

Compost and Vermi-fertiliser Manual



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Why is it necessary to make compost?

If the soil is to provide a healthy environment for crops to grow and produce reliable high yields, there must be a programme which returns the organic matter taken out of the soil, when the crops and their plant residues are removed.

Organic matter provides a structure to the soil which allows air to be retained in the soil, so that the crops roots can 'breathe'. The organic matter also provides the structure in the soil which keeps sufficient moisture near the roots of plants, so that they can 'drink'. Natural fertilisation of crops occurs as soil microbes degrade organic matter, releasing nutrients – so that crops can 'feed'.

What are the different types of compost and organic fertiliser?

Pile compost

Organic matter which is decomposed above the ground, by making a pile of plant materials and other substances, is called 'pile composting'.

This type of compost makes more of a contribution in soil structure than mineral fertilisation because of the size of the individual particles in the compost. Therefore larger amounts of pile compost can be applied to the soil than the vermi-fertiliser described below (which is not a real 'compost').

There will be beneficial microbes growing naturally in the pile compost which will improve soil health.

Solid vermi-fertiliser

This is made from worm casts (faeces) and is a fertiliser, not 'compost'. Therefore the amount of solid vermi-fertiliser applied to the soil has to be controlled, to avoid crop damage from fertiliser scorch.



Fig 1: worm casts (solid vermi-fertiliser)

Liquid vermi-fertiliser

If water is applied to shallow trays of solid vermi-fertiliser, the leachate can be collected and used as a liquid fertiliser, sprayed onto the crop canopy or drenched into the soil. Its concentration and mineral content

is variable and it is not a complete fertiliser. It has to be diluted before spraying to avoid scorching the plant.



Fig 2: worms in the vermi fertiliser production units



Fig 3: vermi-liquid fertiliser collection

How to make pile compost

From construction of a new compost pile to harvest of the '*ready compost*', which takes about 10 weeks, the pile is managed according to the guidelines below.

Weekly Programme

In order to have regular production of *ready compost* (i.e. one pile ready to harvest per week) – the number of piles in a Compost Production Unit (CPU) should be 10 (or a number divisible by 10 or 5). This makes it easier to organise a timetable of work done regularly on a daily basis in a five-day week.

There should be a weekly construction programme for new compost piles. One new pile of one meter height will be made every week. Make the new piles on the same day each week, to keep the production systematic. One new pile will be made every week on a Monday, to replace one pile each week which will be '*ready for harvest*'.

The ready compost (10 weeks old) should be removed from the compost production line and kept in a separate area, to keep the production systematic. Compost should not be removed 'piece meal' from existing piles in the production piles as this destroys the timing of the production system and makes the system difficult to supervise.

Construction method

If there are to be 10 piles in total - start the CPU by marking out and digging ten pairs of shallow pits (1 m x 1 m) - that is twenty pits. This arrangement will enable a supervisor to easily check if the piles have been turned on the days they are supposed to be turned.

One new pile will be made per week, from the material which has been collected during the week.

Organise for there to be two large buckets for the kitchen waste – so that on a daily basis a full bucket is delivered to the CPU and the kitchen go back with a clean, empty bucket. The full bucket remains in the shade with the lid on and the Compost Technician will on a daily basis, add this to the new pile – following the instructions below.

Piles are made up in layers: dry brown waste; fresh moist green waste; sprinkling of manure and/or Trichoderma granules. Trichoderma is a fungus which speeds up compost production.

On a daily basis, make an extra layer (or more, if material is available) in the pile. Alternate a layer of fresh moist vegetable matter (e.g. kitchen waste, weeds without seeds, crop residues, coffee pulp, banana stems etc.) with a layer of dry material (e.g. dry maize stovers, straw, dry bean stems, shredded cardboard and paper etc.). Each layer should be about the width of a man's hand deep. The third layer is a sprinkling of manure and/or Trichoderma granules. Keep piling up the layers until the pile is at least waist-high.

Always cover the new piles with a large sheet of plastic which covers the pile – to keep the heat inside and the birds and rats away. Keep the piles covered with plastic to keep the moisture inside.

