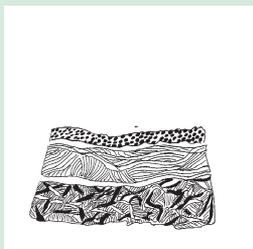


Preparation and use of compost

Agrodok 8 - Preparation and use of compost



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Madeleine Inckel
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Tim Tersmette
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Foreword

Foreword to the third revised edition

This booklet has been compiled to give information about how compost can be applied in the tropics and subtropics. It gives a simple description of the processes taking place in the soil and during composting. Practical suggestions are given for constructing a compost heap. A few selected compost methods and applications are given and a literature list has been added for supplementary information.

The reader is advised to first read through the whole booklet to get a general impression before looking for specific information. We welcome, with interest, any remarks, additions or queries about this booklet or related matters.

The Authors
Wageningen, May 1990.

Foreword to the fourth revised edition

We have made some minor alterations in this third revised edition. Hopefully this Agrodok will continue to be a help to produce your own compost.

The publisher
Wageningen, October 1994.

Foreword to the fifth revised edition

We thank Mira Louis for preparing materials for this 5th revision. KIOF, The Kenyan Institute for Organic Farming in Nairobi, and the Henry Doubleday Research Association (HDRA) in Coventry, UK, both gave us valuable information to improve this Agrodok. We are very grateful to them. Their addresses are given in the back of this book. We hope that many people will make use of the information given.

Marg Leijdens, Coordinator Agrodok Publications
Wageningen, 1999.

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1 Reasons for composting

Compost is an organic fertilizer that can be made on the farm at very low cost. The most important input is the farmer's labour. Compost is decomposed organic matter, such as crop residues and/or animal manure. Most of these ingredients can be easily found around the farm.

Agromisa's Question and Answer Service frequently receives questions from farmers who face a problem with a decreasing fertility of their soils. Due to soil fertility problems, crop returns often decrease and the crops are more susceptible to pests and diseases because they are in bad condition.

In order to increase soil fertility in the short run, nutrients have to be added to the soil. This is often done by applying chemical fertilizers. Chemical fertilizers, however, are expensive to purchase and for most small-scale farmers this is a problem. Preparation and use of compost can be a solution to that problem.

To really improve soil fertility in the long term, it is necessary to improve the soil structure and to increase the organic matter content of the soil. Compost is a good fertilizer because it contains nutrients as well as organic matter. The role of organic matter is explained in more detail in Chapter 2.

Using compost as the only means to maintain soil fertility is possible, but in that case you need a very large quantity of compost. We advise you to apply several practices at the same time in order to maintain the soil fertility in the long term.

Some of these methods to improve soil fertility are:

- Crop husbandry methods, such as: mulching, green manure, agroforestry and improved fallow.
- Applying organic manures such as: compost, liquid manure and animal manure.

If animal manure is applied it should have matured for some time, other-wise it might damage the plants. Composting animal manure makes it a better fertilizer.

These methods to improve soil fertility and others are described extensively in Agrodok no. 2: *'Soil fertility management'* and Agrodok no. 16: *'Agroforestry'*.

Contents of this Agrodok

This Agrodok concentrates on the preparation and use of compost. Chapter 8 gives a recipe of making liquid manure and plant teas. These are organic fertilizers that are easily made to supply plants quickly with nutrients. Bokashi is another type of organic fertilizer, prepared by fermenting organic matter. In Chapter 9 it is explained in detail.

This Agrodok has been written for people who work with small scale farmers in developing countries and for anybody with an interest in composting and organic fertilizers.



Figure 1: Turning compost (Source: KIOF)

2 Fertilizing: the role of organic matter and compost

The presence of organic matter in the soil is fundamental in maintaining the soil fertility and decreasing nutrient losses. Compost is an organic fertilizer; it adds organic matter and nutrients to the soil.

In order to quickly supply a crop with the required nutrients, a chemical fertilizer may be needed. In contrast to organic fertilizers, chemical fertilizers help the plants immediately; organic manures first have to be broken down into nutrients (by soil-organisms) before they can be utilized by the plants.

However, chemical fertilizers are used up by the end of the season, whereas organic matter continues to enhance soil fertility, soil structure and water storage capacity.

Moreover, the presence of organic material ensures that the chemical fertilizer is more efficiently utilized by the crop. Organic matter retains plant nutrients and thus prevents the fertilizer from being washed away. It is in fact a waste of money to apply chemical fertilizer on a soil that is poor in organic matter, if it is not done in combination with measures to increase the level of organic matter in the soil.

2.1 Organic matter and soil processes

Organic matter in the soil consists of fresh organic matter and humus. Fresh organic matter can be (dead) plant material, animal droppings, dead animals etc. The fresh organic matter is transformed into fine organic matter and humus by soil organisms.

Humus gives the soil a dark color and retains nutrients and water. It cannot easily be decomposed further. The fine organic matter, and humus in particular, have the following properties:

- it improves the soil structure.
- it improves the resistance of the soil against the erosive action of rain and wind.
- it retains water and releases it slowly, so that water is available to the plants (water storage capacity) over a longer period.
- it retains nutrients and releases them to the plants slowly over a longer period.
- it contains the main nutrients: nitrogen (N), phosphorus (P) and potassium (K), which become available to the plants after decomposition.

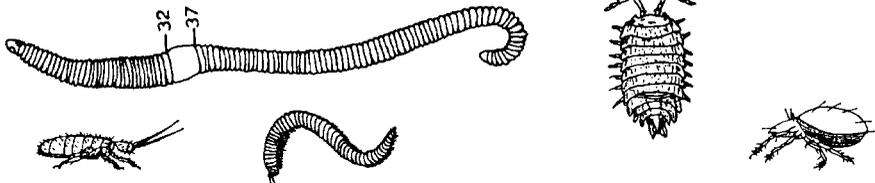


Figure 2: A few soil organisms, some can hardly be seen by the naked eye

The micro-organisms are mainly responsible for further breaking down part of the humus into carbon dioxide, water and nutrients for the plants. This process is called mineralization: nutrients are released and can be taken up directly by plant roots.

The rate of humus production and mineralization in the soil depends on a number of factors. In a hot climate the micro-organisms are more active and the organic materials will break down more rapidly than in a cold climate. Also the acidity of the soil, the composition of the organic matter, the humidity and the availability of oxygen strongly influence the rate of decomposition.

2.2 Compost

The natural decomposition process in the soil can be regulated and speeded up by man. Organic material is collected, and preferably

stacked in a heap. In the heap the decomposition process is more intensive and the conditions more favourable, because the heap is made up almost entirely of organic matter. The end product is strongly decayed organic matter with humus and nutrients. This is known as compost. Compost is used as an organic fertilizer that can be added to the soil.

Fertilizing with compost means, apart from fertilizing the plants, also making use of the good properties of organic material as mentioned in the section above.

Adding compost to sandy soils increases the water retention capacity. This means that water remains longer in the soil and thus remains available to plants for a longer time in periods of drought.

All non-toxic, organic materials can be used for making compost. Superfluous and/or waste material are often applied and in this way can be made use of again. Finally, make sure that the materials used for composting could not be better used for other purposes, such as cattle feed.

3 The composting process

As described in the section on organic matter in soil processes, the composting process happens due to the activity of micro-organisms (bacteria) and other larger organisms like worms and insects. These need certain conditions to live. These include moisture and air.

To make the best possible compost, the micro-organisms must be able to work optimally. This can be achieved if the following four factors are combined to the best advantage:

- type of organic material
- air
- moisture
- temperature

The acidity (pH) is also considered by some to be an important factor. Acidity depends on the air and moisture flow. A compost heap that is properly composed will seldom get too acid.

The composting process will be optimal when:

- various materials of different decomposition rates are combined;
- the different materials are well mixed;
- the size of the heap varies from 1 x 1 meters to 3 x 3 meters. This makes it possible for the temperature to stay constant within the heap.

A good composting process passes through 3 consecutive stages, these are as follows:

- a heating phase (fermentation)
- a cooling down phase
- a maturation phase

It is not easy to draw the line between these stages. The process takes place very gradually and with the help of continuously changing micro-organisms the organic material is converted into compost.

3.1 Heating phase

During the first stage of composting, the compost heap starts to heat up considerably. This effect is known as fermentation and is the result of the breaking down of the complex and tough fibrous material of the organic matter. This fermentation process (decomposition) is strongest in the centre of the heap.

To get the fermentation going quickly and effectively, a number of factors are important. In the first place the compost heap should be made of all sorts of organic materials. Secondly, the right micro-organisms have to be present. Thirdly, it is very important that there is adequate oxygen and water. If these three conditions are met, heat is generated quickly. In the next chapter we explain how to meet these conditions when putting compost making into practice.

During fermentation the micro-organisms multiply and change at a rapid rate, which adds to the heating up process. In this way, a self-accelerated process is started. The fermentation stage usually begins after 4-5 days and may take 1-2 weeks.

Maximum fermentation takes place at a temperature of 60-70 °C in the compost heap. If the temperature is too high, the necessary micro-organisms may die and decomposition comes to a halt.

Due to its temperature, fermentation also has a hygienic effect. In the organic material, many pathogenic germs that are a threat to man, animal and plant, are destroyed. It is often suggested that fermentation kills weed seeds and roots too. However, in practice, this is quite disappointing. Many weed seeds are not destroyed in a normal compost heap, because the temperature is not sufficiently high. In some cases, the germinating power of weed seeds has even been known to increase.

Temperature test

A simple way to see if the fermentation process has started is as follows: put a stick in the centre of the heap about 5 days after completing the compost heap or after the final turning over. Leave it there for about 5 to 10 minutes.

After taking it out, feel it immediately. It should be considerably warmer (60 - 70 °C) than body temperature. If not, then this is an indication that something is wrong, perhaps the material used or aeration is at fault.

3.2 Cooling down phase

The fermentation phase gradually changes into a cooling down phase. Decomposition occurs without much generation of heat and the temperature drops slowly.

