

## 4.4 Composting

### Introduction

Composting is the process of transforming organic material of plant or animal origin into humus in heaps or pits. Compared with uncontrolled decomposition of organic material, decomposition in the composting process occurs at a faster rate, reaches higher temperatures and results in a product of higher quality.

### 4.4.1 The Phases of the Composting Process

Within the process of composting 3 main phases can be distinguished: the heating phase, the cooling phase and the maturing phase. However, these phases can not be clearly separated from one another.

#### *The heating phase:*

- Within 3 days of setting up the compost heap, the temperature in the heap rises to 60 to 70 °C and usually stays at this level for 2–3 weeks. Most of the decomposition occurs during the heating phase.
- In this phase, it is mainly bacteria which are active. The high temperature is a result of energy released during conversion of easily decomposable material by the bacteria. The warm temperature is a typical and important part of the composting process. The heat destroys diseases, pests, weed roots and seeds.
- During this first phase of the composting process the bacteria have a very high oxygen demand due to the rapid development of their population. High temperatures in the heap signal that there is an adequate supply of oxygen for the bacteria. If there is not enough air in the heap, bacterial development will be hindered and the compost will develop an unpleasant odour.
- Humidity is also essential to the composting process as bacteria require humid conditions for their work. The need for water is greatest during the heating phase because of high biological activity and strong evaporation occurring during this phase.
- As the heat increases, the pH of the compost heap rises (i.e. acidity decreases).

#### *The cooling phase:*

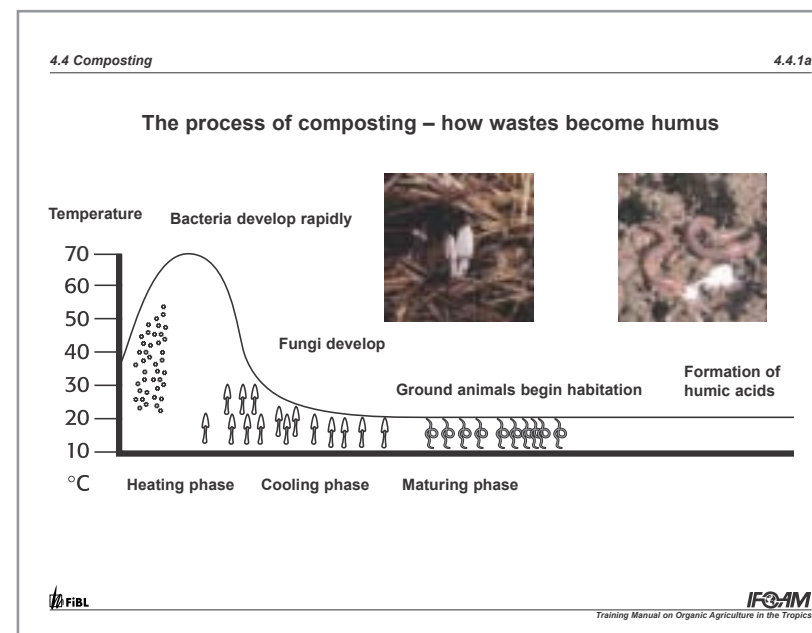
- Once the material which is easily digested by the bacteria has been converted, the temperature in the compost heap declines slowly and will remain at 25–45 °C.

### Lessons to be learnt

- Composting crop residues and animal wastes improves their value.
- To receive a compost of good quality the heap must be set up carefully and the composting process regularly checked.
- To be free of weed seeds and pathogens the compost must go through a period of high temperature.

### Motivation: What does composting mean?

Ask the participants to describe the composting process. Discuss with them the difference between composting and natural decomposition.



Transparency 4.4.1a: The process of composting – how wastes become humus. The three phases of the composting process.

- With the decline in temperature, fungi settle and start the decomposition of straw, fibres and wooden material. As this decomposition process is slower, the temperature of the heap does not rise.
- As the temperature drops, the pH of the composting material declines (i.e. acidity increases).