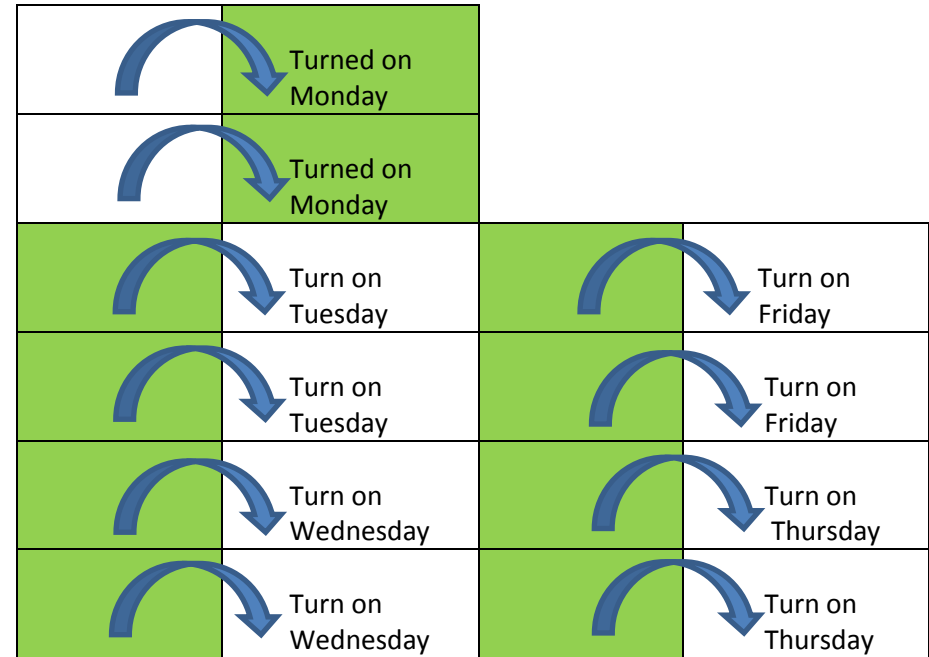
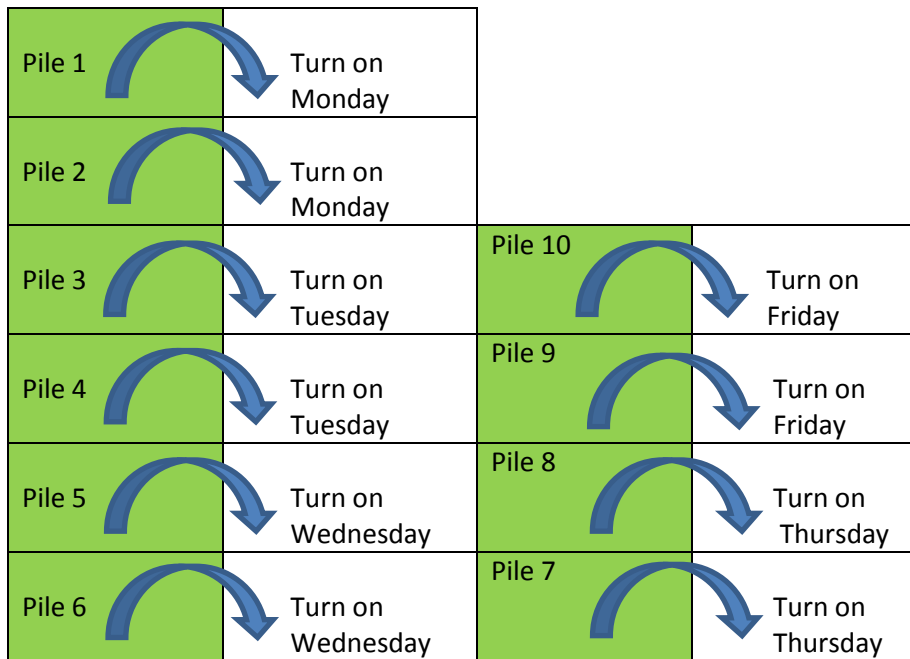
Turn piles every week

Every pile will be turned once per week into the pit next to it, in order to increase the air provided inside the heap and encourage microbes to multiply and the compost to decompose more quickly.

