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EARTHWORMS FOR ORGANIC FARMERS

By Sultan Ahmed Ismail

INTRODUCTION

The earthworm has always been a subject of interest and many ancient scientists, sages and poets have sung its praises. While the Tamil poet Manonmanian Sundaranar has extolled the earthworms as "those who can remediate any type of difficult soil", scientists have praised the earthworms either as "the intestines of the earth" (Aristotle) or as "nature's plough" (Darwin).

Earthworms have always been regarded as *friends of the farmers.* Earthworms have a very positive effect on the physical, chemical and biological parameters of the soils. The earthworm is a soil biotechnologist and a solid waste manager. Earthworms are known to consume large quantities of organic litter or waste and convert them into manure, which is used as valuable compost, known as 'vermicompost'.

General awareness of the problems caused by excessive use of chemicals in agriculture in the form of fertilizers and pesticides, has resulted in a search for alternatives to chemical farming. These alternatives are variously known as organic farming, sustainable farming, biodynamic farming, permaculture, natural farming, non-violent farming, zero-tillage farming, etc., to name a few. The common objective of all these practices is to avoid the application of chemicals that damage both living organisms and the surroundings, and harness instead the energies of natural agents to make agriculture highly productive, while at the same time retaining the fertility of the soil and the health of the land.

The significance of earthworms in soils is manifold. They are unique among soil invertebrates as they bury organic debris, mix organic and inorganic matter in their excreta and modify the structure of the soil through their burrow systems. Their importance in nutrient cycling, soil structure, soil health including soil fertility, productivity, agriculture, and their application in organic waste management has been well established. Therefore the earthworm is considered as the leader in revitalization of the soil.

However, earthworms are not alone in their job. They are one among a group of beneficial organisms, which improve soils. Several microorganisms, and a huge community of creepies and crawlies join the earthworms in maintaining soil health. However, the presence of earthworms is an indicator of soil health. To

diagnose soil health one has to feel the pulse of the soil. Earthworms are the pulse of the soil. Healthier the pulse, healthier is the soil.

EARTHWORMS – BIOLOGICAL FACTS

There are more than 3000 species of earthworms in the world and in India we can boast of more than 500 species identified till date. Most of these are indigenous earthworms, which mean they belong to our soils.

Earthworms are segmented cylindrical organisms. They are most commonly found in healthy soils. Their colour ranges from light purple to brownish, with the ventral side being slightly paler. Based on growth stage, earthworms are generally classified into juveniles, aclitellates, clitellates or adults, and post sexual worms. Mature earthworms are distinguished by the presence of a collar, called the clitellum, nearer to the anterior end of the body.

Life cycle of earthworms:

Earthworms are hermaphrodite, which means that both male and female reproductive organs are present in every worm, yet self-fertilisation is not feasible. So even though you know that both sexes (male and female) are present in each earthworm you must use a minimum of at least 2 mature earthworms (= earthworms having their collars) of the same species to start your culture. After fertilisation, the earthworms shed cocoons. Cocoons are small, spherical, translucent structures. There is variation in the size and shape of the cocoons of the different species. The colour of the cocoon deepens as the young ones (juveniles) hatch out. Though many eggs may be contained in each cocoon, only a few develop into young worms. The surface dwelling composting earthworms produce more young ones per cocoon than the burrowing worms. In about a fortnight the juveniles physically grow into immature adults (nonclitellates or aclitellates) and in the next two weeks the clitellum appears indicating sexual maturity in the earthworm, which is now ready to mate and produce cocoons. The entire cycle from cocoon to cocoon takes about 50 to 60 days in most local varieties of earthworms. The life expectancy of major Indian earthworms is about a year during which period they produce several offspring.

Common Names of Earthworms in India

NAME	LANGUAGE
Kencho	Bengali
Yalisiya	Gujarati
Kechuva	Hindi
Munhulla	Kannada
Mannira	Malayalam
Gaandul	Marathi
Zia	Oriya
Mannpuzhu	Tamil
Vaanpaambu	Telegu
Gandoya	Punjabi

Earthworms enjoy a wide distribution in soils. This is well reflected in the ways the several species live in different soils. Earthworms are found in all but the driest and the coldest land areas of the world. The distribution of earthworms is usually irregular, the numbers varying in relation to soil type, with local factors playing a vital role in their distribution. Each soil system has its own composition of soil organisms and these locally adapted populations of any plant or animal variety are referred to as ecotypes.