#### The maturing phase:

- During the maturing phase nutrients are mineralised and humic acids and antibiotics are built up.
- Red compost worms and other soil organisms start to inhabit the heap during this phase.
- At the end of this phase the compost has lost about half of its original volume, has the colour of dark, fertile soil and is ready to use.
- The longer it is stored from now on, the more it loses its quality as a fertilizer, while its capacity to improve soil structure increases.
- In the maturing phase, the compost needs much less water than in the heating phase.

## 4.4.2 Why to Make Compost?

There are a number of reasons for investing time and effort making good compost.

### Advantages of Compost

During the composting process, some organic material is transformed into humic substances, which are relatively resistant to microbial decomposition. Composting thus helps to maintain or increase soil organic matter content. The other components of compost provide nutrients and micro-nutrients in the right proportion (as compost is built from plant materials) for plants to utilise. Compost has both a long and short term effect on plant nutrition as nutrients are permanently released. Due to its neutral pH, compost improves the availability of nutrients in acid soils. When mixed with soil, compost can suppress soil borne disease pathogens. Mature compost is good for plants and does not impede plant roots and micro-organisms in the soil as do substances released during a rotting process.


Composting certainly has many advantages. However, there are some aspects farmers should take into consideration before starting compost production. During the decomposition process some organic matter and nutrients will be lost. Also compost production is labour intensive and demands regular attention.

### Demonstration: Compost samples?

If available, bring compost samples of different maturation status to the classroom and display them (e.g. on a banana leaf). The advantage of fresh samples is that their smell and texture can also be experienced. Ask the participants to describe the samples of composting material. What does the material look like? What has happened to it? To which phase does it belong?



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### Why to make and why to use compost?



**Because...**

- It is a well balanced fertilizer.
- It is not costly to make.
- The heating phase destroys weed seeds and disease germs.
- It suppresses soil borne disease germs.
- It raises the pH in acid soils.
- It increases soil organic matter content.

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Transparency 4.4.2a: Reasons for making and using compost

**Motivation: When is it worth the effort of making compost?**  
 Ask the participants when it is worth making compost from organic material and when mulching is more appropriate? What is the general local practice (composting or mulching, composting only of selected material, in a specific season, for certain crops etc.)?

### 4.4.3 How to Make Good Compost

#### Different systems and methods

Compost systems can be divided into «continuously» and «batchfed» systems:

- Continuously fed systems: These systems do not heat up during the composting process. They are handy if there is a continuous supply of wastes (e.g. kitchen waste). However, they lack the advantages of the heating phase.
- Batch fed systems (all material is composted at once): These systems lead to a hot composting process. They offer the advantages of reduced nutrient loss death of weed seeds and diseases as a result of the high temperature of composting, the process is fast (within a few weeks) and it results in a compost of superior quality.

If little water is available, composting in pits may be more appropriate since humidity is conserved better in pits than in heaps.

#### Example: «Bangalore-method» and «Indore-method»

The two composting methods described below were developed in India, but are widespread in other countries, too.

- «Bangalore-method»: The composting materials are mixed with urine, slurry or dung. The heap, once set up, is plastered with a layer of mud and is not turned. Due to the mud layer, the composting process becomes semi-anaerobic after a few weeks. The method is simple to use, needs little labour and water. It has less nutrient losses than the «Indore-method», but may not destroy all diseases and needs more time to reach maturity.

In dry areas, the «Bangalore-pit-method» is most appropriate. Here the heap stands with more than half of its height in the ground. To prevent drying out it is best shaded with a roof.

- «Indore-method»: In this method, the heap is turned twice. It is therefore labour intensive but also needs more water than the «Bangalore-method», but has a shorter production period. The rapid conversion of the composting material due to the high temperature in the heating period may lead to considerable losses of carbon and nitrogen.


#### Motivation: How to proceed to make good compost?

Ask the participants what should be considered when planning a compost heap and what should be done in order to make good compost. Conclude with the transparency.