During this period new types of micro-organisms convert the organic components into humus. The heap remains clammy and hot inside and the temperature drops from 50°C to 30°C. By regulating the temperature, air and water supply, the process can be accelerated or slowed down. How long this cooling down stage takes, depends on the type of heap, the material, the attention given to it, the climate etc.

The cooling down period usually takes a few months, but in unfavourable conditions may require up to a year.

3.3 Maturation phase

In this end phase of decomposition, the temperature drops to soil temperature, depending on the climate, 15-25 °C.

Apart from the micro-organisms mentioned, the large soil fauna are active at this stage too. In temperate regions, earthworms in particular, feed on the strongly decomposed organic material, and in this way contribute to decomposition.

In the tropical to semi arid regions, termites in particular play an important role, although these can also be very troublesome. This phase never really comes to an end; the decomposition process can go on infinitely at a slow rate. The compost is ready for use if it feels crumbly and looks like good brown/black organic soil.

4 The practice of composting

In this chapter the important aspects of compost making are explained. Attention must be given to the composition of the organic material and the location of the heap. The measurements and the construction of the heap are described separately.

In the next chapter different specific methods of compost making are given.

4.1 Organic material

In general, any type of organic material of plants and animals can be used. It is essential to mix old and tough materials, which are difficult to decompose (crop residues, small twigs), with young and sappy materials, which are easily decomposable (fruit, vegetable skins, young leaves).

This is because different types of organic matter contain different proportions of carbon (C) and nitrogen (N). The micro-organisms who decompose the organic matter need both carbon and nitrogen to function well.

In general, young, living material that decomposes fast contains low levels of carbon but high levels of nitrogen. Tough, dead material decomposes slowly and contains large amounts of carbon but low amounts of nitrogen. Too little nitrogen-rich material means the composting process will be slow, too much of it will result in the heap becoming acid and smelly.

The ideal ratio of carbon and nitrogen for starting a compost pile is:
C : N ratio = 25-30 : 1

See appendix 1 for the composition of the most important materials for composting.

<i>Examples of nitrogen-rich materials are:</i>
Young leaves, all types of manures, fish meal, fish waste, urine, leguminous plants.
<i>Examples of carbon-rich materials are:</i>
Dry leaves, crop residues of maize, sugarcane, rice, etc., twigs, wood-shavings, coffee pulp, carton, etc.

Table 1: Examples of the C:N ratio of some materials (Source: KIOF).

Material	C:N Ratio
sawdust	up to 400
maize stalks	50-150
straw	50
legumes and farm manure	20-30
manure with bedding material	20-25
hay from legumes	15
animal droppings	15

Be careful not to use toxic materials. For example, plant parts sprayed with chemical pesticides can have an adverse effect on the decomposition and the quality of the compost. Diseased material with rusts and viruses for example, should be kept to a minimum.

During fermentation many disease germs are not destroyed, so the disease cycle continues as compost is added to the soil in the form of manure.

A shortage of easily decomposable material is often the reason for slow conversion in the compost heap. The heap may even become completely inactive. An indication of this is the fall in temperature during fermentation, after about two days.

A compost heap made up of young plant material (easy to decompose) gets going slowly and soon becomes too acid. An acid compost heap begins to rot and smell. Decomposition takes place very slowly and the quality of the compost deteriorates. The combination of young leaf

litter or manure (easy to decompose) with woody plant parts (difficult to decompose) gives the best compost in the shortest time.

In appendix 1 you find a list, showing the composition of many types of organic material which could be used for composting.

4.2 Micro-organisms

The composting process happens due to the activity of micro-organisms and other larger organisms like worms and insects. See figure 2 in Section 2.1.

The first condition for composting is the presence of the composting organisms. Adding these organisms to the heap can be done by mixing ready-made compost with the organic materials. If there is no compost the soil can be added. Collect this soil preferably from a shady and humid place, e.g. from below trees.

Soil that contains moisture, contains micro-organisms. Soil that has been dried out by the sun, usually does not contain many living organisms anymore.

4.3 Air

The micro-organisms in the heap require oxygen to survive and to do their work converting the organic material. The carbon dioxide which is produced by the micro-organisms as a result of their activity needs to be blown out by a flow of air. If there is not enough air in the heap, the useful micro-organisms will not survive. Other micro-organisms that do not need oxygen will thrive and decomposition of the organic material will slow down.

In order to get enough air in the heap do not put the compost heap right up against a wall. When building up the heap put a layer of rough material (twigs) at the bottom, so air can enter the heap. See also section 4.6 with the subsection on air channels.

4.4 Moisture

The micro-organisms need moisture to live and to spread through the heap. The activity of the organisms will slow down if the heap is too dry. But if the heap becomes too wet, then there will not be enough air and the composting organisms will die. This will cause the heap to ferment rather than compost. Judging the right amount of water requires a little experience.

Moisture test

The moisture level of a compost heap can be tested easily. Put a bundle of straw in the heap. If after 5 minutes it feels clammy, then the moisture level is good; if still dry after 5 minutes, the moisture level is too low.

A dry heap has to be sprinkled uniformly, using a watering can or a perforated tin. Water alone can be used or a mixture of urine and water 1:4. Urine enhances the growth of the micro-organisms.

Water droplets on the straw indicate that the heap is too wet and it should be opened up straight away. The material can be spread out and dried in the sun. It can also be mixed with other dry material. After some time the heap can be made up again. If it has become too wet by rain then it is better to cover it. Repeat the test in both cases after a few days.

4.5 Site of the compost heap

Choosing a good place for a compost heap is important. Bear in mind the following points:

Climate

If weather conditions are mainly dry, the heap must be protected against drying out. A shady place, out of the wind, is ideal. This could be behind a building or behind a row of trees. Moisture in the heap will then evaporate less quickly, yet there will be enough air.

A wind-free place also has the advantage that the material is not blown away and the temperature fluctuates less. A water source near the heap is convenient for sprinkling if too dry.

Under wet weather conditions the heap will have to be protected against excess water. Choose a protected and well-drained place on a higher part of the land. A compost heap under a shade tree (mango or cashew, for instance) will usually be well protected against excessive rainfall. Both types of weather conditions are likely to play an important role in determining a suitable place for making a compost heap.

Putting a simple roof above the place where the compost is made protects the heap against the sun and against the rain. The protection against these climatic influences will improve the composting process. Temperature and moisture level will stay more constant.

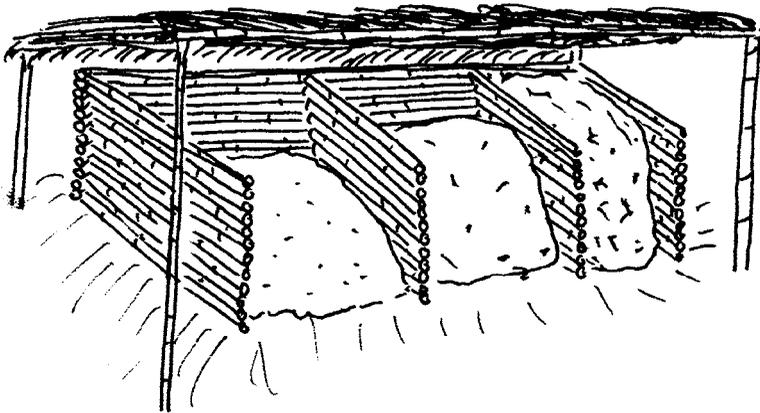


Figure 3: Simple roof above three compost heaps (Mira Louis)

Transport

The heap should be situated as close as possible to the source of organic material (for instance, the field or harvesting place). It should also be near the place where the compost is to be used. This saves time and labour in transport of organic material and compost.

Space around the heap

There should be enough space around the heap to enable the compost to be turned over or examined. A space about 2 to 3 times that of the heap itself is the most practical.

Vermin

A compost heap should always be made outside and not too close to living accommodation or stables. The heap is likely to attract a number of vermin, such as mice, rats, termites and other insects. These transfer diseases to man and animal and attract more dangerous vermin, such as snakes.

4.6 Size and setting up of the heap

Size

The heap has to conform to a certain size; if too broad or too high, aeration is poor. A good basic size is 2 to 2.5 meters wide and 1.5 to 2 meters in height. The length depends on the quantity of organic material available, but it is better to make a shorter heap quickly than a longer heap slowly. It is strongly advised to start with a heap greater than 1 cubic meter, otherwise the temperature in the heap remains low and decomposition is too slow and incomplete.

During the maturation phase the volume of the heap decreases; the heap sags in, as it were.

Setting up the heap

The compost heap can be above ground or underground in a pit or a trench. In Chapter 5 different methods are described. Whichever method is used, the heap of organic material has to be set up in a special way.

Decomposition is easier if the material is cut into small pieces and if easily decomposable material is mixed with material more difficult to decompose.



Figure 4: Cutting the organic material into small pieces

A useful suggestion is to start the heap by a foundation of coarse plant material such as twigs or sugar cane stalks. The outside air can easily flow in under the heap and any excess water flows away more quickly. If the heap is built up in layers, the individual layers should preferably not be thicker than 10 cm for plant material and 2 cm for manure. Apart from the organic material available, the way the heap is made depends also on the individual experience and results.

Covering the heap

In an area of heavy rain the heap will have to be protected against excess water. Preferably it can be kept dry by putting a simple roof above the heap (see figure 3) or even simpler: covering with a layer of leaves, a cloth, jute or plastic etc. If plastic is used then only cover the top, so that the air can penetrate through the sides. Trenches around the heap facilitate the run off of excess rainwater.

Covering the top with the materials mentioned can also be an advantage in dry areas. It prevents excess evaporation of moisture from the heap and it dries out less quickly.

Air channels

It is good advice to put air channels into the heap. This can be done effectively by putting stakes or bundles of twigs, straw or other firm material upright in the heap when composing it. The bundles can remain inside, because they let in enough air, but stakes have to be removed as soon as the heap has been completed.

These air channels should be about 12 cm in diameter and about 1 m apart. After 4-5 days the channels have to be closed up. If there is too much ventilation the fermentation process can turn into a detrimental combustion process.