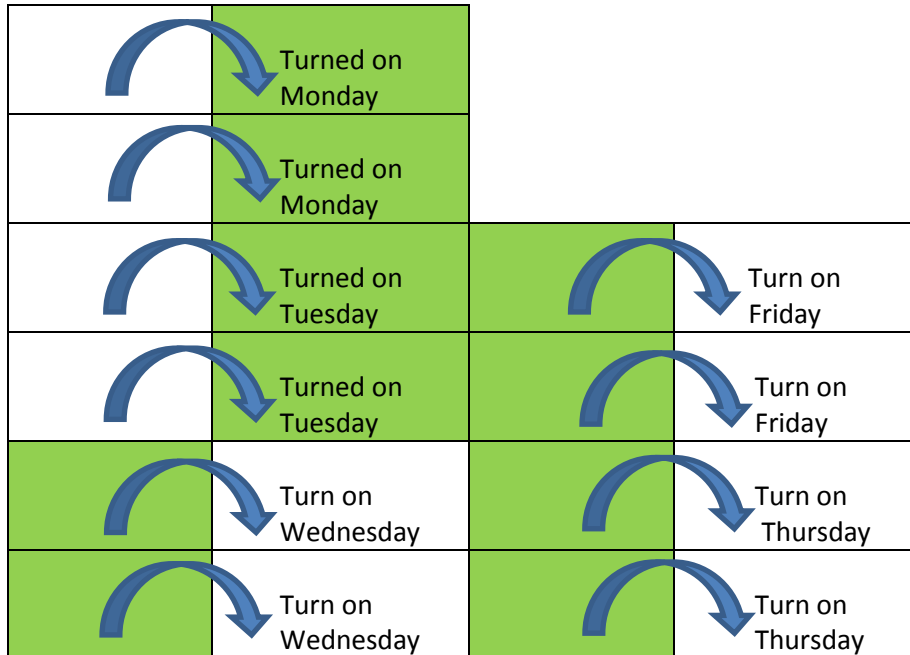
This makes the process easier to supervise, rather than waiting for the heat in the pile to decline before turning it. Turn every pile once per week, irrespective of the temperature in the pile.

To spread the work load, two piles will be turned each weekday:
 2 piles on Monday, 2 piles on Tuesday, 2 piles on Wednesday, 2 piles on Thursday and 2 piles on Friday.

This also makes it simple for a manager to check the piles have been turned in accordance with instructions – since it is possible to see which piles have been turned (according to their position in the two rows).



On Monday the piles positions will be as above and it is easy to check that the Compost Technician has done what was instructed (to turn all piles once per week).



On Tuesday the piles positions will be as above and it is easy to check that the Compost Technician has done what was instructed (to turn all piles once per week).

As the week progresses through to Friday, two additional piles will be turned per day until all piles are now in the second line of pits.

The following week, they will be turned back into the first line of pits (2 piles per day) – in the same way as just described

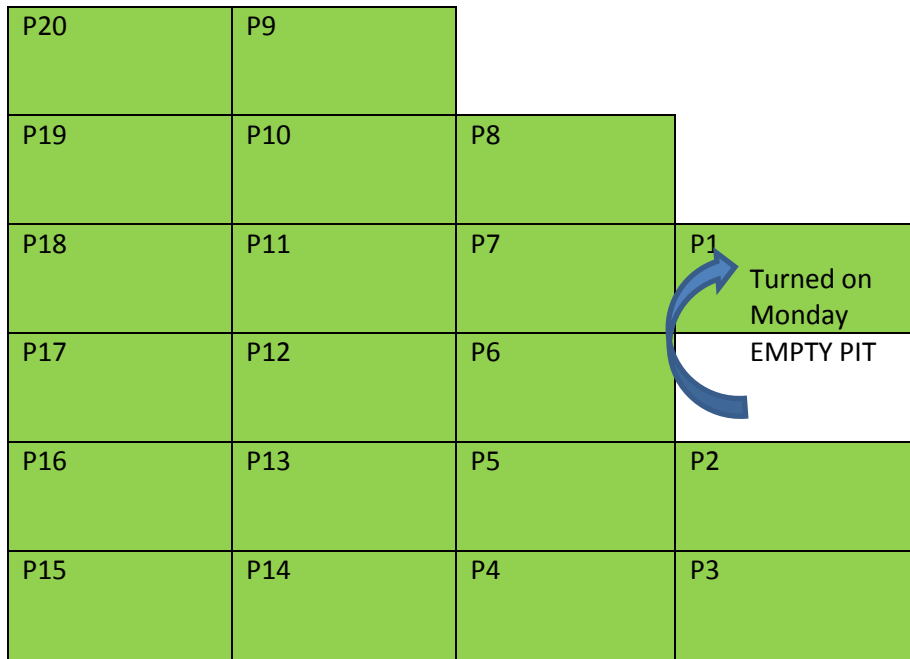
The above method is an easy way to start teaching the Compost Technician to turn the compost and it makes each day's work manageable.

As the technician gets more competent and if the amount of waste increases, then both the size and number of piles can be increased.