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### How to make compost

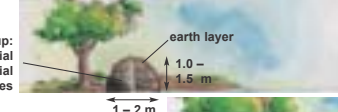
**Collect the composting material**



- Choose a shady location
- Pile up separately
- Collect plenty of plant material
- Chop coarse material

**Set up the heap**


From bottom up:  
N-rich material  
Coarse C-rich material  
Twigs and branches



- Humidify the materials
- Pile up loosely in layers
- Cover with earth or straw


**Turn the heap**



1<sup>st</sup> after 2-3 weeks  
2<sup>nd</sup> after 3 months



- When temperature declines.
- Outside material goes inside.

**Let it rest to mature for 3 months**



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Transparency 4.4.3a: How to make compost

### What to consider when planning a compost heap?

- Location: The compost is ideally located near the source of the composting material and the fields to which the compost will be applied. The site should be shady and near a water source. Water logged sites should be avoided. The compost heap should not be placed too close to houses as the heap may attract rats, snakes and termites etc., and sometimes a bad odour can not be avoided.
- Composting materials: A compost heap should be set up when a lot of plant material is available. If the farm does not supply enough plant material, it may be collected from outside sources.
- Timing: It is easier to produce a good compost during the wet season as the rain saves on labour for watering.
- Size: The compost heap should reach a size of at least 1 m<sup>3</sup> to allow for the correct composting process and so as to allow sufficient aeration should not be more than 2.5 m wide and 1.5 m high.
- Method: The chosen method should be appropriate to the climatic conditions.

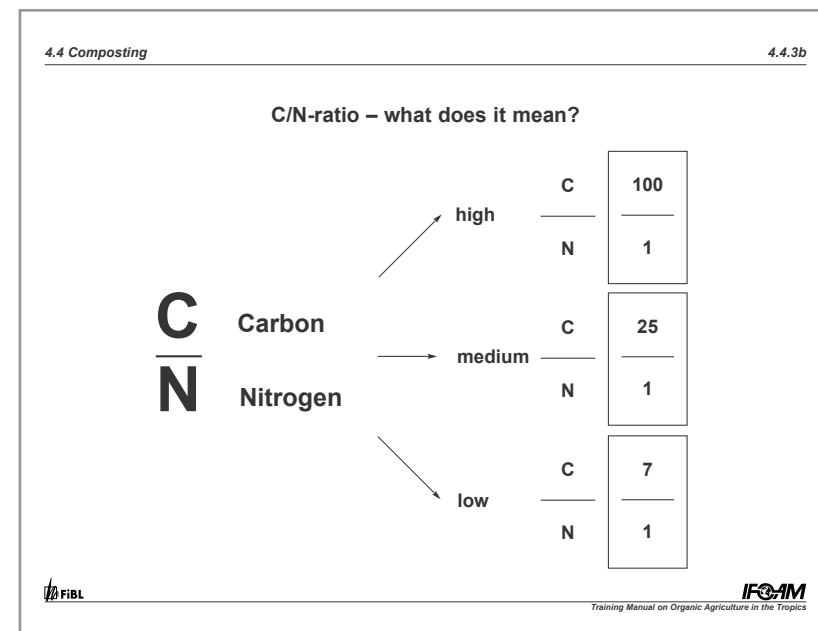
### Selecting the primary materials

The composition of the composting material is of major importance. The C/N-ratio and the structure of the material have a major influence on the composting process. Material which is rich in nitrogen (low C/N-ratio) does not usually contribute to a good structure and thus does not allow for good aeration if composted separately. Material which has a good structure, usually has a low nitrogen content (high C/N-ratio) and does not offer enough nitrogen for the bacteria to feed on. Mixing different materials thus helps to achieve a balanced nutrient composition and a structure which allows for good aeration.

#### Which material, size and mixture?

Material suitable for composting:

- Plant material: a balanced mixture of N-rich and C-rich material.
- Animal dung: cow, pig (rich in K and P), poultry (very rich in P), goat, horse etc.
- Wood ash: contains K, Na, Ca, Mg etc.
- Rock phosphate: the phosphorus binds to the organic material and is thus less fixed to soil minerals. It is therefore better applied to the compost heap than directly to the soil.
- Small quantities of soil, especially soil rich in clay, or groundrock improve the composting process and the quality of the compost. They are mixed with the other material or used to cover the heap to reduce nutrient losses.