5 Methods to make compost

There are many ways of making compost. In this chapter different methods are given. We have gratefully made use of materials of HDRA and KIOF in order to be able to present many different methods of compost making in this Chapter.

Taking into account the factors mentioned before, such as availability of organic materials and weather conditions, a choice can be made from these methods.

In the long run everyone must work out a method to suit oneself. We advise you to experiment and find the method that suits best to your situation. Of course you can always contact Agromisa, HDRA or KIOF ask for specific information. The addresses are given in the section Useful Addresses.

5.1 Indore method

The Indore Method is much used for composting in layers.

Building the heap

The basis of the heap should consist of twigs and cane shoots. The following successive layers are piled on top of this:

- a layer of about 10 cm tough organic material which is difficult to decompose;
- a layer of about 10 cm fresh organic material which decomposes easily;
- a layer of 2 cm animal manure, compost or slurry from a biogas tank.
- a thin layer of soil; the soil should be collected come from the top layer (top 10 cm) of clean (moist) soil (e.g. from under trees). This ensures that the right micro-organisms are brought into the heap.

This sequence of layers is repeated until the heap has reached a final height of 1.5 to 2 meters. In this way the heap is composed of many layers. Building the heap should be done quickly, preferably within a week. See figure 5.

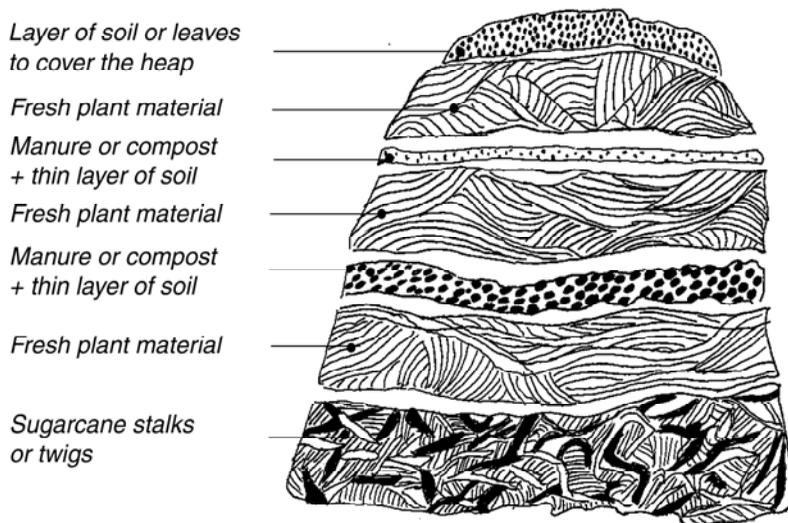


Figure 5: Example of an Indore compost heap

Turning over

During decomposition the heap has to be turned over regularly, in order that it remains well aerated and all the material is converted into compost.

The first turning over of the heap should be done after 2 to 3 weeks. The heap is broken down and built up again next to the old heap. The layers are mixed and the heap is, as it were, turned upside down and inside out. Again, a foundation of coarse plant material is made first. Then the drier and outer, less decomposed part of the old heap is placed in the central part of the new heap. The drier material will have to be watered before the heap can be built up further. This core is covered with the rest of the material. The original layered structure is lost.

The second turning over takes place after 3 weeks and it may even be necessary to turn the heap over again for a third time. Repeat the moisture test and the temperature test a few days after each turning over operation.

Time for decomposition

Decomposition is complete if the plant material has changed into an unrecognizable crumbly, dark mass. Twigs and thick stems do not decompose completely and can still be seen. Under favourable conditions, the decomposition process in the Indore Method takes 3 months, but under adverse conditions it may take longer than 6 months.

Some substances, such as human urine and wood ash promote the growth of the micro-organisms. A small amount of these in the heap is sufficient to accelerate their growth. If the process has to be speeded up spread some urine or wood ash over the thin layers of soil, but only in small quantities; too much ash kills the micro-organisms. Urine, diluted with water 1:4 is sprinkled over the heap, using a watering can. The Indore Method usually gives good results.

The advantages of this method are:

- the process can be kept under control and runs smoothly, because the heap is turned regularly;
- compost is produced in a short time.

Disadvantages of this method are:

- it requires much water;
- it is very labour intensive.

5.2 Bangalore method

The Bangalore Method is another popular composting method. The heap is constructed in a similar way to the Indore Method. Here too, a compost heap of several layers is set up in a week's time.

It differs from the Indore Method as follows:

A few days after completion of the heap, it is completely covered with mud or grass sods, thus closing it off from outside air. Decomposition of organic material continues, but now other types of micro-organisms keep the process going. These micro-organisms decompose the material much more slowly. Therefore, it takes longer before compost is formed than in the Indore Method, although the quality of the compost is about the same.

The major advantages of the Bangalore Method are:

- a saving of water;
- it requires less labour, because the heap is not turned over during the decomposition process.

Disadvantages of the Bangalore Method are:

- more disease germs and weed seeds survive due to the temperature during decomposition;
- the decomposition process is more difficult to control because the heap has to be kept continually covered;
- it is a less suitable method for those with little or no experience in composting.

5.3 Heating process or block method

This method resembles the Bangalore Method. However the treatment is different and it can be used to compost large quantities of organic material.

A continuous heap system

The Heating Process Method is based on a continuous heap system. That is to say, new heaps of organic material are being made all the time, piled up and treated in the following manner (See also figure 6):

On the first day a heap is made of all available material. This heap has a ground surface area of 1 x 1 meter minimum and 3 x 3 meter maximum and a height of about 1 meter.

Leave the heap to stand for two days. Within the heap decomposition starts on its own accord. After these 2 days (Figure 6: day 3), the air is forced out of the heap by trampling over it. The heap is deprived of so much air that an almost comparable situation occurs as in the covered heap of the Bangalore Method.

On day 4 a new heap is built on top of the first heap. This new heap cuts the first heap off completely from the outside air.

In the Heating Process Method a new heap is made every day. In fact, on the second and third day a new heap is made next to the first one. On the fourth day a heap is built on top of the first one. It follows that on day 5 a new heap is put on to the second one. The procedure clarified in figure 6. And so on.

Advantages:

- it is a simple method for large quantities of organic material;
- it is a continuous method.

Disadvantages:

- only suitable for large quantities of material;
- requires much labour and material;
- more chance that disease germs and weed seeds survive the decomposition process at lower temperatures;
- the process is more difficult to check;
- requires much experience and insight in composting.

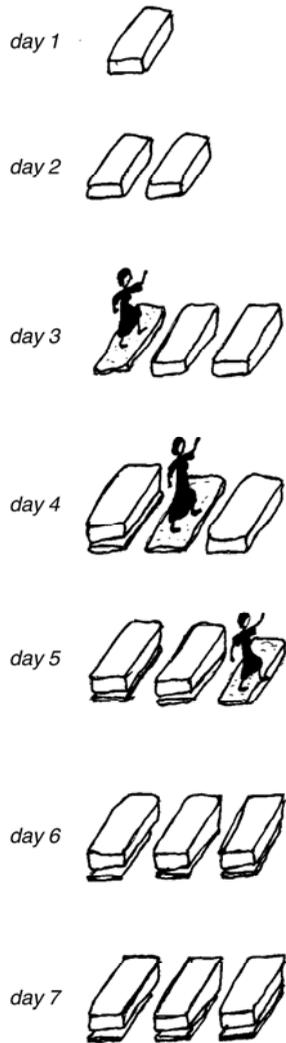


Figure 6: The heating process or Block Method (Source: HDRA)

5.4 Pit composting

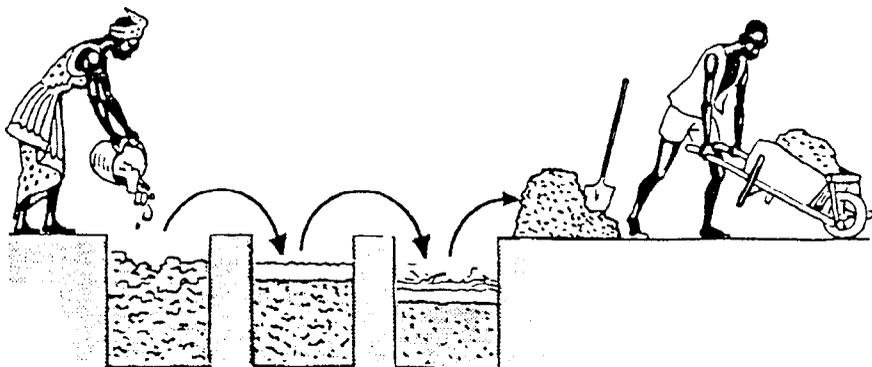


Figure 7: Process of pit composting

This method involves making compost in pits that have been dug in the ground. The best depth for a pit varies according to local soil conditions and the depth of the water table. A typical pit would measure 1.5 to 2m wide, 50cm deep and any length. The pit can be lined with a thin layer of clay to reduce water loss. Often, several trenches are dug next to each other, to allow turning from one pit into the next.

Material should be placed in the pit in layers as described below. For a larger pit measuring 2m wide, 2m long and 1 m high, 1 to 1.5 litres of water should be poured on before applying the layer of soil, which seals the pit.

The layering is as follows:

- 1 10 cm of material, which is difficult to decompose (twigs, stalks)
- 2 10 cm of material which is easy to decompose (green and fresh)
- 3 2 cm of animal manure (if available)
- 4 A thin layer of soil from the surface of arable land to obtain the micro-organisms needed for the composting process
- 5 Repeat these layers until the heap reaches 1 to 1.5m high
- 6 Cover with grass or leaves (such as banana leaves) to prevent water loss.

After 2 to 3 weeks, all the contents of the pit should be turned over into the second pit and 2 to 3 weeks later this should be turned into the third pit. As the decomposing material from pit 1 is turned into pit 2, new material, which is ready for composting, can be put into pit 1, thus creating a process of continual compost making.

