MANUAL

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# GUIDE ON HIGH-QUALITY ON-FARM COMPOSTING

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# REASONS FOR COMPOSTING

In built structures like piles, the natural decomposition process is used to produce a highly valuable and indispensable organic substance – compost. Overall, compost can be considered both a soil conditioner and an organic fertiliser. It enhances crop performance primarily by improving the physical and biological properties of the soil and increasing soil organic matter, rather than by adding significant amounts of plant-available nutrients.

The strongly decayed organic matter with significant humus and nutrient content is created during a process whicha will take three to six months. During this time, the composting process is majorly influenced by temperature, water content and air supply. The application of compost can not only increase crop yields in the short term, but also improve the qualities of agricultural systems in the long term and contribute to climate adaptation and resilience.

However, it is largely dependent on the specific site and farm conditions whether composting makes sense as a strategy or not. There are many different composting systems which can be adapted to the respective conditions. However, this guide will focus on the fundamentals and explain functions and principles of producing high quality compost on your own farm.

**Benefits of soil organic matter supplied by compost:**

- **Enhancing soil fertility**
- **Improving the soil structure**
- **Improving the water storage capacity**
- **Improving the biological soil activity**
- **Reducing the risk of erosion**
- **Retaining nutrients and slowly releasing them when needed**

**Image 1** Simple on-farm compost in Peru

# ORGANIC MATERIALS TO USE FOR COMPOSTING

Compost can be made from almost all organic waste materials that accumulate on a farm. The composting process runs ideally when different materials with different decomposition rates are combined, the different materials are thoroughly mixed.
However, to produce high-quality compost, the materials should be examined closely, and care should be taken to ensure that the compost does not contain any non-decomposable or hazardous materials.
The following table shows possible input materials and various materials that definitely should not be added to the compost heap.

| Which materials can go in the compost heap? | Which materials do not go in? |
|---|---|
| Production by-products (e.g., coffee pulp, sugarcane, cocoa bean husks) | Plant materials with chemical-synthetic residues |
| Harvest residues (e.g., maize stalks, straw) | Dairy products |
| Uncooked, plant-based household residues<br>• Fruit and vegetable leftovers<br>• Eggshells<br>• Coffee and tea leftovers | Fat, meat, bones, carcasses |
| Grass, weeds | Cooked food |
| Leaves | Plastics, textile |
| Shredded sticks/branches | Glass, cans |
| Farmyard manure | Cigarette buds |

An important factor when producing compost is the ratio between carbon and nitrogen (C:N ratio) to ensure successful decomposition. The ratio between carbon and nitrogen in the materials chosen should ideally be 25-30:1, this may be a little higher at warm, humid sites. As composting progresses, the ratio of the mature compost will decrease to 10-15:1.

The following table shows different input materials and their estimated C:N-ratio. This should serve as a guide for adjusting the composition of the materials in the compost heap to achieve an optimal ratio.

| Material | C:N-ratio |
|---|---|
| Saw dust | Up to 400 |
| Maize stalks | 50-150 |
| Straw | 50 |
| Green material from legumes | 15 |
| Dung including bedding | 20-25 |
| Straw from legumes | 15 |
| Farmyard Manure | 15 |
| Topsoil | 10-12 |

## Rule of thumb

The optimal C:N-ratio of 25-30:1 can be reached by using two parts of green, nitrogen-rich materials and one part of brown, carbon-rich materials (e.g., dried leaves, straw, wood shaving, saw dust).


**Image 2** Ratio of compost inputs

Certain solid materials decompose slower than others because of their high carbon percentage. The addition of manure or other fresh materials to the compost heap can help with achieving the optimal C:N-ratio and speed up the decomposition process.

Furthermore, other additives can also be added during composting to further improve the nutrient composition of the compost.

Rock phosphate (phosphorous compounds which have not been broken up and are thus not readily available to plants), for example, can be used by mixing it directly into the compost. During the composting process, and especially in an acidic milieu, the rock phosphate is partly turned into forms that the plants can access. Furthermore, Mycorrhiza fungi can also dissolve phosphates in compost.

