BIOHUB SOLUTIONS

Solutions for today.
Benefits for generations.

# BioTech Series

# Compost

Where science meets sustainability, and your farm's potential meets our passion.

# How We Help

We know that understanding biologicals can be both confusing and overwhelming. Your solution should simple, measurable, and profitable. This is why we developed the **BioPlan**.

- Focus on testing and data to develop the best solution.
- Integrated solutions focusing on soil, nutrition, and plant health.
- Simple crop and soil monitoring providing solution accountability.
- Simple solutions providing agronomic, environmental, and economic returns.

The BioTech Series has been designed to answer some of the more technical questions you may have about our solutions. Or provide some extra information for inquisitive minds wanting to know a little more about biological strategies. When digesting the information in this booklet and others in our series, remember there is no silver bullet. No solution is the same. No challenge is the same. What is the same are the processes that BioHub team members and trained business partners follow under the BioPlan to try to formulate an integrated solution. This integrated solution can involve nutrition, plant health, biologicals, or soil ameliorants.

At BioHub Solutions, we fuse cutting-edge science and data with the wisdom of nature to deliver pioneering biological solutions to the agricultural sector. Our Australian heritage drives us to innovate for the unique challenges faced by local and global farmers, ensuring our products not only boost your bottom line but also safeguard the environment.

Take the guesswork out of biologicals by contacting one of our team or authorised business partners.

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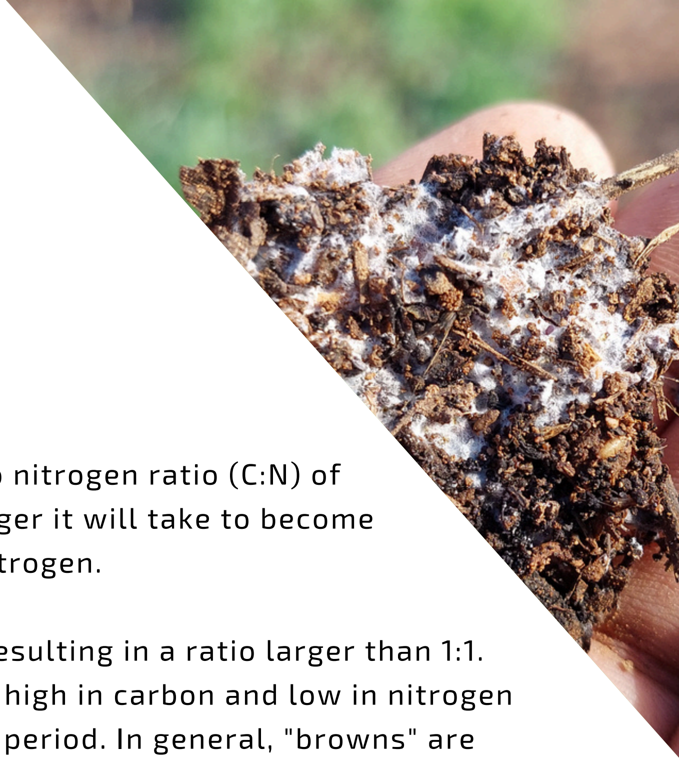
# Introduction

Organic material (OM) is one of the key components of a healthy soil. Healthy soils create healthy plants, and in the process of increasing soil organic matter content and carbon %, we become less dependent on high amounts of fertilizers. However, to cope with the higher amounts of OM In the soil the soil food web would also need to be divers and ultimately the soil physical properties and conditions should be Ideal to create a habitat for the aerobic (creates compost) as well as anaerobic soil microbes (creates humus).

Increasing the OM of the soil can be done through adding "raw" materials, like leaves, pruning clippings and wood chips, that still needs to be broken down and composted by the soil microbes, or compost can be added and Incorporated Into the soil. The benefit of a good quality compost that has been decomposed properly is that nutrients are readily available and the C:N ratio is less affected than when raw OM is deposited in the soil. It is often observed that crops go through a nitrogen deficient stage when "raw" material is added to the soil. During this initial stage, the microbes use fertilized nitrogen or available nitrogen to feed on while decomposing the carbon rich material. So how do we get compost and what is compost exactly?