Advantages:

Pit composting is quick, easy and cheap as it does not require investment in materials. It needs less water so it is useful for dry areas.

Disadvantage:

It is more difficult to follow of the decomposition process than with an above ground heap.

5.5 Trench composting

Trench composting is similar to pit composting except that plants are grown directly onto the trench as opposed to taking the compost out of the pit and spreading it on land. A trench should first be dug. The size depends on how much material you have available and how many plants you are planting in the trench. The width can range from 50cm to several meters, the depth 1m or less and it can be any length. It should then be filled as follows:

- 1 10cm of material which is difficult to decompose (stalks or crop residues)
- 2 10cm of material which is easy to decompose (fruit and vegetable scraps)
- 3 Add 2cm of animal manure (if available)
- 4 A thin layer of soil from the surface of arable land to obtain the micro-organisms needed for the composting process
- 5 Repeat these layers until the pile is about 50cm above the ground
- 6 Cover with soil, grass or leaves (such as banana leaves) to prevent water and nutrient loss and leave to settle for about one month before planting.

Advantages:

Trench composting is especially useful against termite attack as most species live above ground level.

5.6 Basket composting

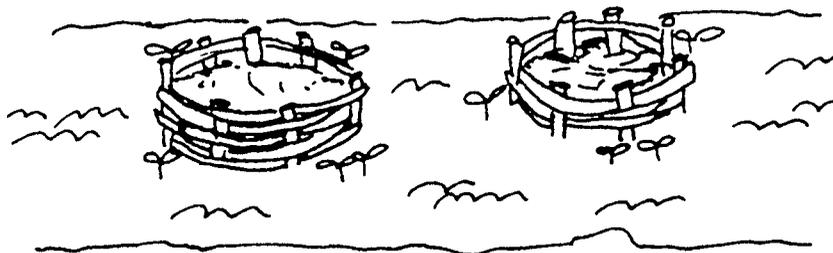


Figure 8: Baskets with compost and seedlings planted around them (HDRA)

If materials for composting are in short supply, you can still make good use of them by using the basket method of composting. It is especially useful for food production in home gardens. The method is as follows:

- 1 Dig circular holes 60 cm in diameter and 60 cm deep
- 2 Line the bottom with material which is difficult to decompose (twigs, stalks)
- 3 Add 8 cm of animal manure
- 4 Add 15 cm of green vegetation (young leaves that have a high water content)
- 5 Add 0.5 cm of ash
- 6 Repeat steps 3 to 5 until the hole is full
- 7 Cover with grass or leaves to prevent water and nutrient loss
- 8 Using thin sticks and weaving them together, mark the circular outline of the pit with a round 'basket', 10cm in height.

Seeds or seedlings can then be planted around the basket structure. The plants will make use of the nutrients in the compost.

If you build more compost baskets in your garden, place them in different areas every time so that the whole garden becomes more fertile.

Advantages:

Basket composting makes good use of nutrients for a small kitchen garden. This method is also good for using up small quantities of waste.

5.7 Boma composting

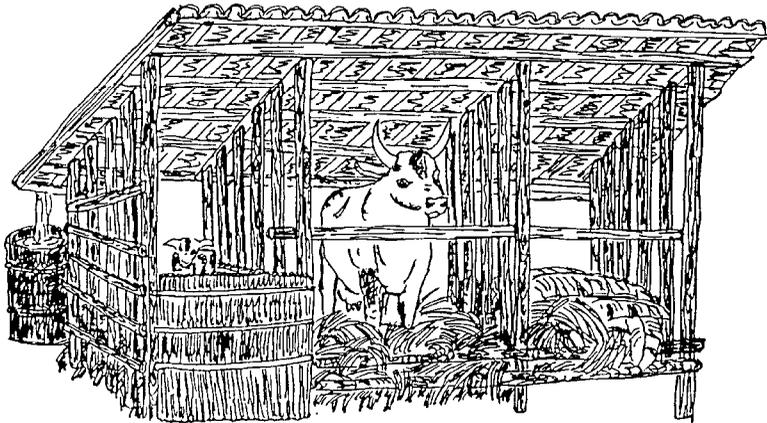


Figure 9: A boma with bedding for composting (Source: Muller-Samann & Kotschi, 1994)

When a farmer keeps animals, there is usually, a boma (enclosure where the animals are kept all the time or only at night) on the farm. In order to keep the animals clean, bedding is put in the boma.

It is advisable to add enough new bedding once a week, so that all urine is soaked up. Any type of dry organic material can be used as bedding. It can be maize stalks, weeds, dry grass or leaves, sawdust, etc.

A mixture of materials is best. Bedding soaks up urine and droppings, which are very rich plant food, and prevents losses through leaching or drying out of manure. The farmer who puts new bedding regularly will make plenty of high quality compost.

Well-mixed manure can be taken out either every day or once a week. If taken out daily, the mixture should be put in a pile and a small amount of soil spread on top each day. This can be continued until there is enough material to build a boma compost.

KIOF has described the following method for making boma compost: Each time manure is taken out of the boma, it should be composted immediately. Sheep, goat, rabbit and chicken manure are all rich manure. Because the bedding is plant material, there is no need to add more greens. It is practical to make the compost next to the boma to save effort moving the manure and used bedding.

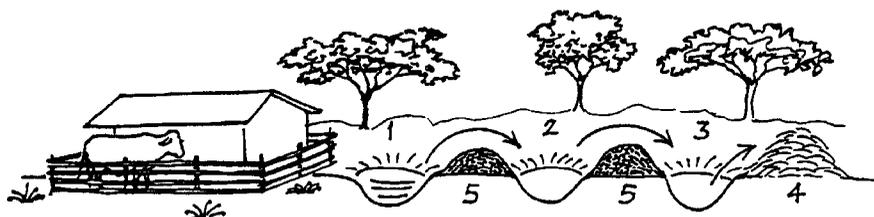


Figure 10: A boma and compost site (Source: KIOF and HDRA)

- 1 Like on the drawing, a trench of 30 cm in depth is dug out behind the boma (A). The soil is put next to the trench. The bottom of the trench is loosened and a layer of dry vegetation is put on the bottom.
- 2 Then a layer of about 10 cm manure and bedding is thrown out of the boma into the trench.
- 3 This is covered by about 5 cm of soil.

- 4 Again a layer of about 10 cm manure is added and again covered by soil. This goes on until the compost pile is completed.
- 5 In the dry season the manure will need watering. During the rains the manure will be very wet. When this is the case, keep the pile low (about one meter). Dry manure can be piled about one-and-a-half meters high.
- 6 When finished, the whole pile is covered with soil and finally with grass, maize stalks or banana leaves to prevent drying up.
- 7 Make sure you use sticks to control the temperature because boma manure becomes very hot. Add water as soon as the stick feels dry or becomes white.
- 8 After two or three weeks the pile is turned into the second trench (B) and after two or three more weeks it is turned into the third trench (C).
- 9 The compost is stored until planting time, in a big, covered pile next to the third trench (D).

Note: If a boma has no roof the manure becomes wet during the rain. To avoid leaching, all manure should be taken out as often as possible and immediately composted and covered. Remember, compost should be moist, not wet.

6 Composting specific materials

Composting a mixture of organic wastes makes decomposition easier and produces a more balanced end product. Sometimes there is a large quantity of one type of material and there is little chance of this being mixed with other materials. However if dealt with properly these materials can make good compost.

6.1 Composting water plants

Waterweeds can be a considerable problem in lakes and waterways, which are becoming more and more unbalanced and disturbed. Such problems often arise when the surface water becomes enriched with nutrients and the introduction of exotic plants, the water hyacinth, *Eichhornia crassipes*, for instance.

Controlling these waterweeds with herbicides is harmful to the environment, expensive, and a waste! Indeed, they can become a valuable soil improver if composted as follows:

- 1 Harvest waterweeds and spread them out for a few days along the water's edge to dry, until the weight has about halved.
- 2 A compost heap can be made, using the wilted plants, soil, ash, animal manure and household waste (kitchen scraps).
- 3 Use the Indore method (Section 5.1) of composting by placing twigs at the bottom and building up the different layers to form a heap. This will help prevent the heap from being too wet.

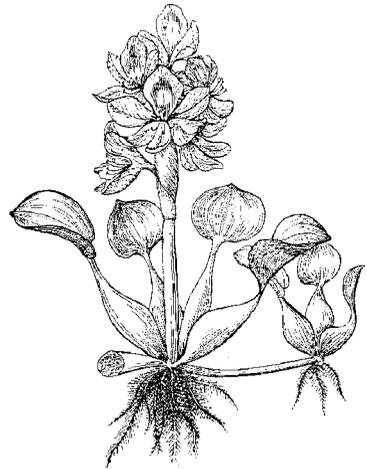


Figure 11: Water Hyacinth

4 Turn over the heap regularly; every two weeks.

Compost made with water hyacinth only, may in some cases reduce yields. Test the compost in small amounts before applying to a crop.

6.2 Composting seaweed

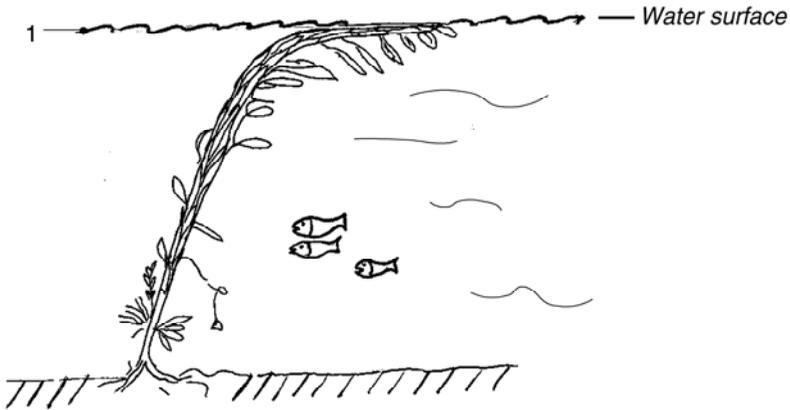


Figure 12: An adult Giant Kelp (*Macrocystis*) plant

Seaweed has been used as a fertilizer since long. For those farmers who are close to the sea, it can be very useful. Many species are known and it is found in most seas.