**Image 3** Compost in Italy

**According to the Naturland standards on production compost inputs or sources other than from your own farm are restricted:**

- Green waste compost, biowaste compost from separate household waste and other compost comprising material not produced on the farm may only be used if it is proven free from harmful residues.
- Naturland must be notified whenever it is applied.
- Detailed regulations imposed by Naturland with respect to quality assurance are given in the corresponding form.
  *QMH_6-1-2_Application_Compost-Intl.pdf*
- Manure is only permitted if it originates from organic or from extensive, conventional animal husbandry.
- Exception: No conventional chicken manure is allowed on Naturland farms.

## SIZE OF ORGANIC MATERIAL

The smaller the organic material, the easier it is for the organisms to decompose it and the faster the compost will be ready. Also, very fine material, like grass clippings, are too compact and can lead to a block air flow in the compost heap. Therefore, it is advisable to shred larger materials such as branches into compartments of 5 to 10 cm length.

**Image 4** Shredded organic material for better decomposition

# WHAT HAPPENS IN THE COMPOST PILE

Soil dwellers such as earthworms, arthropods including insects and their larvae, as well as microorganisms (microscopic bacteria and fungi) are the main actors responsible for decomposing organic material in the compost heap. These soil organisms eat, degrade, and digest the organic material. They are responsible for decomposing the material into the end product: compost.

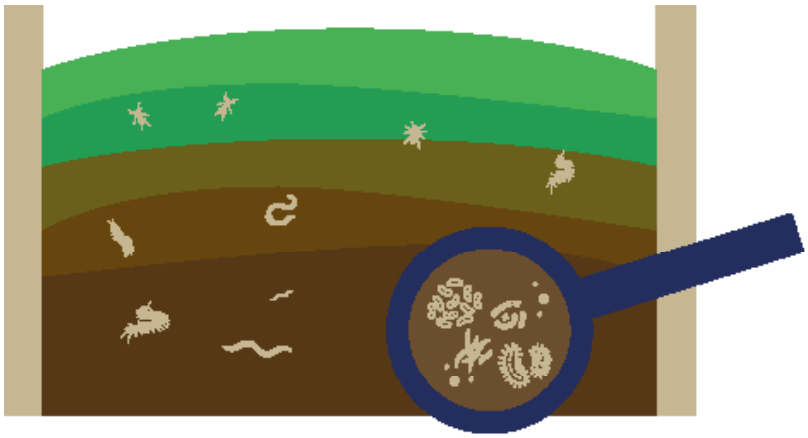

**Image 5** Main actors in compost production - soil dwellers

The composting process consists of three stages. Firstly, there is the heating phase, where the major decomposition of the material happens. During this stage the compost heap is heating up considerably and the microorganism, mostly different bacteria, are very active and develop rapidly.

Secondly, the cooling down phase begins when the temperature in the compost pile drops to about 30°C. During this stage other types of microorganisms, like different fungi, are more present and there is still decomposition happening.

And thirdly, there is the maturation phase where especially small soil-living animals like earthworms are present in the compost pile and contribute further to decomposition. This process is happening for a long time and very slowly since temperatures dropped down during this time to soil temperature of about 15 to 20°C depending on the climate. During this last phase, the humic acids are formed in the compost.

The distinction between these phases is not easy to determine, as the process is gradual.

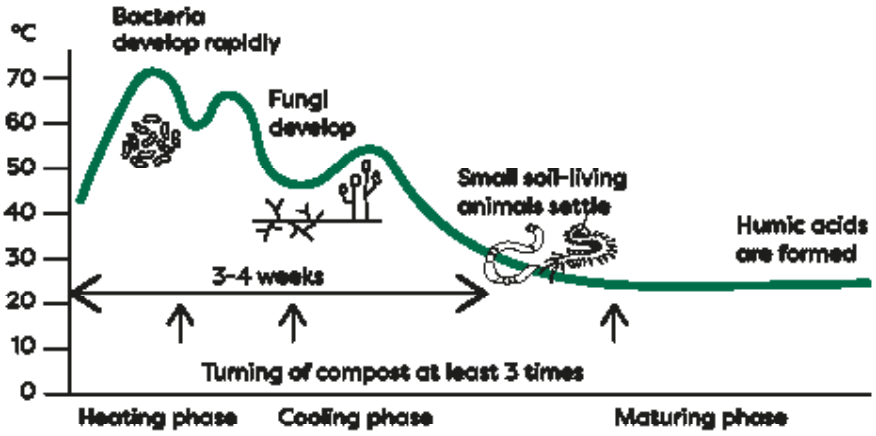


**Image 6** Temperature changes during composting

# OPTIMAL CONDITIONS FOR THE COMPOST

For the before  explained mechanisms to work properly and therefore to ensure optimal decomposition of organic material, it is important to monitor the three key aspects air flow, water content and temperature.