In short compost is the product obtained from a managed biological decomposition of organic materials. Compost is a stable, humus like product produced by microbes. It is a very natural process that is managed to obtain compost in a shorter time. To get to the ideal compost to have the best effect on your soil we will investigate what makes a good compost and what role microorganisms play in the composting process.



# Components of Compost

The driving force behind composting is the carbon to nitrogen ratio (C:N) of materials. The higher the C:N of the material the longer it will take to become compost unless additions are made in the form of nitrogen.

All plants have more carbon than nitrogen, always resulting in a ratio larger than 1:1. Brown materials are classified as materials that are high in carbon and low in nitrogen like wood chips, resulting in a prolonged breakdown period. In general, "browns" are "dead" material of plants such as straw, dried weeds, autumn leaves and woodchips (including sawdust), and need wetting before added to a compost pile.

Materials like grass clippings that have low carbon content and higher nitrogen content are classified as green materials. Green materials are digested faster than brown materials. Combining the two will result in a good microbial diet. The green materials are rich in nitrogen and provides nutrition to the microbes though the amino acids and proteins produced in the plants' cells.

Table 1. Table showing the C:N ratios for different materials that can be used for composting

| Greens C:N <30 | | Browns C:N >30 | |
|---|---|---|---|
| **Material** | **C:N Ratio** | **Material** | **C:N Ratio** |
| Aged Chicken Manure | 7:1 | Nut Shells | 35:1 |
| Soil Microbes | 8:1 | Corn Stover | 57:1 |
| Pig Manure | 8:1 | Peat Moss | 58:1 |
| Humus (soil) | 10:1 | Oat Straw | 70:1 |
| Sheep Manure | 10:1 | Wheat Straw | 80:1 |
| Grass Clippings (young) | 12:1 | Dried Leaves | 60-80:1 |
| Young Alfalfa Hay | 13:1 | Rye Straw | 82:1 |

| Greens C:N <30 | | Browns C:N >30 | |
|---|---|---|---|
| **Material** | **C:N Ratio** | **Material** | **C:N Ratio** |
| Beef and Horse Manure | 14-25:1 | Pine Needles | 60-110:1 |
| Legume Hay | 17:1 | Shredded Newspaper | 175:1 |
| Vegetable Scraps | 17:1 | Sawdust | 500:1 |
| Seaweed | 19:1 | Woody Chips | 400-700:1 |
| Rotted Barnyard Manure | 20:1 | | |
| Coffee | 25:1 | | |
| Fresh Grass Clippings | 25:1 | | |
| Mature Alfalfa Hay | 25:1 | | |
| Rye Cover Crop | 26:1 | | |
| Fruit Waste | 30:1 | | |



# Process of Composting

The degradation of organic material is a natural process that starts immediately as the material is generated and meets soil biology, like earthworms, nematodes, bacteria, fungi, protozoa and insects like mites, sow-bugs, spring-tails, ants, and beetles

## Stage One. Psychrophilic Stage

The first stage of composting is typically a few days to a few weeks, depending on the ambient temperature, during which the psychrophilic bacteria (active at low temperatures: 13 - 20oC) are responsible for degrading the material. They never produce much heat.

## Stage Two. Mesophilic Stage

As temperatures increase mesophilic microorganisms (temperatures between 20 - 45oC) start replacing the psychrophilic bacteria. Under favourable conditions they can double their numbers in 30 minutes. In this stage the simple sugars and starch is utilized. As heat is a by-product in the composting process, temperatures quickly rise to over 40oC. At this stage, the fungi and actinomycetes are located on the outer 5 - 15cm of the pile. Some moulds also grow on the outside of the pile.

## Stage Three. Thermophilic Stage

As temperatures rise the mesophilic organisms are replaced by thermophilic organisms (40 - 70°C) that break down the material into finer pieces. The thermophilic breakdown stage can last a few days to months. Proteins, fats, cellulose, hemicellulose, and complex carbohydrates are broken down more effectively at these higher temperatures. If temperatures are left to rise too high, the beneficial microbes will also be negatively affected. It is during the thermophilic stage that most of the organic matter is converted to humus and carbon dioxide. Microorganism numbers also increase rapidly.