Instead of only having ten piles of compost the technician can manage 20 piles of compost, if he/she adds one extra pit, to permit the turning to occur in a circular fashion, rather from side to side as described above.

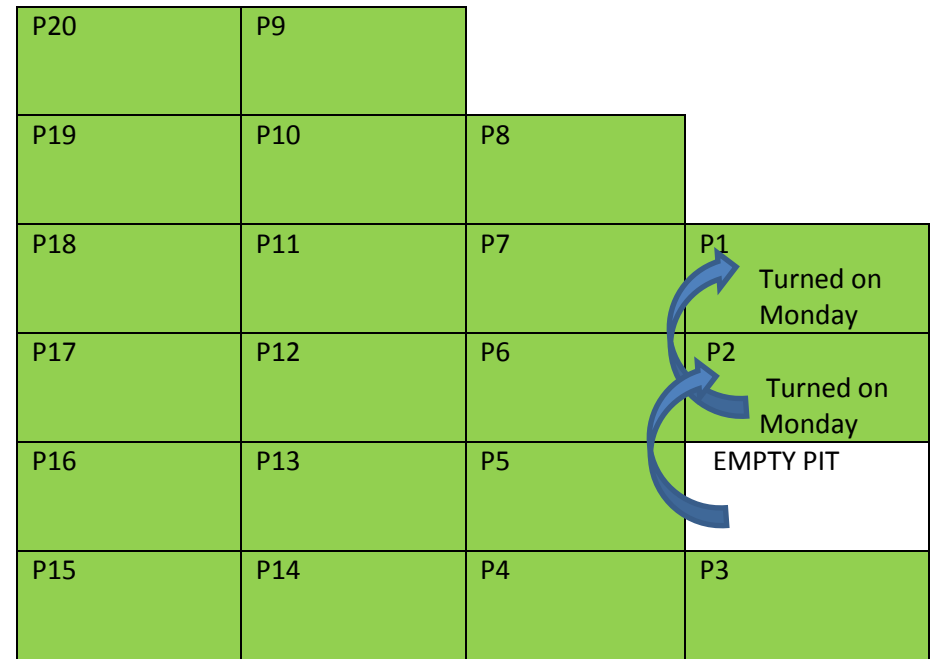
P20	P9		
P19	P10	P8	
P18	P11	P7	EMPTY PIT
P17	P12	P6	P1
P16	P13	P5	P2
P15	P14	P4	P3

See above the layout of 20 piles with one empty pit to permit turning space for two piles per week



Step 1:

On Monday, turn PILE 1 into the adjacent EMPTY PIT, creating a new EMPTY PIT next to PILE 2.



Step 2:

On Monday, turn pile 2 into the adjacent EMPTY PIT, creating a new EMPTY PIT next to Pile 3.

P20	P9		
P19	P10	P8	
P18	P11	P7	P1 Turned on Monday
P17	P12	P6	P2 Turned on Monday
P16	P13	P5	P3 Turned on Tuesday
P15	P14	P4	EMPTY PIT

Step 3:

On Tuesday, turn pile 3 into the adjacent EMPTY PIT, creating a new EMPTY PIT next to Pile 4.

P20	P9		
P19	P10	P8	
P18	P11	P7	P1 Turned on Monday
P17	P12	P6	P2 Turned on Monday
P16	P13	P5	P3 Turned on Tuesday
P15	P14	EMPTY PIT	P4 Turned on Tuesday

Step 4:

On Tuesday, turn pile 4 into the adjacent EMPTY PIT, creating a new EMPTY PIT next to Pile 4.

The process continues in this pattern, turning two piles every day into the new 'empty pit nearby (created by the previous days tuning of piles).

Watering compost piles

Check the moisture levels of all piles every day by pushing a long stick into the centre of the pile, removing it, and feeling the wetness of the stick. The whole pile should be kept moist. Add water with a hosepipe on a daily basis if the pile is not moist. Do not over-water, as this will wash out nutrients – no more than one minute per pile should be spent watering the pile.

Ready Compost

Once per week, the oldest pile (10 weeks old) will be removed and placed in a Ready Compost Area, whether it is ready or not – to make room for the building of the new compost pile in the system

Ready compost MUST be removed from the Ready Compost Area and cannot be just taken as needed from the Compost Production Unit piles – to prevent the system from breaking down and making it more difficult to supervise.

What type of worm is needed?

The worms used are called red litter worms which look very much like earthworms. However, they only feed on the soil surface taking debris and eating it. They do not burrow into the soil like earthworms. This is why they are very efficient at turning waste into fertiliser. Vermi-fertiliser worms are available from Real Impact NGO at 500 Ksh per kilo.