Seaweed is a potential fertilizer, which is literally waiting to be 'picked up'. It contains many trace elements and growth regulating substances, which are highly beneficial to crops.

Removing the salt

The main requirement when composting seaweed is to remove most of the salt. This can be done simply: In the rainy season seaweed is collected seaweed and spread out or put in small heaps. After some time the rain washes out the salt.

Direct use of seaweed as a fertilizer

The simplest method of application of seaweed as a fertilizer starts with the drying of the seaweed, after which it is ground. The powder thus obtained can be used directly as a fertilizer.

Composting

The other fertilizer application of seaweed is composting. If the seaweed is wet then it should be mixed with a large amount of dry material such as straw. Dried seaweed can be used in a normal compost heap. Generally the decomposition of seaweed is very quick.

To summarize, for farmers along the coast, seaweed is a potential source of manure. The seaweed will always have to be de-salted first. Seaweed can bring about a reasonable yield increase, but is not a wonder cure. The working of growth regulating substances is again very dependent on the soil type to which these are applied.

6.3 Composting coffee pulp

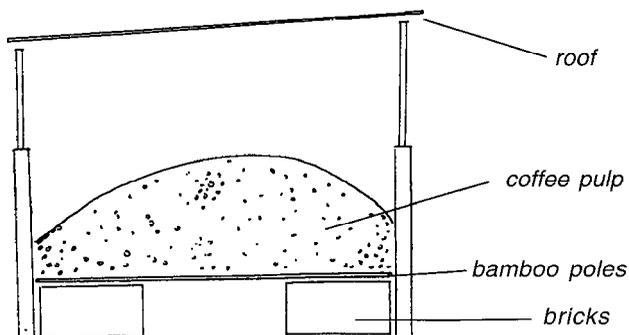


Figure 13: Elevated compost heap (Source: HDRA)

In coffee producing areas, large quantities of coffee pulp are a problem. The fermenting piles give off unpleasant smells; breed flies and pollute waterways. Coffee pulp is a good fertilizer as it is rich in organic matter, nitrogen and potassium. Some growers spread the heavy

wet pulp on their coffee plantations but there can be problems with transport and spreading and this can lead to smells and plant growth problems.

It is much better to compost the material first so that it can be used more effectively.

Good aeration

This dense material needs good aeration so a number of above-ground, elevated heaps should be constructed. These elevated heaps need to be roofed or covered to stop too much water from entering the compost heap. The elevated floor can be made of bamboo poles mounted on bricks or stones.

Before composting, the pulp needs to be drained and loaded into the pits to a height of about one meter. Vegetable waste can be mixed in if available as well as some soil or compost. This is to obtain the right micro-organisms that decompose the waste. The heap should be turned every 4 to 6 weeks and the compost should be ready in 4 to 6 months.

6.4 Composting domestic waste

Domestic waste includes any kind of decomposable household waste such as kitchen scraps, paper, sweepings or wood ash. It should not include meat or slaughter wastes. These attract vermin and insects and give an unpleasant smell. Neither should it include excreta from humans, cats or dogs as these contain toxins, which can be harmful if not composted properly (see section on human waste composting). It is also better not to use too much of the same type of material.

Remember that the composition of domestic waste is culturally and regionally defined. In Asia, in particular, composting of household waste is an old technique.

Composting in a heap

Most domestic waste is produced in small quantities, but at regular intervals. It is advisable not to put small amounts on the heap every day, but to save it before putting it on the compost heap.

As a guideline: add a new layer when you have enough material to make a layer of about 30 cm thick. Extra material could also be collected to add to the heap, but this costs time and energy. Because the amount of organic waste available is often small, only a small compost heap can be made.

Since most domestic waste has little structure (such as food remains and wood ash) it is likely that aeration will be poor. Therefore, when composting domestic refuse, considerable attention has to be given to ventilation of the heap. See section 4.3 and 4.6 - subsection on air channels.

Composting in a barrel

In Mali at the institute IPR/IFRA (address in the section Useful Addresses) a method has been developed to make compost from domestic waste in a barrel.

Using barrels might make it easier and more hygienic to practice composting near the house. The barrel also regulates the air, humidity and temperature during composting.

➤ *Preparing the barrel*

Paint the inside of the barrel to prevent it from rusting.

Make three holes (1 cm in diameter) around the top third and the bottom third of the barrel, at a distance of 52 cm from each other.

Make another hole of 1 cm in the base of the barrel. Through this bottom hole the liquid from the decomposing organic matter can seep from the barrel. If it stayed in the barrel the material at the bottom will start to rot, which causes a bad smell and not good compost.

Remove the top; it is used as a lid for regulating the composting process when the barrel is filled. As the organic materials decom-

pose, it will shrink in size, and the lid will slide down and close the barrel.

Make an opening about 20 cm above the base of the barrel, 65 cm high and 20 cm wide, so that you can check on how the composting is progressing. You should normally keep this opening covered. Place the barrel on a tripod stand of 25 cm high, so that you can put a vessel underneath to catch any fermented liquid.

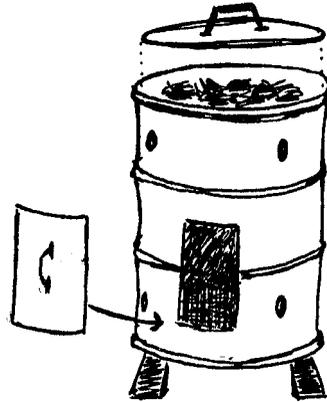


Figure 14: Barrel adjusted for compost making

➤ *Method of making compost*

It is best to work with two or three barrels: the first can be used for an initial compost, which is sieved and put in the second barrel for further composting. The third barrel is used to store ready-to-use compost. There is no need to make holes in the second and third barrels.

Any organic matter can be used to make compost in the barrels, especially domestic waste. Cut the organic matter into small pieces before putting it into the barrel and mix the different materials. If you have enough material, you can fill the barrel in one go otherwise you can fill the barrel slowly.

An improvement to the process is to collect the liquid that seeps from the barrel through the bottom hole and add it again to the decomposing organic matter in the barrel. In this way the loss of nutrients is diminished to a minimum.

➤ *Filling the barrel in one go*

If you fill the barrel in one go, the humidity of the mixture in the barrel will stay more or less constant. Air will enter through the holes in the barrel. After 4 or 5 days you can turn the mixture into the second barrel, in which it will stay for 8 to 10 days. After that

period the compost will probably be ready. Of course the time for the composting process depends on the climate (temperature).

The IPR/IFRA has developed a recipe using the method described above. Compost the following materials:

- 52 kg of sawdust
- 1.7 kg of poultry manure
- 2.5 kg of natural Tilemsi phosphate
- 800 ml of urine.

After 45 days the composting should be well advanced.

➤ *Filling the barrel slowly*

If you fill the barrel slowly, you have to count the number of days for the process from the time when the barrel was filled to the top. Then after 4 to 5 days the mixture is sieved. The fine material can be put into the second barrel. The large pieces and any not yet decomposed material is put back in the first barrel, which you can fill up again slowly.

6.5 Composting human waste or sewage

Composting human waste or sewage is a useful way to dispose of it and it is a good source of nutrients for plants. There are however a number of problems in dealing with human waste or sewage. Diseases can spread through handling the waste and through the consumption of the crops grown on this composted human waste.

It is very important to use appropriate methods when dealing with it and to have previous experience of the composting process.

The mentioned problems should not prevent the use of human waste or sewage in a compost heap. In this book we do not explain in detail how to compost human waste. If you want to experiment, we refer you to the books mentioned in the section 'Further Reading'. You also can write for more information to either Agromisa's Question and Answer Service or the HDRA Overseas Advisory Section (See the section 'Useful Addresses').

7 Putting compost to use

Some of the many uses of compost are given in this chapter.

Examples are:

- fertilizing;
- potting soil, nursery soil, planting trees;
- erosion prevention;
- fish feed.
- mushroom growing - (not treated in this Agrodok).

When the compost is ready, it can not always be used straight away and it has to be kept for a while until it can be put to use. Care has to be taken that the compost does not lose its fertility during storage.

Caring for the stored compost

Compost should never be left uncovered in the rain or in the sun. The rain washes out the nutrients and the sun can cause burning. The compost then loses its fertility. To reduce this loss the compost should be covered. Some useful covers are: banana leaves, intertwined palm leaves or a sheet of plastic. If the compost is left too long, it may also become a breeding place for unwanted insects, such as termites and the rhinoceros beetle (*Oryctes rhinoceros*).

7.1 Fertilizing

The advantage of using compost for fertilizing is that it improves soil fertility in the long run, by improving the soil structure. Organic matter is the key factor in improving the soil structure. Organic matter contains a lot of micro-elements important for plant growth and it improves the water retention capacity of the soil. Another aspect is that compost releases the nutrients slowly, which means that the effect of compost is one in the long run.

Artificial fertilizers contain only a few nutrients (Nitrogen, Phosphorus and Potassium) but of these nutrients the concentration is far

higher than in compost. Nutrients from artificial fertilizer are released quickly. This means that artificial fertilizers are a quick one-off supply of nutrients to satisfy the needs of a crop.

Adding artificial fertilizer alone is not sufficient to retain a sufficient level of soil fertility. Organic matter is needed to retain the water and nutrients. In a degraded soil, where there is no organic matter, yields will still decrease, even if artificial fertilizer is added. This means that whenever artificial fertilizers are being used, the farmer needs to take care of the organic matter content of the soil. An integrated approach, combining the application of compost with an application of artificial fertilizer is a good strategy when a crop quickly needs nutrients..

In the long run artificial fertilizers might even have a negative effect on the soil, because the soil might become exhausted and degraded if no organic matter is added and it might become acid because of the chemical composition of the fertilizer. See also Agrodok 2 : *'Soil fertility management'*.