Transparency 4.4.3b: Explaining the meaning of the C/N-ratio of compost or mulch materials.

Material not suitable for composting:

- Plant material affected by diseases like rust or virus.
- Persistent perennial weeds unless first dried in the sun.
- Materials of unnatural origin such as metal or plastic.
- Material with hard prickles or thorns.

The finer the material, the greater its surface and the easier it can be digested by bacteria. An ideal length of the material is 2 to 5 cm. If some of the material is smaller (e.g. short grass, kitchen waste, ash), it must be mixed with more bulky material to ensure a good aeration of the heap.

To allow an ideal composting process, the mixture should consist of approximately:

- One third bulky material with a rich structure (chopped branches and tree bark, bulky material separated from previous composts)
- One third medium to fine material with a high C/N-ratio (straw, leaves, crop residues etc.)
- One third fine material with a low C/N-ratio (household wastes, animal manure etc.)
- 5 to 10 % soil.

#### Setting up a compost heap

- Prepare the composting material properly: Chop coarse woody material to increase its surface area and encourage decomposition by fungi and bacteria.
- If dry, soak the composting material before mixing it.
- At the bottom of the heap, put twigs and branches to allow for good drainage of excess water.
- Pile up coarse carbon rich and nitrogen rich material in alternating layers.
- Manure or old compost applied to each layer enhances the composting process.
- Thin earth layers between the compost help to prevent nitrogen loss.
- A 10 cm thick cover of straw or leaves in the initial stage, and an impermeable cover (sacks, plastic sheet etc.) in the final stage prevent potassium and nitrogen being washed out of the heap. In dry climates, cover the heap with a 15 cm thick layer of mud.
- If the heap is not moist enough, from time to time pour water or liquid manure over the compost.

#### Turning the compost

Two to three weeks after building up the compost heap, it will have decreased to about half its original size. This is the right time to turn it. Turning the compost helps to accelerate the process, but it is not essential.

#### C/N-ratios of composting materials

|                                      | Nitrogen content<br>(% of dry matter) | Carbon to nitrogen<br>ratio (C/N ratio) |
|--------------------------------------|---------------------------------------|---|
| <i>Low C/N → high N content</i>      |                                       |   |
| Chicken manure                       | 3–6                                   | 10–12                                   |
| Young grass hay                      | 4                                     | 12                                      |
| Cassava leaves                       | 4                                     | 12                                      |
| Farmyard manure                      | 2–3                                   | 14                                      |
| Groundnut straw                      | 2–3                                   | 20                                      |
| <i>Medium C/N → medium N content</i> |                                       |   |
| Crotalaria                           | 2                                     | 26                                      |
| Cassava stems                        | 1.3                                   | 40                                      |
| Fallen leaves                        | 0.4                                   | 45                                      |
| Maize stalks and leaves              | 0.7                                   | 60–70                                   |
| <i>High C/N → low N content</i>      |                                       |   |
| Wheat or rice straw                  | 0.4                                   | 100                                     |
| Sugar cane trash                     | 0.2                                   | 150                                     |
| Saw dust                             | 0.1                                   | 500                                     |

*Transparency 4.4.3c: Nitrogen contents and C/N-ratios of some common composting materials.*

#### **Demonstration: Knowing the materials**

*During a field excursion, ask the participants to collect different materials for composting. Arrange the materials according to their C/N-ratio and discuss their availability. Alternatively, you could bring samples of different material to the classroom.*

Turning has a number of advantages:

- It improves aeration and encourages the process of composting.
- It ensures that material from the outside of the heap can decompose properly by being put into the centre.
- It allows the quality of the composting process to be checked and for any non ideal conditions to be improved.

