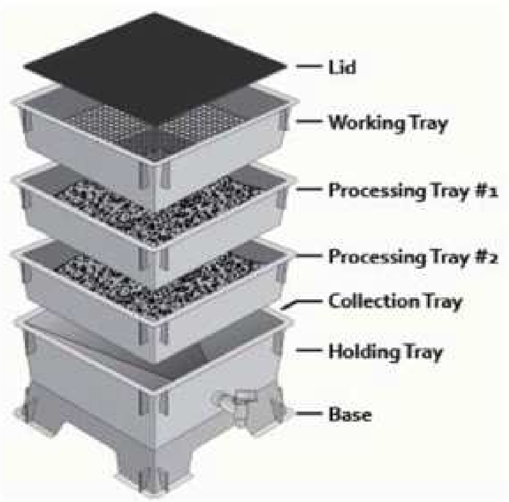

Figure 2: Worm box and its layers.

The size of the unit should be geared to your household's production of kitchen scraps. One or two people usually produce about 4 lb of food waste a week: use a 2ft x 2ft box 8" deep. For three people make it 12" deep, for more, 2ft x 3ft x 12" deep -- or two 2-person boxes might be better, because bigger boxes can be too heavy to move when they're full.

Use exterior-grade 1/2" plywood. Don't use chemically-treated wood. Treat the wood with a non-toxic wood preservative, or paint it with vegetable oil, or linseed oil. Use galvanized nails. Drill at least a dozen 1/2" holes in the bottom for aeration, and arrange it so that two opposite sides are half-an-inch deeper so that the bottom stands off the ground. Stand the box in a tray, because it will probably leak a bit. Once filled, cover the surface with black plastic sheeting (a garbage bag) slightly smaller than the surface area: this will keep the moisture in, and the worms will work right up to the surface. If this makes it too wet, use a couple of newspapers instead. Make a lid for the box. Keep it anywhere convenient.

Bedding:

Fill the box with moist bedding for the worms to burrow in and to bury the food scraps in. You need about 6 lb (dry weight) for a 2ft x 2ft x 8" box. Worms will eat the bedding as well as the food scraps, so you'll need to top it up in a few months. Adding new bedding (Greater Vancouver Regional District)Any inert, non-toxic, fluffy material that holds moisture and allows air to circulate will do. Don't use anything that will decompose too rapidly when you moisten it and get hot, like manure that's not aged enough or hay, especially alfalfa hay. Mixed bedding is better, but no need to be too complicated: 2/3 corrugated cardboard and 1/3 sphagnum peat moss or coco peat moss is a good mixture, or sphagnum peat moss, shredded leaves and sawdust; or just cardboard and/or newspaper. Cardboard cartons (corrugated): cut them up into strips an inch wide and a few inches long. Don't use the shredded cardboard sold for insulation because it's treated with toxic chemicals. Newspaper: tear it into 1" strips -- it's easy to tear with the grain. Black ink is non-toxic, avoid glossy paper. Shredded computer paper.

Autumn leaves: spread them thickly in the driveway and drive over them with the car a few times to break them up, or shred them with a lawnmower. Or moisten them, sprinkle some lime, ground limestone or wood ash over them and bundle them up in a garbage bag, tie the top closed, and in a few months they'll have broken down enough to be excellent worm bedding. Or just use them as is, though it'll take a bit longer for the worms to break them down. Aged manure, or composted manure: cow, horse, and rabbit. Sphagnum peat moss: use Canadian peat moss, soak it in water for 24 hours, squeeze it out and sprinkle some lime on it.

Coco peat moss or coir (coconut fiber): comes in compressed bricks, soak in water and they swell up -- no need to add lime.

Chopped-up straw or other dead plant material, spoiled hay, yard clippings, and dried grass clippings: any plant material "aged" beyond the green stage. Sawdust, wood shavings: from non-aromatic wood, avoid treated wood, about a quarter to a third of the bedding mixture. Add a couple of hand full of soil or sand -- it helps the worms grind up the food in their gizzards. Sprinkle a bit of lime, ground limestone or wood ash over the bedding (not too much!). Ground limestone is best.

Worm bedding and feed can be wetter than compost material: 75%, compared with 65% maximum for compost. Dry bedding usually needs a bit less than three times its weight in water (a pint of water weighs a pound, a litre weighs a kilogram).Once it's all suitably shredded, mixed and moist, put it in the box and add the worms (about 1lb -- 1,000 worms). Leave it for two or three days to let the worms settle in before adding wastes.