Application at location where needed

If compost is to be used for direct fertilizing of a field crop on a large piece of land, a very big quantity will have to be applied. This is a disadvantage of compost.

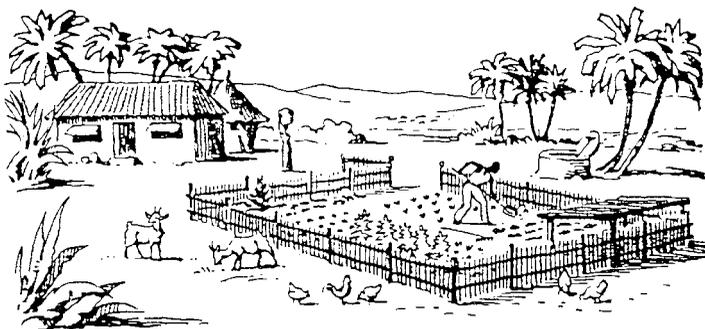


Figure 15: Vegetable garden

Using compost in the vegetable garden, or on small plots of land is very suitable. It is important to take care to apply the compost locally at the specific places where it is needed.

For example:

- When preparing a sowing bed the compost can be mixed superficially through the top soil. The fertile compost is then easily available for the seedlings.
- Apply compost in pits or trenches in which the crops are planted.

This method is particularly useful in dry regions. The crop is planted in pure compost or compost mixed with top soil.

7.2 Nursery soil, potting soil, planting trees

Compost is very beneficial for nursing seedlings, either in a seedbed or nursery where they germinate, or in pots or pits where young plants and trees are planted. Compost retains the water well, so young plants will not easily get stressed by water shortage, and they get all the nutrients they need from the compost.

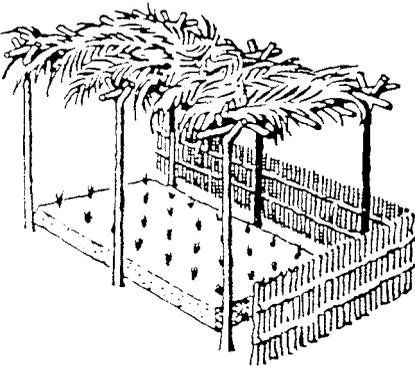


Figure 16: A nursery bed made of compost

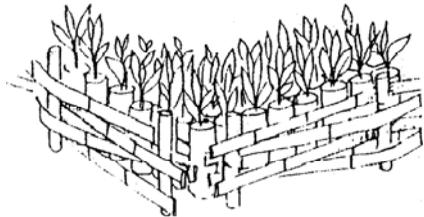


Figure 17: Pots filled with compost



Figure 18: Tree planting: compost is put in the holes in which the trees are planted. Cover the compost again with the soil from the bottom of the pit, to prevent the compost from drying out. See also Agrodok no. 19: Propagating and planting trees.

7.3 Erosion prevention and erosion control

The use of compost to prevent erosion is strongly linked with improving soil fertility. A fertile soil is in general less susceptible to erosion, because the organic matter holds the soil together. In addition compost used as a ground cover counteracts splash erosion caused by rain. See the Agrodok no 11: ‘Erosion control in the tropics’, to read more about the role of organic matter in reducing soil erosion.

Collecting water run off

A measure to control erosion by means of compost is to make well drained ditches parallel to the contour and fill them with compost to collect the water run off.

7.4 Compost for fish feed

Compost is a good type of fish feed, through fertilizing the fish pond. The naturally occurring food in the fish pond consists of very small plants (algae or phytoplankton) and very small animals (zooplankton).

Compost (or manure) is added to the pond as an indirect feed for fish. It accelerates the growth of the plankton in the water. Many fish species, such as the Tilapia sp. and Carp sp. (Cyprinidae) feed on plankton. In general fish respond well to the addition of fertilizer and their numbers may rise considerably.

Managing the pond

The water in a pond must be of good quality so that the fish will be healthy and grow well. In order to grow, fish need oxygen. This is produced mainly by the algae floating in the water; if a large amount of algae is present, the water will have a green colour.

Good fertilizer practice is important to maintain water quality and to maintain a good amount of naturally occurring fish food available in the water. The amount of fertilizer added to the water depends on the number of fish in the pond. If too little fertilizer is put in less natural food will grow and less fish will be produced. Putting in too much fertilizer or fertilizing irregularly can lead to oxygen shortage (because the algae and plankton use oxygen during the night) and fish will die.

Application of compost to the pond

Compost should be applied at least once a week, and it is best to do this every day. It is important to spread the compost evenly over the pond in order to ensure optimal use by the algae and plankton so that they can multiply.

In practice coarse organic material is often added to fish ponds. Much of this starts to rot, using up a lot of oxygen from the water. In this case it is very likely that the fish will not be able to get enough oxygen and will suffocate.

Using compost instead of coarse organic waste material is advantageous, because compost is ready decomposed material. When compost is added to fish ponds, the oxygen level does not decrease much. There are two reasons for this: compost uses only little oxygen and adding compost induces strong growth in phytoplankton that produce

oxygen. Because of these positive effects, much more compost than fresh organic refuse can be added to the water without difficulty, and more fish can be produced. Compost can also be directly consumed by some types of fish, which is not the case for fertilizers.

In conclusion, compost appears to be one of the most ideal feeds for intensive fish ponds. There will be no shortage of oxygen so more feed can be added and much higher yields can be attained.

A well-managed and fertilized pond can sustain 3 kg fish per 100 m² per day. In practice this amount is usually lower.

In some places composting is done in the corner of a pond. This method is less effective than making compost on land and then spreading it afterwards over the whole pond. Fish production is higher using the latter method. This is probably because the nutrients from a compost heap in the corner of a pond are not spread well throughout the pond.

Fish food from composted Water Hyacinth

Fish food made from composted Water Hyacinth (see section 6.1), dung and rice straw fed to Nile tilapia can give a production level of 360 kg per 100 m². The following recipe is used for the compost:

- Dry 1,000 kg of water hyacinth in the sun until the weight is reduced to approximately 400 kg. Then mix the dried water hyacinth well and spread it over a layer of (rice) straw measuring 3 x 3 m. Make the compost heap about one meter high and drive bamboo sticks through it so that air can reach the inside.

- Mix the compost heap every two weeks by bringing the material at the bottom up to the top and the material at the top down to the bottom. After two months the compost will be ready to be spread over the pond.

To harvest 25 kg Nile tilapia from a pond of about 100 m² after six months, you need to feed them 2 kg of compost every day. For these

quantities you will need four compost heaps of the size described above.

See also:

Agrodok no 15: '*Small-scale fresh water fish farming*' for more general information on fishponds, and,

Agrodok no 21: '*On-farm fish culture*' for detailed information on integrated ways to feed fish.

8 Liquid manure and plant teas

The aim of making liquid manure and plant teas is to quickly provide a crop with adequate natural plant food during the growing season. Liquid manure and plant teas are ready for use after two or three weeks, as compared to six weeks or more for compost.

Liquid manure and plant teas may seem unnecessary in an organic system, where emphasis is on feeding the soil, not the plants. There are occasions, however, when liquid feed is the only answer, such as when roots have been damaged and cannot take up enough nutrients.

Liquid feed from animal manure or a plant as comfrey (*Symphytum* spp., French: *Consoude*) supplies nutrients fast.

A liquid feed is also essential when plants are grown in the restricted environment of a pot or plastic bag.

8.1 How to make liquid manure and plant teas

Note: the instructions for plant teas begin at number 3.

You will need the following materials and equipment:

- Manure – either chicken or rabbit or a mixture of both
- A container – a drum or half a drum (bucket) for small quantities
- One strong bag or gunny bag
- One strong pole and rope

- 1 Put the chicken manure or rabbit manure (or a mixture of both) in a strong sack or gunny bag with 50 kg of manure for one drum of water. Fill it in such a way that you can tie the top of the bag securely.
- 2 Suspend the bag containing manure in a container full of clean water. The bag should be tied securely with a rope and suspended on a strong pole placed across the top of the drum.



Figure 19: Making liquid manure (Source: KIOF)

- 3 When preparing plant teas, branches and green sappy leaves are chopped up and placed in a drum, full of clean water. It is not necessary to put the leaves in a bag.
- 4 Leave the manure (for the liquid manure) or chopped leaves (for the plant teas) to stand for 15 days. Cover the drum to prevent excessive evaporation.
- 5 After three days and every other day thereafter, stir the liquid in the drum. For liquid manure stir by lifting the bag several times using the pole.
- 6 After 15 days the water will have turned blackish and most of the plant food (nutrients) in the manure will have been dissolved into the water. Remove the bag.
- 7 Dilute the contents of the drum 1:2 (to one part of the liquid manure or plant tea add two parts of clean water). Spray the crop at the stem and not at the leaves.

8 Water the crop with this liquid manure or plant tea for two or three weeks. It is effective as top dressing after planting the crop using compost.



Figure 20: Making liquid tea (Source: KIOF)

9 Bokashi

Bokashi is an organic fertilizer, which is made by fermenting organic matter. The name Bokashi is a Japanese word, which means: fermented organic matter. Bokashi contains a lot of nutrients and it serves as a rapid working fertilizer. You can compare it with an artificial fertilizer like NPK. Traditionally Japanese farmers use Bokashi to improve soil fertility and supply the crops with nutrients.

Bokashi is made through fermenting organic matter either in the open air or in a closed off situation. In the open air the mixture is in contact with oxygen from the air; this is called an aerobic situation. It is comparable with the normal composting process. When the fermenting mixture is closed off from the air (in plastic bags for example) it is called an anaerobic situation.

The organic matter for the Bokashi fermentation needs special selected ingredients (rice bran, wheat bran, fish meal, etc.), together with organic waste materials. Bokashi has been developed in Japan by Prof. Teruo Higa.

Bokashi compared to compost

The fermentation process of Bokashi conserves nutrients in the organic material better than the process of decomposition that takes place when composting. The reason that nutrients are better conserved is that during the fermentation process, the temperatures does not become as high as in the normal composting process.