Fig 4: Red wiggler worm (*Lumbricus rubellus*)

How to make solid vermi fertiliser in trenches

From construction of a new vermi-fertiliser trench to harvest of the 'ready fertiliser' takes about 12 weeks; the pile is managed according to the guidelines below.

The permanent trenches are made by digging out one meter deep trenches by one meter wide. The length of the trench depends on the volume of fresh material available to feed the worms. The sides of the trench should be lined with plastic to stop soil erosion of the walls.

Fortnightly trench preparation programme

In order to have regular production of *ready fertiliser* (i.e. one trench ready to harvest per fortnight) – the number of trenches in a Vermi Fertiliser Production Unit (VFPU) should be 6 (or a number divisible by 6). This makes it easier to organise a timetable of work done regularly on a fortnightly basis.

One ready fertiliser trench will be harvested every two weeks and it will be started again in the same week – so a new trench will be started every two weeks.

Dig a trench one meter deep and line it with plastic on the sides, to stop the sides from falling in. Site the trench in the shade of trees.



Fig 5: vermi fertiliser trench

The ready fertiliser (12 weeks old) should be removed from the trench and bagged for storage or use as a fertiliser straight away. Vermi fertiliser should not be removed ‘piece meal’ from existing trenches in the VFPU as this delays the timing of restarting the next trench in the production system and makes the system difficult to supervise.

Setting up a new trench

1. Apply a layer of **bedding for the worms** in the base of the trench. The bedding can be a layer (three fingers width deep) of ready pile compost.
2. Next, apply **five kilos of worms per meter square of trench** (50 kilos per 10 meter-long trench). Use a one-litre (ice cream) tub to measure out one kilo of worms from a mature trench and apply evenly to the surface of the new trench
3. Immediately, apply a layer of **fresh chopped green waste, three fingers deep**, on top of the worms to stop them dying of dehydration or heat – and also to feed them.

Weekly feeding

Every week apply a new layer of chopped green waste, the width of three fingers deep. In a ten meter trench this is about 8 wheelbarrows full of green waste.



Fig 6: Recent application of worm food to trench

Daily watering

Water each 10-meter trench for two minutes only with a water hose. Cover the trench with shade net to make sure the worms are kept moist and do not overheat.

If the trenches are smaller (due to lack of feeding material or only having a small number of worms to start with) then apply small amounts of water. The worm casts must just be slightly moist and never WET. If it is too wet the worms may drown and will be colder (therefore breed more slowly).

Set up programme for trenches

Trench 1 – set up in week 1
Trench 2 – set up in week 3
Trench 3 – set up in week 5
Trench 4 – set up in week 7
Trench 5 – set up in week 9
Trench 6 – set up in week 11

By week 12 the first trench will be ready to harvest and set up again

Cover the trench with shade net to keep cool and stop birds feeding on worms. Preferably, site trenches under a tunnel to stop rain filling trench and drowning worms

Garden and Kitchen waste for worm food

All ingredients must be finely chopped before applying to the vermi-compost unit. Apply thin layers of materials (one inch deep) at a time and re-apply when this is finished.

- maize stalks, coffee or rice husks, cereal chaff, grass cuttings

- coffee pulp, avocado skins and pulp
- animal manure (any type except human, pig, poultry)
- kitchen fruit & vegetable waste

Use equal portions of the above groups, premixed before applying.

Do not use:

- Fats, meat, cooked food, blood or bone.

Green material from coppices

The above recommendations are adequate for use as a feed stock for worms. However the mineral content is very variable due to the varied inputs.

If the farmer wants to produce a consistent mineral content in the vermi-fertilisers, then the ingredients fed to the worms need to be standardised.

The following concept is under-going testing at Real Impact's demonstration farm and forms part of the Compost Training Course.

Coppicing of plants to produce large volumes of green waste materials to feed the worms, will save time collecting materials and guarantee supply of enough food material to keep the production process on schedule.

- **Russian Comfrey** – transplant comfrey side shoots into a drip-irrigated bed in two lines of plants (zig-zag pattern) at 40 cm between plants

- **Tithonia** – stick 12-inch cuttings into the soil at 20 cm between cuttings with four lines per bed
- **Amaranth** – transplant seedlings at 20 cm between transplants with four lines per bed

Bed preparation for coppices

Production of the coppice green waste plants should be done in raised beds amended with one wheelbarrow of compost per 3 meters of bed. Beds are 1.2 meters wide and 15 cm high. Use three lines of drip irrigation per bed. There are six vermi-fertiliser trenches and there should be six beds each of the three coppice plants

Harvesting worm food from coppices

Each week cut back one bed of Amaranth and one bed of Tithonia to 6 inches height. Do this in a systematic way, so that there will be six beds each with a different height of crop.