Earthworms are classified into surface dwellers and sub-surface dwellers.

Surface dwellers:

These earthworms live above the mineral soil surface, typically in the litter layers of the soil. They mainly feed on organic matter. *Perionyx excavatus, Eisenia fetida, Eudrilus eugeniae,* and *Lumbricus rubellus* are examples of surface dwelling earthworms. Surface dwellers are usually darker in colour, mostly purplish or reddish. They largely consume decaying organic matter and convert it into manure. That's the reason why in organic farming practices application of mulch is recommended. This mulch can always be a habitat in which all these soil organisms including the earthworms would live comfortably and churn out excellent nutrients for the soil. Moreover such mulch retains moisture in the soil.

Sub-surface dwellers:

These earthworms live in burrows created by them in the soil. These burrows are scientifically known as drilospheres (drilo=drilled; sphere=space). Such drilospheres are treasure homes of microbial activity and favourite "jaunts" of growing roots. These sub-surface dwellers can again be divided into two categories: the predominant vertical burrowers and the horizontal burrowers. Organic farming appreciates the presence of air in the soil. The burrowing earthworms indirectly also aerate the soil.

Some of these earthworms come to the surface through the burrows to feed on dead leaves and other surface litter. Many of these species deposit their casts on the surface of the soil while others deposit them within their burrows. Incidentally, the cast deposit by these earthworms is related directly to the bulk density of the soil, which means they generally leave their casts within the burrows if the soil is loose and on the surface if it is somewhat compact. *Lampito mauritii, Octochaetona serrata* and *Lumbricus terrestris*, are examples of such earthworms. The horizontal burrowers depend on the organic matter in the soils for their food. *Pontosolex carethrurus* and *Octochaetona thurstoni* are examples of such earthworms.

The common factors that chiefly affect earthworm distribution in the soil include soil temperature, pH, moisture, organic matter, and soil texture. Temperature and moisture, apart from pH, largely affect earthworm activity. Yet, compared to temperate conditions, tropical species (Indian earthworms for example) can withstand higher temperatures. Hence, in earthworm culture, the need for the

identification and the application of local species of earthworms is essential, especially in the tropics where the general biodiversity of earthworms is higher.

How do I look for local earthworms?

It is easy to identify worm-inhabited soils by observing earthworm castings on the soil surface. Try this experiment – Mark an area 1m x 0.5m on the soil for convenience. Dissolve about 500 gm jaggery (also known as native sugar or unrefined sugar or brown sugar) and 500 gm of fresh cattle dung in 20 litres of water. Sprinkle this mixture on the marked area and cover it with straw and small lumps of cattle dung over which an old gunny sack or jute bag should be placed. Keep this moist by watering for about 20 to 30 days. When the gunny sack is removed after that period a combination of surface earthworms and burrowing native earthworms will be seen. These can be manually collected and used. Always remember to transfer such local earthworms with some quantity of local soil from where you collect the earthworms. The success rate of retaining earthworms is higher by doing that.

Earthworms are very sensitive to chemicals that may be added to the soil. Thus addition of chemical fertilizers and pesticides can affect the very survival of the earthworms in the soil.

You can try a simple experiment. Place an earthworm on your palm; add a little water to keep the earthworm moist. Take a pinch of common kitchen salt and apply it on the earthworm. See how it hurts the earthworm as it twitches in pain. Wash the earthworm immediately in water and put it back in the soil.

COMPOSTING AND VERMITECH

What is composting?

Composting is a scientific process of organised decomposition with the assistance of several soil organisms under proper conditions of moisture and aeration. Several microorganisms participate in the composting process as well as the earthworms. Aerobic composting (done in open air) is superior to anaerobic (done in closed pits) composting, as the byproducts of aerobic composting are superior to the anaerobic.

Composting, in which earthworms are used is called vermicomposting. Several species of earthworms have been used worldwide for the vermicomposting process. In nature, the surface dwelling earthworms in particular, and the vertical burrowers in general, function as the “natural composters” for the ecosystem.