IV. VERMICOMPOST PREPARATION

Vermicomposting utilizes the impressive appetites of earthworms to produce compost in confined spaces. Red wiggler earthworms (Eisenia fetida) can eat their weight in garbage every day, and their digestive systems act as miniature composting units, converting that garbage into castings rich in nutrients and organic matter. Furthermore, because vermicomposting requires very little space, apartment dwellers and homeowners without room for an outdoor compost pile can use worms as a low-odour, low-mess means to produce compost.

Step 1: Buy and Prepare the Bin

Drill holes in the sides of the Rubbermaid storage bin, bottom and top (too few or too many holes can be a bad thing, so keep the total number around 20) for air circulation and drainage. Buy a bin that is opaque and not clear – the worms need for it to be dark inside.

Step 2: Find a Spot for the Compost Bin

Placement of the compost bin is important. Many apartment complexes don’t allow storage on balconies, so you may have to strategically hide the compost bin so it is not visible from the outside. Also keep the bin in a shady spot. You don’t want the worms to get too hot or have too much light.

Step 3: Shred Paper for Bedding

Shred newspaper into thin strips to make bedding for the worms you will add. Avoid glossy paper, such as the paper ads are often printed on. Newspaper and the paper inside of phone books are safe for composting worms because the inks used in this papers are strictly regulated by the government. Any other paper is questionable, so recycle any other paper in another way. Cardboard, such as toilet paper tubes, and egg cartons are also suitable for worm bedding. (Glossy boxes, such as cereal boxes are not appropriate.) Spray the paper so that it is moist, but not soaking wet. Always keep the bedding at this moist consistency.

Step 4: Add Food and Wait

Add a little bit of food and a small scoop of dirt and wait about two weeks. The food grows a good crop of microbes that the worms will eat.

Step 5: Add Worms

Eisenia fetid, or red worms, are the best worms for your vermicomposting bin. You can find boxes of them at your local garden center or order them online for about $20. They should breed in your bin, so you should only need to invest in worms once. Don’t put earthworms in your bin. They will die and your compost will fail.

Step 6: Feed the Bin

You will be "feeding the bin" (instead of feeding the worms) because although worms do eat some of the waste material put into the compost bin, they mostly feed on the microbes that break down the waste. Good food to put in the bin includes fruits and vegetables (feed citrus in moderation), coffee grounds, tea bags and crushed eggshells. For foods to add only in moderation include citrus, starches (bread, rice, etc.), spicy peppers, onions, oily food and sugary food. Never add meat or dairy, or any kind of human or pet waste. Don’t add too much food. Watch the bin and see what foods break down and what foods don’t. Foods like lettuce break down right away, while banana peels take a long time to decompose. When you feed the bin, add new shredded newspaper or spray with water, if needed.

Step 7: Harvest the Castings

In a few months, there may be some nutrient-rich worm castings that you can harvest from your bin and use as fertilizer for your garden plants. To harvest the castings, get another container and a plastic bag with holes cut into it. Place the bag over the top of the new container, and make sure it's taught over the opening. Put the new container in the sun, and start putting the contents of your worm bin onto the top of the bag. The worms will burrow through the holes and into the new container because they don't want to be out in the sun. This way you can separate the castings from the worms. When you are done harvesting, put the worms back into their compost bin.

V. BIODIVERSITY IN VERMICOMPOST

In the present study, vermicompost samples were collected and analyzed for microbial diversity and population studies. The vermicompost samples were collected in sterile containers from the rings before harvesting the compost. To compare microbial diversity, samples from the partially decomposed dry organic waste material, ready for the release of the earthworms, were also collected and checked for diversity and population counts. Total microbial populations of bacteria, fungi and Actinomycetes from the substrates were determined by using dilution plate techniques with suitable media (Nutrient Agar, Potato Dextrose Agar, and Actinomycetes Isolation Agar-HI Media). The number of colony forming units (CFU) was expressed as CFU g-1.Several authors have noted that the earthworms play a major role in affecting populations of soil Organisms, especially in causing changes in the soil microbial community [20]. The present work recorded higher microbial populations in the partially decomposed dry organic waste material for vermicompost than the vermicompost (Table 1). This may be due to the existing temperatures and pH in the partially decomposed raw material. But compared to conventional hemophilic composts, vermicompost is much richer in microbial diversity, populations and activities [21].