| 4.4 Composting   |                                 | 4.4.3d   |   |
|--|---------------------------------|--|---|
| <b>Possible Problems and solutions in the composting process</b> |                                 |  |   |
| Diagnosis  | Problem                         | Possible Reasons   | Solutions   |
| Temperature does not rise  | Microorganisms can not develop  | <ul style="list-style-type: none"> <li>• Material too dry or too wet</li> <li>• Lack of air or too much air</li> <li>• C/N-ratio is not correct</li> <li>• Too much earth</li> </ul>       | <ul style="list-style-type: none"> <li>• Wetten with water or urine</li> <li>• Pile looser</li> <li>• Mix more fresh green material or dung to it</li> </ul>            |
| Sudden decrease of the temperature                               | Transformation process stops    | <ul style="list-style-type: none"> <li>• Material has become too dry</li> <li>• All available nitrogen used</li> </ul>   | <ul style="list-style-type: none"> <li>• Wetten with water or urine</li> <li>• Add nitrogen rich material</li> </ul>  |
| Composting material gets dusty white                             | Too strong development of fungi | <ul style="list-style-type: none"> <li>• Material too dry</li> <li>• Material not mixed for a longer time</li> </ul>   | <ul style="list-style-type: none"> <li>• Mix and set up the pile again</li> <li>• Wetten with water or urine</li> <li>• Add nitrogen rich material</li> </ul>           |
| Material gets blackish-greenish, foul smelling                   | Composting material is fouling  | <ul style="list-style-type: none"> <li>• Lack of air and structure</li> <li>• C/N-ratio too low</li> <li>• Material too wet</li> <li>• Material has not been mixed sufficiently</li> </ul> | <ul style="list-style-type: none"> <li>• Set up pile again adding bulky material with high C/N-ratio</li> <li>• Turn compost more often during heating phase</li> </ul> |

Transparency 4.4.3d: Possible problems and solutions in the composting process

**Practical exercise: Setting up a compost heap**

If possible go to a farm or a field and set up a compost heap together with the participants. Ask the participants to comment on their work. When finished, discuss the possible mistakes in the different phases. If possible come back to the compost heap in the following days and observe the progress.

### Vermi-Composting

Earthworms are highly efficient in transforming dead biomass such as leaves into excellent humus. They usually become very active in a compost heap after the heating phase. Vermicomposting is mainly based on the activity of worms and does not go through a heating phase at all. As worms transform biomass into excrement within a short period of time, the process can be faster than ordinary composting. The excrement of worms is stable crumbles of soil closely bound to organic matter. They have high nutrient levels and good water retention. In addition, the excrement has a growth promoting effect on plants. Some experienced farmers use «vermi-wash», the liquid collected from the compost heap after sprinkling, as a leaf fertilizer and plant tonic. This can even help plants to get rid of pests (e.g. aphids) and diseases. Worms are very sensitive to fluctuations in moisture and temperature. They need a continuous supply of «food», i.e. compost material. They are also attacked by ants and termites. Therefore, a solid base is needed which protects the worms from predators. To remove the compost, let the top of the heap dry out so that the worms move to the deeper layers. Though vermi-compost is definitely a very good manure, it requires more investments (tank and worms), labour and permanent care when compared with ordinary composting methods.

### Vermi-composting



*Transparency 4.4.3e: A vermi-compost heap in South-India. There are various worm species suitable for vermi-composting.*


### Application of compost

There is no one definite stage of maturity. Compost ripens in an endless process. Compost can be used as soon as the original composting material is not recognisable anymore. The compost has then turned into a dark brown or blackish colour and has a pleasant smell.


Compost is a scarce and valuable manure for most organic farmers. Usually it is not possible to produce sufficient amounts for fertilising all fields. Therefore, farmers should think carefully about where compost application would be most beneficial. High efficiency is achieved in nurseries and when planting seedlings or saplings.

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**Apply the compost where it benefits most**




*In seedling cultivation/  
nurseries*



*Into plant holes*

- Not too deep



*Spread out*

- Ripe compost worked in superficially
- immature compost spread out as mulch

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Transparency 4.4.3.f: Apply compost where it benefits most

#### Recommended Readings:

- «Field notes on organic farming», KIOF.
- «The preparation and use of compost», Agrodok Series No. 8, Agromisa.
- «Composting in the Tropics I and II», HDRA.
- «Preparacion del compost», CAB, Ecuador.