Comfrey plants should have all but three leaves carefully cut from the plant – so that there are enough leaves to feed the re-growth of the plants.

Fertiliser for coppice worm food plants

Spray once per week with vermi-liquid (10% solution) onto the foliage of the plants.

Top dress beds with vermi-compost after cutting back (every six weeks) – one wheel barrow per 20 meter bed.

How to make vermi liquid fertiliser in trays

- Vermi-liquid is made by allowing water to leach the nutrients out of the vermi-fertiliser.
- The leachate is collected and diluted (1 part vermi-liquid to 9 parts water) before using as a soil drench or as a 2% solution as a foliar spray.
- The vermi-fertiliser can be held in either a large tray system (with a 1% slope) or in a bin-system.
- The large tray system has plastic corrugated sheets in the base – not metal sheets, as these will corrode.
- Line the end of the tray (where the vermi-liquid drips into the gutter) with netting to stop worms and compost leaking out into the gutter.
- The gutter is positioned so that it drains into a container for the vermi-liquid.
- Cover the entrance to the vermi-liquid container with netting to stop flies coming into the container.
- Feed the worms in the same way as the worms for the vermi-fertiliser.
- Treat the legs of the worm trays with grease to stop ants attacking the worms.

- Do not over-water (worms will drown). Do not under water (worms will dehydrate).



Fig 7: Vermi-liquid fertiliser collection from Real Impact Propagation House Kit (which includes vermi-liquid tray)

Vermi-fertiliser application rates

Vermi-liquid can either be drenched in the soil or sprayed as a foliar fertiliser. A strong concentration of 1 part vermi-liquid to 9 parts water can be used for the drench, but this must not be used for the foliar spray, as it will scorch the plant.

Foliar spray must not exceed a 2% solution, or the leaves will be scorched (20 ml of vermi-liquid in one litre of water). Use the same amount of 'vermi-liquid-solution' as the usual volume of irrigation water.

- Pumpkin, cabbage, spinach: 100 g per m sq. at end of previous crop.
- Fine beans: 50 g per meter square
- Banana: 2 kg per tree at planting; 5 kg 1-5 yrs old; 10 kg 6 – 9 yrs old; 20 kg > 10 yrs old
- Bag gardens (kales and amaranth) 1 kg/bag at planting
- Moringa tree: 3 kg per tree at planting.
- Propagation trays 10% VF with sieved sterile soil.
- Do not use for root crops (carrots, sweet potato)

How to make vermi liquid fertiliser in bins

What is the worm bin for?

The worm bin is designed primarily to produce **vermi-liquid fertiliser** for spraying as a foliar feed or drenching into the soil. It will also produce small quantities of **vermi-solid fertiliser** (worm castings or droppings) for use as a fertiliser applied to the soil. In this process a population of **worms** will build up in the bin, which could be used to make extra worm bins, or fed to chickens.

What is inside the worm bin?

Inside the bin is a basin with holes in the base. The worms and vegetable waste are placed in this basin. The basin is positioned near the base of the bin with a gap beneath it, so that vermi-liquid can drain out of the

basin and into the reservoir below. A tap allows vermi-liquid to drain out of this reservoir to be used in the garden.



Fig 8: Vermi-liquid fertiliser collection from Real Impact Worm Bin

How does it work?

The system works, by the worms feeding on small quantities of chopped fresh vegetable waste which are sprinkled onto the surface, where the worms will be waiting to feed. Only small quantities of suitable vegetable waste are applied at a time for the worms to feed on. The concentrated vermi-compost fertiliser is the 'worm poo' (or worm castes) made when the worms feed on the waste vegetable matter. There are holes at the top of the bin around the rim to provide some ventilation and a sheet of netting rests on the surface of the vermi-compost to reduce interference by flies.

Over a period of three months the level of the vermi compost fertiliser (worm poo) in the worm bin will fill up (as you gradually add weekly food that is digested by the worms) and eventually it will need to be emptied and the system re-started.

The amount of vermi-liquid which you can obtain per week from the bin will increase as the depth of the vermi-compost increases over time. The deeper the layer of compost, the more water can be applied each week, without drowning in the worms.