## Temperature

The rising temperatures in the compost heap are a natural process of decomposition and very crucial for hygienisation of the final product. During the heating phase disease carriers and weed seeds are killed off. But it is important to maintain and closely monitor the rise in temperature, since too high temperatures will destroy the active microorganisms and valuable nutrients. The compost should heat up considerably in the first two to three months as the temperature is closely linked to the biological activity within the composting system. The optimal temperature range that is reached in the compost heap is 55 °C up to 70 °C. Even temperatures of up to 80 °C are possible, but undesired because they lead to the destruction of microorganism populations and nutrients, especially nitrogen.
The illustration "How to check moisture during composting" below shows the average temperature range during the decomposition process.

To check the temperature, insert a sharpened stick into the compost 10 days after the pile was formed. After a few days, pull out the stick - it should just be too hot to touch. Alternatively, you can also check it with a soil thermometer.

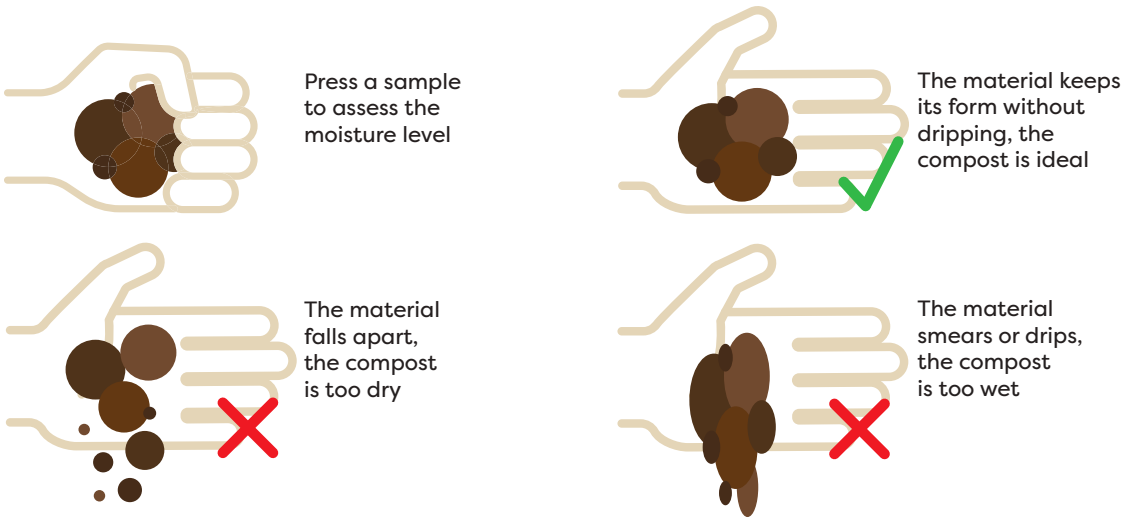


**Image 7** How to check moisture during composting

## Moisture

Another crucial factor for the compost-forming process is the moisture of the organic material. Nonetheless, on the one hand, too much water can lead to the compost heap becoming anaerobic and unfavourable microorganism populations will form. On the other hand, when the compost pile will get too dry, the beneficial microorganisms stop multiplying and the decomposition process will come to a standstill. Anaerobic conditions in the compost heap means that there is not enough oxygen available for the decomposing microorganism to work properly and anaerobic bacteria will take over, which will not lead to the desired decomposition process to unfold. The anaerobic process is considered fermentation and is also considered decay or putrefaction. In general, water content in the compost heap of about 45-50% is recommended.

> To check the water level, take a handful of compost and press it firmly together. If the compost keeps its shape, the water content is correct. However, if it falls apart it is too dry or if water flows out it is too wet. If available, you can also check it with a soil hydrometer.