Of the earthworm species that are distributed in the world, a few have become prominent either by their inclusion as type specimens in zoology text books or their use in vermiculture for purpose of angling or for preparation of vermicompost. These are:

Eisenia andrei
Eisenia fetida
Eudrilus eugeniae
Lampito mauritii
Lumbricus rubellus
Metaphire posthuma
Perionyx excavatus
Polypheretima elongata

Local species that are generally used in India in composting units are *Perionyx excavatus* and *Lampito mauritii*. An advantage of adding *Lampito mauritii* which is a burrowing variety is that it not only helps in composting but also helps in soil amelioration by burrowing into the soil. *Perionyx excavatus* and *Lampito mauritii* coexist in Indian situations and can comfortably be used together in vermicomposting units.

What is Vermitech? I coined the term 'Vermitech' for all experiments relating to the application of earthworm technology. For the first time, a simplified culture method for locally collected earthworms comprising the epigeic and the anecic was standardised by setting up a culture bed, which I called vermibed. This has major implications.

In India farmers can be classified into farmers with large holdings, farmers with smallholdings and marginal farmers. It is difficult for the small and marginal farmers to spend money to purchase exotic species of earthworms and then spend money on the construction of thatched roofs for the earthworm composting units of the exotic earthworms.

With vermitech, anybody using simple local inputs like broken bricks, coarse sand, loam soil, locally collected earthworms, along with a small quantity of cattle dung and straw can culture earthworms.

It is best to choose a local or native species of earthworm for the soil and for vermicomposting. There is no need to import earthworms from elsewhere. In fact, it is entirely undesirable to transfer species of earthworms from one place to another for the purpose of composting, when every soil has its own endemic species of earthworms. The converse can be true only if the reasons are genuine. It is not desirable to have exotic species of earthworms for the following reasons:

1. The process of vermicomposting becomes dependent on only those species of earthworms.
2. Transfer of exotics usually displaces local species of earthworms.
3. Transfer of exotics may also transfer undesirable microbes from one place to another.
4. Exotics do not necessarily have the same degree of tolerance when compared to the locals and hence extra effort and infrastructure have to be set up to accommodate them, and,
5. Exotic surface dwellers are absolutely useless in soil amelioration, as they cannot dig into local soils.

Dominant species of local earthworms have the ability to tide over adverse conditions in their respective soils in different ways, while exotics may not be similarly capable of adapting to our local conditions. Some species of earthworms like *Lampito mauritii* for example migrate either horizontally to moist soils or vertically to about one metre, while *Octochaetona serrata* which live in hard red laterite soils undergo diapause. Earthworms, especially such sub-surface dwellers, assist in soil comminution, that is breaking down of soil into finer structures. Of the soil that is consumed by *Lampito mauritii,* 70% comminutes to finer particles during passage through its gut. The capability of the earthworms to derive energy from organic surface litter or the organic matter in the soils is of great importance as this result in recycling of nutrients, also known scientifically as biogeochemical cycles.

For example, the earthworm *Octochaetona serrata* predominantly lives in red laterite soil which is acidic. This native earthworm has been blessed with calciferous glands associated with its digestive system. As the nutrient amended acidic soil enters through the mouth of the earthworm and as this food passes through the alimentary canal the calciferous glands discharge calcium carbonate which gets mixed with the food and neutralizes the acidity in the food. This enables not only digestion but also the cast, which comes out, is near neutral, offering an excellent media for multiplication of microorganisms. That is one of the chief advantages of selecting local earthworms for your soil.

In spite of the availability of natural biodiversity in countries like India, vermicomposting only through exotic species of earthworms is preferred due to the conspicuous action of these earthworms and because of their voracious feeding habits. Since 1982 *Eudrilus eugeniae* also called as the African night crawler, has been promoted for waste degradation in India, because laboratory experiments had indicated that *E. eugeniae* surpassed both in feeding and reproductive rates compared to other species of earthworms. *Eisenia fetida* (also known as the red worm or tiger worm) however is used in certain areas in India for waste composting.

HOW TO VERMICOMPOST

It is desirable to have a vermiculture unit in your place if you are doing vermicomposting on a large scale. It is preferable to have the unit in a sheltered place, protected from predators. If only surface dwellers are being cultured, it would be sufficient to have pre-digested cattle dung (dung that has lost heat and gas) as the chief ingredient. Surface dwellers love that and keep multiplying. In case burrowers are cultured along with the surface dwellers then it is desirous to have a small volume (say 10 to 15 cm of loamy soil at the base), as these sub-surface dwellers love to burrow in the soil.