In the anaerobic Bokashi fermentation process temperatures rise to about 40 °C , while in the aerobic process and in the normal composting process temperatures can rise to about 70 °C and possibly higher. This means that in the anaerobic process the conservation is even better than in the aerobic process. However, when you use the anaerobic process it is difficult to prepare large quantities of Bokashi, this is easier when using the aerobic process.

Bokashi is made in a short period: 6-8 days in a tropical climate and 2-3 weeks in a more temperate climate. It can be applied to the soil directly after preparation, although you should wait 14 days before planting or sowing.

Effective Micro-organisms

The important aspect of Bokashi preparation is adding Effective Micro-organisms (EM). This is an artificially prepared mixture of useful soil micro-organisms. When applied to the soil these effective micro-organisms settle in the soil and will oust the harmful micro-organisms. It improves the effectiveness of the organic matter in the soil and the soil fertility will be improved.

The Effective Micro-organisms can be bought from the institutes where Bokashi is developed and researched. You can find addresses in the section 'Useful Addresses'. If you cannot get hold of the EM mixture it is also possible to use clean soil; preferably fresh, moist soil from a forest. This soil contains a lot of micro-organisms and is most probably not polluted with chemicals. Although this will not be as effective as the artificially selected EM, it can still give you an adequate result.

9.1 The organic materials

For making Bokashi you can use any type of organic matter. Use at least 3 different materials to enhance the diversity of micro-organisms. It is important to have a combination of materials that have either a lot of nitrogen (low C:N ratio) or carbon (high C:N ratio). The quality of Bokashi is improved by adding finely ground sea shells (chalk meal) and Bentonite clay minerals to the fermenting mixture.

N-sources

Poultry manure is a good source of Nitrogen. Other types of manure (cow manure, donkey manure, pigeon manure, etc.) can be used as well, though the quantity has to be multiplied by 1½ .

Alternative sources of Nitrogen are fish meal, bone meal, or nitrogen fixing plants (leguminous plants), e.g. Mucuna, Crotalaria, Leucaena leaves, etc. These plants have to be dried and cut into pieces before being used. They also contain other important nutrients.

Carbon Source

Rice bran is a good source for carbon. It contains carbohydrates and phosphorus too. Rice bran is important because it is a good stimulant for the fermentation and it feeds the micro-organisms well. Instead of rice bran you can use other types of bran like wheat bran and maize bran or root crops, such as cassava, yam or potatoes. These need to be cut into small pieces before using. Alternatively, fruits as bananas can be used too. Straw, weeds and sawdust are also sources of C.

Charcoal

Charcoal is a porous material, which increases the nutrient holding capacity and improves soil structure. It also acts as harbouring point for the micro-organisms. If charcoal is not available you can use straw, kelp (dried sea weed) or bean husks. An alternative is to roast rice husks.

Do not use ash; this decreases the activity of the micro-organisms.

Sugar cane trash

Adding sugar cane trash (bagasse) to the Bokashi ensures a good air supply and water retention during the fermentation process. It also retains the nutrients such as Nitrogen. Alternative materials for this are: rice husks, coffee husks, wood chips/shavings, maize cobs, dried grass.

Effective Micro-organisms

Old Bokashi contains a lot of micro-organisms; these micro-organisms start the fermentation process. The artificially prepared mixture of Effective Micro-organisms can be bought from the institutes of which you can find the addresses in the section 'Useful Addresses'. If you

make Bokashi for the first time and you cannot buy the EM mixture easily, use clean and moist soil, preferably from a forest.

Molasses

Molasses is a by-product of sugar production. It contains a lot of energy and stimulates the fermentation process by feeding the microorganisms. An alternative is using sugar or honey, but of course these are much more expensive.

Humidity

The production of Bokashi needs little water. If Bokashi is too wet, it stinks. For the recipe that is given in the next section, 20 litres are needed. The amount needed depends also on the moisture content of the materials.

The moisture content should be 30-40%. You can check it by squeezing a handful of the mixture. Water should not drip from the squeezed mixture, but it should remain as a single unit without crumbling. However, on touching it should crumble easily.

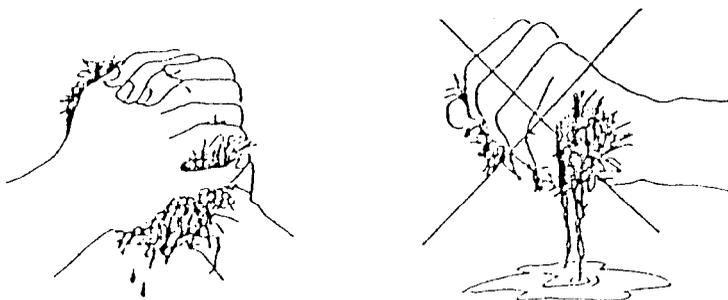


Figure 21: Checking the moisture content

9.2 Preparation of bokashi

If you need to prepare large quantities it is easiest to use the aerobic process. For preparing small quantities it is advisable to use the anaerobic process, because more nutrients are retained.

In the recipe below, organic matters are specified, using the information in the last section you can vary these materials and experiment to find the best way of preparing Bokashi in your specific situation.

Aerobic method

A recipe for the aerobic preparation of Bokashi (from Costa Rica):

What you need:

- 1 bag of poultry manure (Nitrogen-rich material)
- 1 bag of rice bran (Carbon-rich material)
- 1 bag of charcoal (small pieces 1-2 cm)
- 1 bag sugar cane trash
- 2 liters molasses
- ½ bag of Bokashi or compost (containing EM)
- 2 bags of clean soil
- water

Mixing:

It is important to mix the materials well. A good way to do so is:

- Cut all the materials into fine pieces and put them into piles.
- Dissolve the molasses in water (20 l); heating may make it dissolve easier.
- Spread out a layer of one of the materials: Use one third of the quantity of the recipe for one layer.
- Water the layer with the molasses solution. Use a watering can.
- Put another layer of a different material (1/3 of the quantity) on top of the first layer.
- Water this layer too with the molasses solution.
- Continue this process until all the materials are used.
- When you have one heap of the moistened materials, turn the heap over again to increase the mixing of the materials.
- Finally make a heap of about 50 cm high. In colder areas this might be a bit higher to reach high enough temperatures in the heap. (In warmer areas the heap might be a bit lower for the opposite effect).

- Cover the heap with sacks or mats. Don't use plastic because the air can't pass.
- Turn the heap over, every 12 hours. Do it in such a way that the material, which was on the outside, ends up in the inside and the other way round. If the heap is very hot, turn it over a few times to lower the temperature. After one day the mixture will be brown, and when taking away the cover you probably see fungus growing.
- After the third day take the cover off the heap in order to let the mixture dry. The colour will change from brown to greyish. The heap will have a sweet-sour smell.
- Continue to turn over the heap every 12 hours, to let it dry more quickly. Dry the Bokashi very well.

Preparation time

In tropical areas the aerobically prepared Bokashi is ready after 5-7 days. In temperate climates it will take longer, possibly 2-3 weeks. The colour is grey and the texture is fine and like dust.

Storage

Direct use is preferred, but it can also be put in sacks and stored for about 3 months in a dry, well-ventilated place, out of the sun.

Anaerobic preparation

If you need to prepare only small quantities it is advisable to use the anaerobic process.

The start of the preparation, the mixing and the watering is the same as in the aerobic process. When the mixing is done, you have to pack the mixture in large black plastic bag or container. Close these air tight. Don't put them in direct sunlight.

The Bokashi is ready when it has a sweet smell of fermented matter (beer or wine smell), and when you see white fungal growth. If the smell is bad (rotten), the Bokashi is not well fermented and should not be used

Preparation time

The time needed for fermentation is 3 - 4 days in tropical areas and 7-8 days in temperate areas.

If the Bokashi production is not successful, try out various types and different quantities of materials.

9.3 Applying bokashi

Bokashi is used in the same way that artificial fertilizers are used. It can be applied to the soil directly after preparation, although you should wait 14 days before planting or sowing.

Dig the Bokashi into the soil 5-10 cm deep. It is important to cover the Bokashi with soil because the micro-organisms don't survive sun shine.

- For most vegetable crops it is sufficient to apply the Bokashi three times during the growing season. Adding handful (30 grams) to the soil 15 -20 cm away from the roots of the plants.
- Apart from using Bokashi in vegetables it is of good use in coffee, banana and tobacco plantations, etc.
- For field crops on average 100 - 200 gram of Bokashi per square meter is sufficient. If the soil has a low content of organic matter add more Bokashi. A maximum application is 1 kg per square meter.
- Bokashi can also be added to planting holes. Cover the Bokashi with soil before planting the seedlings.

Bokashi should never be in direct contact with the plant stems or roots: After applying it to the soil, wait 14 days before planting or sowing.

10 Your own organic fertilizer

This chapter deals with general advantages and disadvantages of preparing your own organic fertilizer. They are not always straightforward: what may be a disadvantage in one situation may an advantage in another situation. At the end of the chapter, a general checklist is given as a guideline to make your own decision.

10.1 Advantages and disadvantages

Advantages

- Preparing your own fertilizer is much cheaper than having to buy fertilizers;
- Organic refuse, containing nutrients, is been put to use again, otherwise it would be left to decay and the nutrients would be lost.
- An application of organic fertilizer improves the soil structure;
- Soil fertility is improved in the long run: nutrients from the organic fertilizer are released gradually over a long period;
- The capacity of the soil to retain water is improved, because of the increase in organic matter.
- Organic fertilizer contains many trace elements not normally found in fertilizers;
- Plants grown in organically fertilized soil might be more disease resistant than in soils with artificial fertilizer only.

Disadvantages

- Preparing compost, liquid manure or bokashi is very labour intensive and time consuming;
- Making your own organic fertilizers is not possible everywhere. It depends on space, available material, local conditions and other factors;

- applying compost could enhance weeds and diseases in the crop to be grown;
- a compost heap attracts vermin, such as insects, rats, mice and also snakes!
- the concentration of available nutrients in organic fertilizers is considerably lower than in fertilizers.