Never apply deep layers of vegetables for the worms to eat, as this will begin to decompose and may produce heat because of decomposition, which will not be beneficial for the worms.

What do I need to do with the worm bin when I get it home?

The Real Impact worm bin has been set up with a colony of worms already feeding on a vegetable waste with some existing vermi-compost in the basin inside the bin. There will even be a 'picnic lunch' in the worm bin (some fresh chopped vegetables on the surface). You should not have

to feed the worms for another two weeks, after delivery. The vermi-compost will be slightly moist when you receive it. Feel the moisture with your fingers so you can learn how moist you need to keep the compost (by applying small amounts of water). Place the worm bin in the shade. Worms die if they overheat or dry out.

How much food should I give the worms?

The key to feeding is the activity of the worms. Continuous presence of the worms at the top of the bin indicates they have exhausted their food and need more food.

The other indicator is the state of the materials in the bin. If this looks 'soil like' with very small regular shaped pieces (known as worm castings) then the worms need more food. Regulate the amount of food to match the consumption of the worms.

The insect netting inside the bin is there to reduce the flies which may enter the bin and try to lay eggs in pieces of fruit and vegetables. It rests on the compost surface. When adding new worm foods, take off the netting, then always bury the new worm food by pulling aside some of the finished black vermi-compost, sprinkle the fresh finely chopped vegetable waste over the surface, and then cover it up with the black vermi-compost again. This will make it less attractive to flies, as they will not be able to smell the fruit and vegetables so easily. Replace the netting onto the surface after feeding. Feeding frequency may be once a week to be increased or decreased as the feeding of the worms dictates.

While worms will eat almost anything you should avoid feeding them with material containing meat or milk products. Avoid overfeeding with products that promote acidic conditions such as peelings of pineapples, oranges or citrus fruits. You can feed the worms with egg shells,

vegetables and fruits, coffee grounds or tea bags including the bag or filter, any composted plant residue. If you are uncertain about any food type add a little and observe how the worms behave. Always chop the food finely before adding to the worm bin. Never put more than a one inch deep layer of new worm food. Never add food until the last application has been finished.

Worms LOVE	Worms HATE
breads & grains cereal coffee grounds & filter fruits tea bags vegetables	dairy products fats meat oils cigarette butts

Small amounts of animal manure (sheep, goat, horse and cow) should be added with the vegetable waste, to increase the nitrogen content of the resulting vermi-liquid. However, avoid very strong manures such as pig and poultry manure. When composing the weekly worm feed, the manure component should not exceed more than 20% of the total feed material.

Wash your hands after feeding the worms or working with the worm bin.

How much water should I apply to the compost?

The volume of vermi-liquid produced by the bin depends on the amount of vermi-compost inside the bin and the amount of water which is applied during the week.

The concentration of the nutrients in the vermi-liquid will depend on the amount of water applied in relation to the volume of vermi-compost in the bin. If the volume of compost is small and a lot of water is applied, the vermi-liquid will be weak.

If the volume of compost is large and the volume of water that is applied is low – the concentration of the vermi-liquid will be high. Generally, the darker the colour of the vermi-liquid, the stronger the concentration.

- Check the moisture of the compost – never let it dry out (the worms will die).
- It is equally important never to over-water the compost so that the compost is very wet. It should just be moist. If there is too much water in the compost, the worms cannot breathe and they will drown – as a guide, apply the following amounts of water as the bin matures
- If the worms are leaving the vermi-compost and climbing the walls of the bin – they may be escaping water-logged conditions. Stop watering and empty the compost onto newspaper in the shade to dry it out, before returning it to the bin.

vermi-compost level in bin	Average amount of water applied (depending on moisture level of compost)
< 25%	One cup every 3-4 days
25 – 50%	One cup every 2-3 days
50 – 75%	One cup per 1-2 days

- Don't forget to drain off the vermi-liquid in the reservoir every week, to prevent the level rising too much and coming back through the holes in the basin – this would over-wet the vermi-compost and may drown the worms above.

How should I use the vermi-liquid?

Vermi-liquid can be a strong fertiliser – its strength is indicated by the deepness of the colour. It will range in colour from black to very weak brown. As explained above the colour (or strength) of the vermi-liquid is regulated by the amount of water applied in relation to the amount of vermi-compost which has been made by the worms.

As a general rule, it should be diluted at about 1 part vermi-liquid to 9 parts water before it is applied as either a foliar feed to plants leaves. It can be drenched 'neat' to the soil, as long as it does not touch the plant stems.