## Air

Furthermore, to stop anaerobic conditions from developing in the compost heap, the air supply is a crucial factor to closely observe as well. Linked to the water content and as already mentioned, the air supply is of crucial importance for soil organisms and therefore the composting process. A clear sign of a lack of air in the heap is a strong smell of decay, but also fly occurrence and buildup of mold. Therefore, the compost heap should be turned over around three times during its 3- to 6-month decomposition cycle. To increase the air supply, turn over the compost with a pitch-fork. For bigger compost production a tractor with a loading bucket or machine-pulled compost turners can be used.


**Image 8** Machine-pulled compost turner

# RIGHT LOCATIONS FOR THE COMPOST HEAP

The location of the compost heap can help control the three key conditions of the compost heap: temperature, humidity, and air. The ideal location for the compost heap should therefore be carefully considered.

For instance, the compost heap should be in a protected place, for example, under a tree or in a small shelter. There it will be protected from rainfall, excessive sunlight, as well as strong winds. This will keep the heap from leaching or respectively from drying out. The compost heap could also be protected with mulch material.

Furthermore, the heap should be positioned in a safe distance from water sources to avoid contamination and floodings. In addition, locations with  should be avoided.

A further point to consider is the amount of time and labour needed when working on the compost. For example, the location should be close to labour-intensive areas such as the fields where the material for the compost heap is gathered and the compost is then applied subsequently.

**Image 9** Outdoor compost construction in India

**Image 10** Sheltered compost production site

# CONSTRUCTING THE COMPOST PILE

There are many different forms of compost systems and each of them requires different compost heap structures.

But there are some basic rules that need to be followed when constructing any sort of compost system.

### The following basic rules should be heeded:

- The organic material needs to be mixed by chopping it up (into small pieces, yet not too small) or layered alternately.
- Plant remains that are very woody need to be chopped to aid decomposition.
- The foundation needs to be well-drained. If the ground has a tendency towards waterlogging, the first layer should consist of loose material (e.g., branches).
- The compost heap should be protected from drying out and/or leaching by covering it with natural materials (e.g., straw or banana leaves) or with perforated foil (the perforations allow gases to escape and prevent internal sweating).

A roof-type of structure can help to drain off any rainwater and thus prevent waterlogging – especially in wet climates. In extremely dry regions, it can make sense to dig compost pits. The construction of compost heaps which measure approximately 1,5 m high, 2 m wide have proven themselves in practice. The length varies depending on the amount of organic material available. All these measures ensure good aeration and stable temperatures within the heap.

### Basic layering concept of a compost heap:

(1) Hard to decompose organic material,

(2) fresh organic material,

(3) organic animal manure,

(4) thin layer of mature compost or moist topsoil.

These layers are repeated until the heap reached the desired height of 1,5 to 2 m.

# FINAL LEVEL OF MATURITY

An optimal composting process converts organic material into stable compost that is free from odours, weed seeds and pathogens. In addition, the volume and weight of the organic materials will be significantly reduced.

The individual components of the compost will no longer be recognizable, there are only traces of rotting material. Large residual pieces can eventually be sieved out. The compost is ready when it smells of damp earth or forest soil, is dark brown to black in colour and has a spongy consistency, but without releasing water when tested with a fist.

The mature compost can also be stored – under optimal conditions up for several weeks without deteriorating. For this, keep the compost in a sheltered place to keep it dry and covered. A compost heap structure, covered with leaves or other materials, is suitable for this.

**Image 11** Matured compost

# APPLICATION OF COMPOST

Application: Once the compost fulfills the above-mentioned criteria it can be used in the fields or plant nurseries. Make sure to use only fully mature compost for seedlings and pots to not inhibit germination in too acidic ph.

The time that compost is added is most important. This depends upon the growing period of the crop and its respective nutrient requirements. A well-timed application of compost can also control the water in the soil during a dry period when applied at the end of the rain season.

Next to incorporating compost into the soil, there is also another way to utilise compost: compost tea is the extract of compost dissolved in water. These water-soluble compounds of compost can be applied as foliar spray or with irrigation water.