10.2 Whether or not to start preparing organic fertilizers

Before starting to produce organic fertilizers it is important to check on a few points to increase the chance that you will be successful and to prevent disappointments.

- Do you, or the people you work with, have enough time and energy to invest into making organic fertilizers?
- What will you gain by starting to do so?

(Compare prices of artificial fertilizer, look at the status of the soil fertility, etc.)

- Is there enough organic material to make organic fertilizer?

(Think of the possibilities to actively seek for organic leftovers or to plant hedges or so from which leaves could be cut)

- If you work with farmers, are they motivated to introduce a new method?
- Are there cheaper and easier alternatives, such as green manuring?

All these and other aspects have to be considered. It is therefore very advisable to discuss matters before making a start.

10.3 Practical questions as a guideline for starting

The following practical questions can serve as a guideline when you start making organic fertilizers:

- what do people need to learn about making these fertilizers?
- where should the heap be set up?
- how big can/may the heap be?
- how much and which types of organic material are available?
- is there a regular supply of organic material ?
- what is the quality of the organic material?
- who is going to do the work?
- how much time can be spent on it?
- at times when much organic material is available, is there time to use it?
- how much fertilizer should or can be produced?
- how will the organic fertilizer be used?
- are there any taboos or other cultural socio-economic aspects which make it difficult to use certain types of organic material?

When you start making your own organic fertilizer, take your time to experiment, and give the first experimental process its time too.

Things will probably not go as well as they should, the first time, but in this way it is possible to experiment and to discover the most suitable method in your specific situation. Do not expect wonders straight away!

Appendix 1: Composition of organic materials

Material	% nitrogen (N2)	% phosphorus (P2O5)	% potassium (K2O)	% lime (CaO)	C/N ratio
Manures					
Cow (fresh)	0.3	0.3	0.1		20
Cow (dried)	2.0	1.5	2.0	4.0	
Cow urine (fresh)	0.6		0.5		
Duck (fresh)	1.2	1.5	0.6		
Goat/sheep (fresh)	0.6	0.6	0.3	0.3	
Goat/sheep (dried)	2.0	1.5	3.0	2.0/5.0	
Goat/sheep urine (fresh)	2.0		2.3		
Horse (fresh)	0.7	0.4	0.5	0.2	
Horse	2.0	1.5	1.5	1.5	
Poultry:					5.6
- layers (fresh)	1.6	1.5	0.9		
- layers (dried)	5.0	3.0	1.5	4.0	
- broilers (dried)	4.0	2.0	1.2	1.0	
Swine (fresh)	0.6	0.5	0.5		11.4
Swine (dried)		5.5	1.5	4.1	
Swine urine (fresh)	0.4		0.8		
Animal by-products					
Blood (dried)	12.0	2.5	1.0	0.5	3.0
Bone ash	-	35.0	-	46.0	8.0
Bone meal (raw)	4.0	22.5	0.2	33.0	
Bone meal (steamed)	2.0	25.0		33.0	
Fish scraps (fresh)	7.0	4.0	-		
Hoof and horn meal	12.0	2.0	-	6.5	
Plant residues					
Ash of banana skin	-	3.3	41.8		
Ash of banana stalk	-	2.3	49.9		
Ash of cotton-seed hull	-	5.5	27.0	9.5	
Ash of sunflower stalk	-	2.5	36.0	18.5	
Ash, wood	-	2.0	5.0	32.5	
Bark, pulverized	1.6	0.9	0.5	4.7	
Barley straw	0.6	0.5	1.0	0.4	80

Material	% nitrogen (N ₂)	% phosphorus (P ₂ O ₅)	% potassium (K ₂ O)	% lime (CaO)	C/N ratio
Brewers wastes	4.0				15
White clover, green	0.5	0.2	0.3		
Red clover, hay	2.0	0.5	2.0		
Cocoa shell dust	1.0	1.5	3.0		
Cocoa meal	4.0	2.0	2.5	0.5	
Coconut fiber waste	0.5				300
Coffee pulp	1.0	-	0.8	0.8	
Cottonseed meal	7.0	3.0	2.0	0.5	
Fallen leaves	0.5	0.2	0.5	1.0	45
Grass, immature	1.0		1.2		20
Groundnut meal	7.0	1.5	1.5	0.5	
Maiz stalks	0.8	0.2	1.4	0.2	
Millet/sorghum stalk	0.7	0.1	1.4	0.4	70
Melasse	0.7	-	5.5		
Orange culls	0.2	0.1	0.2		
Pigeon pea stalks	0.7				70
Rapeseed meal	5.5	2.5	1.5	1.0	
Peanut shells	1.3	0.1	0.6	1.4	
Peanut stems	0.7	0.1	0.6	0.5	
Rice husk	0.5	-	0.5	0.1	
Rice bran	2.0	1.9	1.3	-	
Rice straw	0.7	0.1	1.0	0.3	100
Sawdust, rotted	0.2				200
Sawdust, fresh	0.1				500
Soot	5.5	1.0	0.4		
Soybean meal	7.0	1.5	2.5	0.5	
Soybean stems	1.4	0.1	1.0	0.9	
Sugar cane trash	0.3				150
Tobacco stems			6.0		
Dried water hyacinths	2.2	0.3	3.9	2.0	23
Weeds	0.5	0.2	0.7	0.5	
Green manures (dried)					
Clover	2.4	0.2	0.9	2.0	
Crotalaria juncea	2.0	0.2	1.0	0.8	
Sesbania seban	2.1	0.2	1.1	0.8	

Source of this table: Minnich, J., et al. 1979, Rodale Guide of Composting.

Further reading

Agromisa, **Agrodok no 2: Soil fertility management**. 2001.

Agromisa, **Agrodok no 11: Erosion control in the tropics**. 2002.

Agromisa, **Agrodok 13: Water harvesting and soil moisture retention**. 2001.

Agromisa, **Agrodok 21: On-farm fish culture**. 1998.

Available from Agromisa, Wageningen, The Netherlands

The address you find inside on the inside of the front cover.

Attfield, H.H.D. **Composting Privy**. 1978, 12 pp., Technical Bulletin 7 VITA, USA.

Barnjee, R.K. & Srinivasan, K.V., **Composted urban refuse and primary sewage sludge as a fish pond manure**. *Agricultural Wastes* 7, no. 4, 1983, pp. 209-219.

Dalpado, V.E., **Mimeographed information describing compost making from city refuse, aquatic weeds and other materials available in developing countries**. 1976.

Drechsel, P., Kunze, D., **Waste composting for urban and peri-urban agriculture: Closing the rural -urban nutrient cycle in sub-saharan africa**. 2001, 229 pp., CABI. ISBN: 08 51 99 5489.

Edwards, P., **A review of recycling organic wastes into fish with emphasis on the tropics**. *Aquaculture* 21, 1980. pp. 261-297.

Encyclopedia of Organic Farming, Rodale Press.

FAO, **Soil management: Compost production and use in tropical and sub-tropical environments**. FAO soils bulletin 56, 1987, 177 pp., FAO, Rome, Italy.

Gopal, B.R.I.J., **Waterhyacinth as mulch, waterhyacinth as compost**. 1987, pp. 272-275. *Waterhyacinth*, Amsterdam, Elsevier.

Hart, D., Plumiers, J., **Wasted Agriculture. The use of compost in urban agriculture**. 1996, 100 pp., Waste, UWEP Programme.

HDRA, **Composting in the tropics I + II**, 1998, Henry Doubleday Research Association, Coventry, UK.

Hsieh, S.H., Hsieh, C.F., **The use of organic matter in crop production**. No. 315, ASPAC.

Jenkins, J.C., **The Humanure handbook: a guide to composting human manure**. 1994, 198 pp., Jenkins Publishing. ISBN: 0-9644258-4-x.

Lindsey, K., Hirt, H., **Use water hyacinth!** A practical handbook of uses for the water hyacinth from across the world. 1999, Germany.

Minnich, J., Hunt, M., & editors of Organic Gardening magazine, **The Rodale guide to composting**. 1979, USA.

Muller-Samann, K.M., Kotschi, J., **Sustaining Growth: Soil fertility management in tropical smallholdings**. 1994, 486 pp., ICTA; GTZ. Transl.: Christine Ernsting and Simon Chaterj, Margraf, Weikersheim, Germany.

National Academy of Sciences, National Research Council. **Making aquatic weeds useful: some perspectives for developing countries**. Washington DC, USA.

Ngeze, P.B., **Learn how to make and use compost manure in farming**. 1998, 45 pp., Stantex Publishers. ISBN: 9966-917-04-7.

Njoroge J.W., **Field notes on organic farming**, 1994, KIOF, Nairobi, Kenya.

Suval, H.I., Gunnerson, C.G., Julius, D.S., **Night soil composting; Appropriate Technology for water Supply and Sanitation**. 1981, 81 pp., World Bank.

Roulac, J., **Backyard composting**. 1996, 96 pp., Devon, Green Earth Books. ISBN: 1900322048.

Tyler, R.W., **Winning the organic game**. The compost marketer's handbook. 1996, 269 pp., Alexandria, ASHS Press. ISBN: 096150272X.

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HDRA is the leading organisation promoting, researching and demonstrating organic horticulture and agriculture in the United Kingdom and overseas. HDRA's programme provides a question and answer service on organic agriculture and agroforestry for NGO's, self-help groups, schools and other organisations in the tropics and sub-tropics. Requests for information should be directed to the Overseas Advisory Section at the address given above.

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KIOF was established in 1986 to encourage sustainable methods of agriculture, mainly among smallholder farmers. The initial programme was farmers' training and extension carried out in the central districts of Kenya. The programme has been extended with the following:

- Creating awareness and providing practical training in organic farming to farmers.
- On-farm trials and data gathering in organic farming in medium and high potential areas in Kenya.
- Gathering and disseminating information on organic farming throughout Eastern Africa.
- Stimulating formation of organizations and networks on organic farming.

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