It is not necessary that vermicomposting is done only in pits. The following alternatives with slight modifications in the thickness of layers constituting the vermibed can also make effective vermicomposting units:

- Tanks of brick and mortar with proper water drainage outlets
- Plastic crates (each 600mm x 300mm x 300mm) with holes drilled at the bottom
- Wooden crates (deal wood boxes / apple cases)
- Well rings made of cement or clay of any convenient diameter and height
- Worn out car-tyres placed one above the other
- 25 litre bucket with water drainage outlets

Waste that can be used:

Agricultural waste: Crop stubble, husk, straw, and farmyard manure. Stems, leaf matter, fruit rind and pulp can also be used. But be careful while handling an all-citric waste.

Animal waste: Dung, urine and biogas slurry.

Urban solid waste**:** Kitchen waste from household and restaurants, waste from market yards, and sludge from sewage treatment plants.

Agro industries: Waste from food processing units. For example, peel, rind and unused pulp of fruits and vegetables, fine bagasse, pressmud and seed husk, stems, leaves and flowers after extraction of oil.

Pre-digestion:

When using organic matter in bulk, it is desirable to pre-digest the organic matter, since if fresh, it gives out heat as well as gases during decomposition that may be harmful to the earthworms. Pre-digestion is a simple procedure in which the organic matter is sprayed with a diluted mixture of cattle dung or available manure and kept moist. The heap should not generally exceed 5 to 6 feet in height. The temperature will increase to about 50 to 60 ^{o}C within the first few (roughly 3 to 5) days. After a few turnovers over a period of twenty to thirty days the material is digested and ready for vermicomposting.

A simple process called the ‘biodung composting method’ can alternatively precede vermicomposting. Here the organic matter is set up as windrows or heaps of any convenient length, but not more than 4 to 5 feet in height and 4 to 5 feet in width. The base is a layer of twigs about one foot in height. A layer of biomass (green/dry leaves or organic solid waste from the market) is then spread over the layer of twigs up to a height of about one foot. This layer is sprinkled with diluted cattle dung slurry or biogas slurry followed by water. Such biomass layers with slurry spread on them are placed one above the other until the desired height is reached. The entire heap or windrow is then loosely covered with black polythene sheet (polythene covering is preferable but not essential). Turning over of the heaps/windrows may be done once in 10 to 15days. The material is ready for vermicomposting after 30 to 45 days based on the type of

bulking material used. If you do not desire vermicompost, but need compost only then continue the same for 60 to 90 days the biomass transforms into biodung compost.

Stocking density of earthworms

Many views exist on the stocking density of earthworms. Introduction of a handful earthworms (say about 50 numbers) for a crate 60cm x 30cm x 30cm is sufficient to start the culture. The question of whether the earthworm is a male or a female does not arise as each earthworm has in it both the sexes (hermaphrodites). At least two earthworms, however, are required to build up the population.

Feed

Just like we have a choice of food, earthworms also love a variety of food. The best is a desired combination of carbon and nitrogen rich components in such a way that the carbon content is at least 40 times that of nitrogen, or less. Too much of carbon just fattens the earthworms. Too much of nitrogen with very low C: N ratios will release ammonia, which in turn is bad to earthworms.

How often should earthworms be fed?

The earthworms have to eat to defecate, which is called as casts and these casts (called vermicastings) together with other organic products of microbial decomposition in the units is called vermicompost. Though they are efficient converters, care has to be taken that too much is not added on them just because they are capable to worm their way through garbage. Moderate feeding, which one can visually see and decide, is sufficient.

It is better to feed pre-digested waste. If earthworms are introduced into a fresh pile of garbage, the fresh garbage gradually passes through a thermal stage (heat) where the temperature increases to >50^{o}C. This could literally kill the earthworms. It is therefore essential to predigest the waste so that the waste loses its heat before being fed to the earthworms. Placing bricks (20cm x 10cm) with gaps between them, on top of the biomass accelerates the deposit of castings as it causes mild compaction of the organic matter. It also enables one to collect the compost with ease.