## Stage Four. Curing or Maturation Stage

This stage can also last for months. Once the available supply of compounds has been consumed by the thermophilic organisms, the temperatures start to decrease, and the mesophilic organisms resume control of the remainder of the organic material in the pile converting it all to usable humus. Fungi prefer a temperature range between 20 and 25oC and become very active during this phase. Fungi is very efficient in breaking down cellulose and lignin. Assisting the fungi during this stage is Actinomycetes. They are

fungi like bacteria, light greyish in colour and credited with creating the earth like aroma of good compost. Actinomycetes are very effective in breaking down complex woody materials containing lignin, chitin, cellulose, and proteins.

# Factors Influencing Microbial Activity

When conditions that are favourable for microorganisms are created rapid composting can occur. To create these conditions an understanding of microbe functioning is needed. Microbes require water, oxygen, nutrition, and a comfortable temperature to thrive. The following factors influence microbial activity.

## Moisture

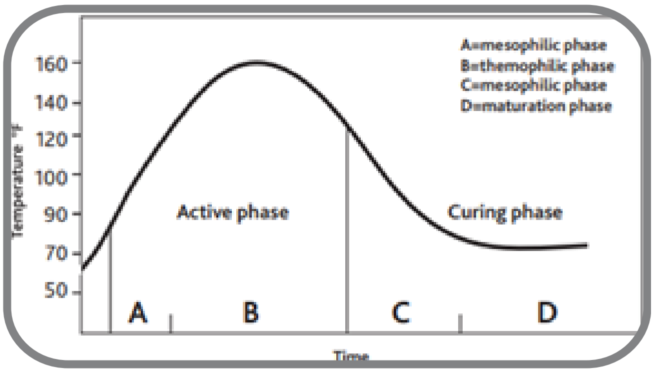
Microbes require moisture to live and maintaining a 40-60% moisture status of the compost will enable microbes to function optimally. The ideal time to moisten the compost is during the building or turning stage of the pile. If a compost pile has been kept too wet, the anaerobic conditions can be improved by turning the pile as turning dries out the pile.

## Aeration

As humans, microbes require oxygen to survive. Microbes reproduce fast and can deplete the available oxygen quick through their activity. By aerating the pile through turning oxygen levels are maintained.

## Compost Temperature

The temperature of a compost pile is less affected by the direct sunlight as opposed to the microbial activity in the pile. The temperature originates from their metabolism, reproduction, and conversion of the composting materials to energy. It is beneficial to maintain a pile temperature of 55oC for three days to prevent weed seeds from germinating and destroy pathogens.




Temperature changes in an average compost pile. (Source: Cooperband, L 2002. The Art and Science of Composting. Center for Integrated Systems, University of Wisconsin. http://www.cias.wisc.edu)

### Particle Size

The larger the composting material's particle size the longer it will take to be broken down. Reducing the particle size before piling will reduce the pile size, saving space and optimizing the surface area for microbial digestion. Too small particle size like sawdust will compact too easily and can create anaerobic conditions that are counterproductive to composting.

### Carbon to Nitrogen Ratio

For ideal composting a carbon to nitrogen ratio (C:N) of 30:1, calculated on a dry-weight base, is required. The ratio of green and brown materials should be calculated to determine whether an addition of nitrogen is needed. Only brown material will take longer to become compost than a good mix of brown and green.

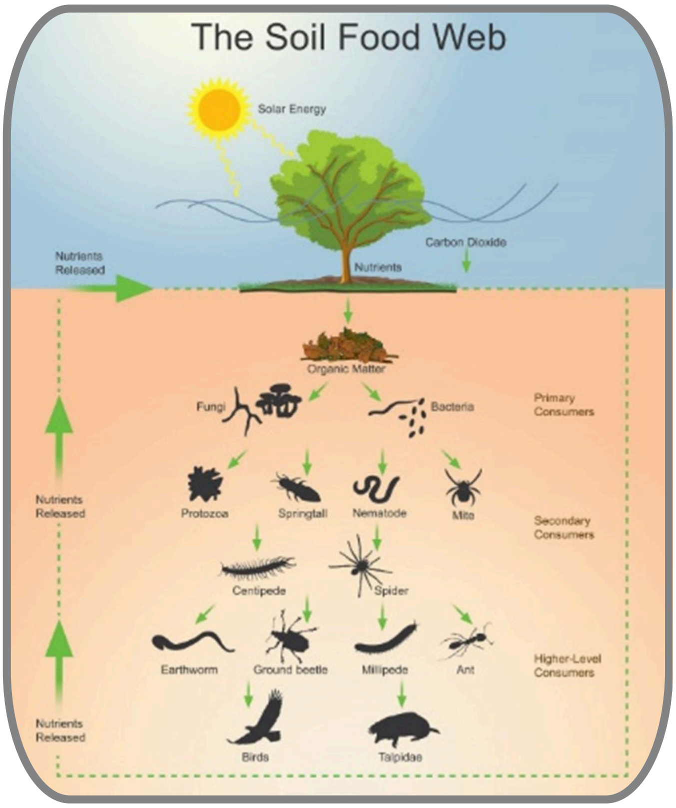
## How Does the Soil/Compost Food Web Contribute to Composting?