The production of high-quality compost requires time, so it is also worth taking care to apply it properly in the field. Appropriate times for application are early in the morning or late in the afternoon. The compost should be spread evenly in the field and lightly worked in. Compost can be put in the bottom of the planting hole, when planting new seedlings or trees. For established trees or shrubs, the compost can be applied in a circle around the stem, covered lightly with some soil.
The quantity of compost applied per year, depends on the specific crop and its nutrient requirements, as well as the desired harvest output of the respective crops and the use of additional organic fertilizers. It should be noted that the nutrients from compost are released slower than those from mineral fertilizers.

The following weights of contents give a general indication of how to integrate the dosing of compost material into the total nutrient cycle:

| Substance | Weight in dry matter [in %] |
|---|---|
| Organic substance | 60 |
| Carbon | 35 |
| Nitrogen | 2,8 |
| Phosphorous [$P_2O_5$] | 2,2 |
| Potassium [$K_2O$] | 2,6 |
| Calcium [CaO] | 3,1 |
| Ash | 40 |

**Image 12** Compost production site in Paraguay

# COMMON CHALLENGES: CAUSES AND SOLUTIONS

A farmer should consider some aspects before making the decision on composting on the own farm.

Consideration should be given to whether there are better uses for materials that are used for composting, such as hay or freshly cut grass which could be used for animal feed instead. If this is the case, alternatively the animal dung can be used since successful composting generally goes alongside with keeping livestock.

In general, composting is a time-consuming process which also needs good planning to efficiently use the materials that accumulate on the farm. Compost production requires regular work steps, such as monitoring the temperature, but also includes spontaneous actions, such as reacting to an increased temperature. Work peaks can occur for example during the layering of the pile and the application of the finished compost. Please verify that this additional workload can be included on your farm to sustainably benefit and implement the composting system.

When producing compost on-farm, close observation and care are necessary. The following table shows different scenarios of difficulties of compost production and their possible causes as well as possible solutions.

| Problem | Possible causes | Solutions |
|---|---|---|
| Smell of decay | Lack of air<br>Surplus of water | Add dry material<br>Turn the compost heap |
| The material won't decompose | Lack of water | Add wet material or water the compost heap |
| The temperature won't increase | Lack of nitrogen<br>Lack of water | If the heap is exposed, cover it for a time with a plastic<br>Add wet material with high N contents |
| The temperature exceeds 80°C | Too much exposure to sunlight<br>Covering without need | Remove covering<br>Water the heap<br>Turn the heap over |
| There are a lot of flies | Surplus of water<br>Uncovered slopes | Cover fresh slopes with dry materials |

# IMPRINT – ADDITIONAL INFORMATION

Next to compost made from organic plant material, there are composting processes worth mentioning in the course of this manual.

**(1) Vermicompost** actively uses (purchased) earthworms to compost organic materials in special compost heap constructions. You can find more information about it in the following Naturland vermicompost guide: *https://www.naturland.de/images/01_naturland/_en/Documents/Documents_Producers/02_TechnicalInformation/03_FertilizationSoil/Vermicompost.pdf.*

**(2) Biol** is a liquid fertilizer which is produced in anaerobic decomposition within one to four months. You can find more information about it in the following Naturland Biol guide: *https://www.naturland.de/images/01_naturland/_en/Documents/Documents_Producers/02_TechnicalInformation/03_FertilizationSoil/Manual_Biol.pdf*

## Additional information platforms

- *https://academy.naturland.org/local/dash/dashboard.php?id=1*
- *https://www.best4soil.eu/videos*
- *https://www.ecoagtube.org/all-videos?term_node_tid_depth=All&field_awsets_languages_target_id=All&combine=compost*
- *https://www.accessagriculture.org/search/compost/all*

## Picture sources

- Title image: freepik
- Image 6: adapted from FiBL (2020), originally illustrated by Deogratius G. Okudi, developed in the framework of the 'Green Innovation Centres for the Agriculture and Food Sector' (GIC) project with funding support from BMZ through GIZ
- Image 7: adapted from FiBL (2020), originally illustrated by Deogratius G. Okudi, developed in the framework of the 'Green Innovation Centres for the Agriculture and Food Sector' (GIC) project with funding support from BMZ through GIZ
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