Predators

Vermiculture and vermicompost units should be protected from ants, especially the red ants and the big black ones, centipedes, snakes, birds, rats and wild boars. These may easily find their way into units to feed on the earthworms. Ingenuity should prevail to protect the worms from these attacks. To prevent ants, small channels can be designed on the brim or base of the tanks that could be filled with water every day while watering the culture/composting units. 100 grams of chilli powder together with 100 grams of turmeric powder and 100 grams of salt diluted in 10 litres of water or made as a paste and applied in the channels or around the tanks distracts the ants effectively.

Harvesting of compost

The compost is ready when the material is moderately loose and crumbly and the colour of the compost is dark brown. It will be black, granular, lightweight and humus-rich. The smell is earth-like. Any bad odour is a sign that fermentation has not reached its final goal and that the bacterial processes are still going on. A musty smell indicates the presence of overheating which leads to loss of nitrogen. If this happens, aerate the heap better or start again, adding more fibrous material and keeping the heap drier.

The compost heap can become ripe in three weeks but it can take up to three months also depending on the nature of the bulking material used in composting.

A couple of days prior to harvesting the compost, watering the units are to be suspended. Surface layers dry up and the earthworms gradually enter the vermibed. The compost is removed and placed on solid ground in the form of a heap in daylight. Worms, if any, further wriggle down due to heat on the surface layers. The compost is then screened through a 2.5 to 3 mm sieve, packed and stored. If it is to be stored for longer period, then avoid packing. Store the harvested vermicompost in the shade covered by gunny (jute) cloth. Spray 10% dilute cow’s urine once in 10 days on the compost and turn it over to provide nutrients. Pack into bags before despatch. To enhance the quality of the vermicompost it is desirable to add one handful each of microbial fertilizers such as azotobacter or azospirillum for each bag of 50 kg. Generally if phosphate content needs to be enhanced it is better to add 500 gm of rock phosphate or bone meal to the bag along with a handful of PSM (phosphate solubulising bacteria).

There are now several agencies thoughout the world that is specializing in the culture and sale of vermicompost or earthworms or their seeding materials. Custom designed composting units using earthworms are fast becoming eco-friendly devices for handling waste in the domestic sector as well as in the commercial production of valuable manure.

USES OF VERMITECH

Vermitech has been successfully implemented for domestic use, agricultural use, and in several other places in organic waste management.

Vermiwash – A foliar spray:

Foliar sprays have become an important component of the organic farming package and have recently become a part of plant growing practices. Vermiwash is one of the components of vermitech. Worm worked soils are markedly different from soils devoid of earthworms, as burrowing earthworms create drilospheres. Earthworms are most active during the night. This concept is made use of in obtaining vermiwash from containers in which the surface and sub-surface earthworms forage on cattle dung and straw and the drops of water from a suspended container wash all the active ingredients of the earthworm’s

activities and excretion through the burrows as vermiwash. Vermiwash is based on the principle that the nutrients and other characteristics of the earthworm's faeces, urine, mucus and coelomic fluid are washed with the help of water and a filter unit, and the filtrate is used as a foliar spray.

Vermicompost - **Soil fertility management:**

Vermicompost facilitates multiplication of microorganisms in the soil. Soils with earthworms are well known to promote plant growth. Apart from the presence of macronutrients and micronutrients, vermicasts are reported to contain substances responsible for stimulating plant growth, vitamins of the B group and pro-vitamin D, free amino acids as well as plant growth promoting substances like auxins and cytokinins. It is also proved that populations of VAM (Vesicular Arbuscular Mycorrhizae) increase in the presence of earthworms. Vermicompost also contains useful microorganisms such as Azotobacter, Actinomycetes and a variety of fungi and phosphate solubilising microbes.

The success of vermitech in crop production depends on Vermicompost – Earthworms – Mulch – Plant interactions. These interactions are essential for an effective utilization of soil resources in agriculture. Vermicompost application varies with the type of crop being cultivated. As such, the availability of nutrients in soils, tilled by earthworms is considerably increased.

Utilizing vermicompost along with microbial fertilizers has proved that the synergistic effect of microbial fertilizers with vermicompost has more positive impact on both the plant and the soil. However, the presence of earthworms in the soil (soil faunal component) along with the organic inputs enhances productivity and also the soil health status, because by virtue of their behavioural properties, earthworms improve soil structure, soil health, promote soil aggregation, encourage favourable soil reactions and enrich the nutrient status of the soils, thereby promoting plant growth and improving the quality of the harvested produce.