Do not apply foliar feeds to plants in the same week as fruit or vegetable is to be harvested, to ensure the fruit is clean when harvested. Always wash fruits and vegetables harvested in the garden before use. During harvesting and any other time, vermi-liquid can be drenched in the soil.

Never apply a foliar feed (or even water sprays) during the heat of the day – as this will scorch the leaves of the plant. Apply once or twice per week during periods of active plant growth. One (15 L) knapsack will cover about 60 meter square of crop in the ground.

Vermi-liquid can be stored in sealed containers if it is not needed for the garden.

What is vermi-fertiliser?

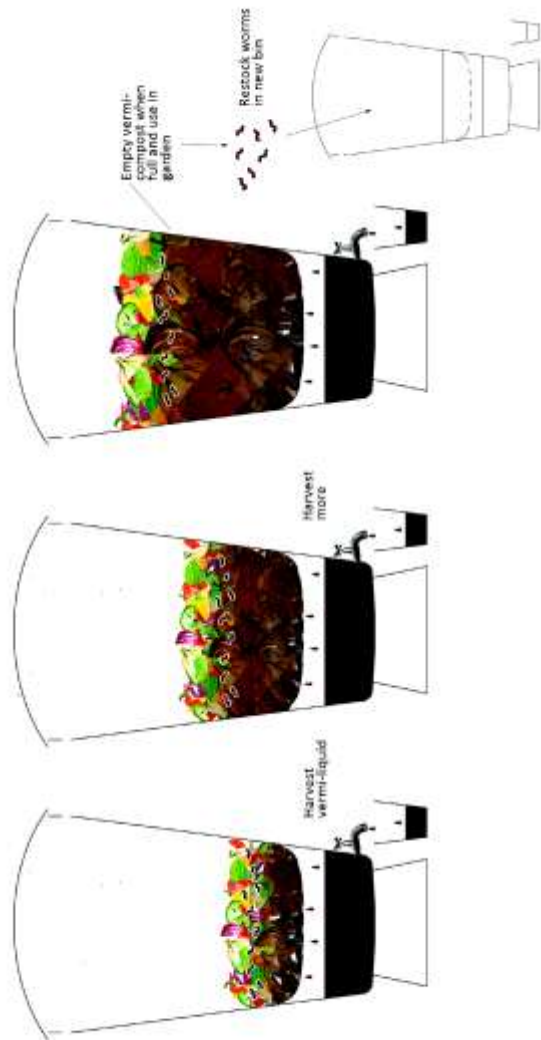
The black worm casts are the poo excreted by the worms, having eaten the vegetable waste provided. This is an organic fertiliser. It is too

'strong' to be used on its own in seed trays and is best used in the soil, in the same way as base dressings are added to the soil before planting.

What happens when the bin is full?

When the bin is full and there are no recognisable scraps of food left - empty the vermi-compost from the bin and use it in the garden. First sieve the worms out of the vermi-compost, so they can be re-used to start two new bins, or feed some of the worms to chickens or fish.

Clean the worm bin. Then ensure the basin is correctly in position as before. Place two inches of the old vermi-compost in the base of the basin and add a one inch layer of chopped vegetables to the surface. Make sure the vermi-compost is the correct moisture level. Then place one kilo of earthworms back onto the surface – they will quickly burrow beneath the fresh vegetable waste and begin feeding. Put the insect netting over the surface then replace the lid. Put the worm bin back in a shady position.



Troubleshooting

Problem	Possible cause	Action
Worms are dying or trying to escape	Too wet	Check the reservoir is not over full and drain the vermi-liquid reservoir more often; do not apply so much water every week. If it is very wet and worms are dying – then remove all the compost from the bin and put the live worms to one side in the shade in a sealed box and dry out the vermi-liquid on newspaper in the sun until it is the correct moisture. Replace the worms and the vermi-compost (follow instructions as per re-starting a bin). Do not keep worms away from the food for more than 4 hours whilst drying the compost out
	Too dry	Moisten the vermi-compost adequately
	food is used up	Add food– or harvest the bin if it is full
Bin stinks	Not enough air	Gently lift and separate the vermi-compost by using a stick or your hand to aerate the compost (wash hands afterwards)
	Too much food	Remove uneaten food and follow instructions about amounts of food to be applied.
Fruit flies	Exposed large pieces of fruit/veg	Follow instructions and chop food more finely, and bury the food with a small layer of vermi-compost so the fruits and vegetables are not exposed to fruit flies on the surface.