	Bacteria (CFU g^{-1})	Fungi (CFU g^{-1})	Actinomycetes (CFU g^{-1})
Vermicompost	54×10^6	8×10^4	1×10^4
Partially decomposed dry organic waste material for vermicompost	69×10^6	11×10^4	2×10^4

Table 1. Microbial populations from the samples of vermicompost

The fungal isolates from the samples were identified up to species level (Table 2). Much diversity was observed between the two samples collected. *Aspergillus*, *Fusarium*, *Mucor*, *Cladosporium*, and*Trichoderma* were the common genera observed in both the samples. Genera like *Absidia*, and *Stachbotrys* were recorded in vermicompost. Genera like *Alternaria*, *penicillium*, and *Thermomyces* were isolated from partially decomposed dry organic waste material for vermicompost. This clearly indicates that the fungal diversity is more in the decomposed material than in the vermicompost. The digestive epithelium of the simple straight tubular gut of worms is known to secrete cellulase, amylase, invertase, protease, phosphatase [22]. Earthworms inevitably consume the soil microbes during the ingestion of litter and soil. It has been recently estimated that earthworms necessarily have to feed on microbes, particularly fungi for their protein/nitrogen requirement [23]. This may be the reason for the less diversity of fungi and microbial counts seen in the vermicompost collected.

In both the samples percentage of *Aspergillus* was more when compared with other genera. *Tricoderma* and *Penicillium* have antibiotic activities and can also be used as biological control on soil borne pathogens. Only a few studies have investigated that the suppression of soil borne plant pathogens by vermicompost [24], or disease suppression in the presence of earthworms [24]. Disease suppression by compost has been attributed to the activities of competitive or antagonistic microorganisms as well as the antibiotic compounds present in the vermicompost.

Partially decomposed dry organic waste for vermicompost	Vermicompost
Alternaria citri	*Absidia cylindrospora*
Aspergillus fumigatus	*Aspergillus fumigatus*
Aspergillus niger	*Aspergillus niger*
Aspergillus cervinus	*Aspergillus clavoto nanicus*
Aspergillus terreus	*Aspergillus terreus*
Aspergillus sydowii	*Aspergillus sydowii*
Aspergillus niveus	*Aspergillus nidulans*
Aspergillus sclerotiorum	*Cladosporium herbarum*
Cladosporium cladosporioides	*Fusarium oxysporum*
Cladosporium herbarum	*Fusarium semitactum*
Fusarium samucinum	*Fusarium nivale*
Fusarium dimerum	*Mucor circinelloides*
Mucor racemosus	*Stachbotrys chartarum*
Penicillium chrysogenum	*Trichoderma viride*
Penicillium thomii	
Penicillium citrinum	
Trichoderma viride	
Thermomyces lanuginous	

Table 7. List of fungi isolated from partially decomposed dry organic waste for vermicompost and vermicompost.

VI. CONCLUSIONS

The production of degradable organic waste and its safe disposal becomes the current global problem. Meanwhile the rejuvenation of degraded soils by protecting topsoil and sustainability of productive soils is a major concern at the international level. Provision of a sustainable environment in the soil by amending with good quality organic soil additives enhances the water holding capacity and nutrient supplying capacity of soil and also the development of resistance in plants to pests and diseases. By reducing the time of humification process and by evolving the methods to minimize the loss of nutrients during the course of decomposition, the fantasy becomes fact. Earthworms can serve as tools to facilitate these functions. They serve as "nature's plowman" and form nature's gift to produce good humus, which is the most precious material to fulfill the nutritional needs of crops. The utilization of vermicompost results in several benefits to farmers, industries, environment and overall national economy.

To Farmers:

• Less reliance on purchased inputs of nutrients leading to lower cost of production

• Increased soil productivity through improved soil quality

• Better quantity and quality of crops

• For landless people provides additional source of income generation

To Industries:

• Cost-effective pollution abatement technology

To environment:

• Wastes create no pollution, as they become valuable raw materials for enhancing soil fertility

To national economy:

• Boost to rural economy

• Savings in purchased inputs

• Less wasteland formation

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