Solid waste management

With the growing population and the consequent garbage generation, the concept of solid and liquid waste management has also diversified. More and more importance today is laid on waste management. Both solid and liquid wastes have been creating environmental as well as health hazards. Vermicomposting of organic wastes has been one of the few successful methods employed and recommended in the USA, UK, Australia, Germany, etc. In India, unfortunately much of the work in this direction is presently sporadic and is yet to be properly organized.

Liquid waste management:

Liquid waste management systems include the use of black water and grey water. Grey water is free from sewage contamination that is there is no inclusion from the toilet discharge. Grey water systems can be managed with the help of low maintenance wastewater treatment systems (LOMWATS) or simple

wastewater treatment systems called the DOWWATS, meaning Domestic Waste Water Treatment Systems. Scope has existed in such wastewater treatment systems involving reeds or root zone treatments incorporating vermitech in root zone treatment systems. This treated water can be used for gardening purposes.

COMMON QUESTIONS ASKED:

Can I make compost without earthworms?

Yes, the method has been described above. Continuation of the biodung method of composting with occasional turnovers can yield compost in about 60 to 90 days. But earthworms speed up the process as they break down the organic debris speedily. The presence of earthworms in the composting process thus decreases the time of composting. Moreover the compost is of superior quality.

My worms haven't eaten the waste even though I started my worm farm weeks ago.

When first starting a new worm farm the worms need time to get used to their new surroundings. They usually start eating the original bedding material first but then soon move up to the new food source. Add just add enough waste initially until you can see worms moving around in it. Later you can add more waste for the worms to feed on.

My worms are trying to escape, what is wrong?

Worms are very specific about the conditions they will live in and if they don't like them they will try to leave en-masse. If this is happening you must go back to the vermibed and check on the conditions that may be forcing them to want to leave. These include what you are feeding them, whether the bedding material is too moist, etc. These problems are usually fixed quickly and easily and without losing too many worms. Some of the surface earthworms have a tendency to "wander" when humidity is high and the place is dark. In such cases it would be desirable to have an electric light "on" above the vermicomposting units to discourage the worms from coming out.

I have ants in my worm bin, how can I get rid of them.

Having ants moving into your worm bin usually means that the bedding material is not moist enough. To fix this problem gently turn the bedding material with a garden fork and water the bedding material, remembering not to over water. Alternately you can make trenches on the upper crest of the tanks or at the tank base and keep these filled with water. In case of domestic units if possible rest the legs of your worm bin in a container of water so as to discourage the ants from returning. You can also try the chilli+turmeric+salt paste mentioned above.

Little flies have invaded my worm bin, how can I get rid of them?

These are little fruit flies and are usually there because of any fruit and vegetable waste put into the bin. To get rid of them or at least control them,

bury the waste into the bedding material a little, then cover it with moist newspaper or jute bag or a fine mesh or sprinkle some soil on the waste.

My worm bin has become smelly and the worms haven't eaten all the food. What have I done wrong and how can I fix it.

This is a sign that you have over fed your worms and they cannot keep up with the amount of food that is being added into the worm bin. To fix this, stop feeding them and remove any of the uneaten food. Then gently turn over the bedding material with a garden fork so as to aerate the bedding material. If acidic, add a handful of lime to help correct the levels and then start feeding the worms again, only little amounts at first so you get an idea of how much they can consume and do not over feed them again.

Whilst I am away on holidays, will my worms starve to death?

No, they should be okay, but avoid adding any fresh food material just before you leave. Remember to add some dung pats as feed during your absence. Also, cover the bedding surface with moist newspaper or gunny (jute) bags so as to keep the bedding material from drying out. You may also leave mud pots containing water covered with lids, half buried into the pits/tanks. Even if the surrounding material dries up, the earthworms may move and stay beneath these moist pots. If you are planning to go away for an extended time (month or more) you may want to get a friend or neighbour to take over looking after your worms during the time you are away.

If I cut a worm in half, will I have two worms?

Bad news, the answer is a firm NO, so be careful when you are turning your bedding over so as not to cut any worms in half. If the earthworm gets cut, the only the front piece of the earthworm shall regenerate and survive, while the hind portion will die and decompose.

HAPPY WORMING FOR EARTH'S SAKE