During the process of composting many organisms part take in the process. Some can be seen by the human eye, whilst others need to be viewed under a microscope. A succession of microbes and insects combine efforts to turn organic material into fully decomposed usable humus.

Composting microorganisms are categorized under aerobic and anaerobic microbes. Aerobic microorganisms require at least 5% oxygen levels to survive and function, whereas anaerobic organisms do not require oxygen. Aerobic organisms digest organic waste much more efficiently than anaerobic organisms and excrete useful organic compounds for plant nutrition. In turn anaerobic organisms produce chemicals like phenols, aldehydes and hydrogen sulphide that are harmful to plants.

According to the Cornell University about 80 - 90 percent of all microorganisms found in compost piles are bacteria, with the remainder comprised of species of fungi, including moulds and yeasts. Insects that contribute to composting are pill bugs, centipedes, and worms, which find their way to the composting pile.

The compost food web can be represented by three levels.




## Third Level Decomposers

These are larger creatures, known as macro-organisms, that physically break down the organic material by chewing and tearing it into smaller pieces. They also feed on second level decomposers. In this group you will find:

- Ants
- Beetles
- Centipedes
- Millipedes
- Slugs
- Snails
- Spiders
- Woodlice

## Second Level Decomposers

These organisms tend to smaller than the third level decomposers and the use of a hand lens is needed to see them. They consume organic matter as well as the organisms that make up the first level decomposers.

- Springtails
- Nematodes

- Beetle mites
- Mold mites
- Protozoa

## First Level Decomposers

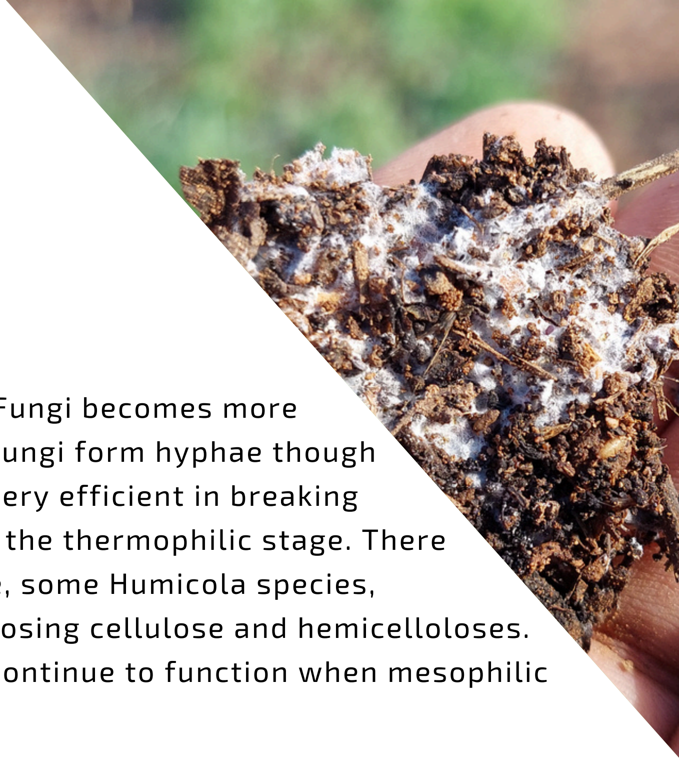
This group of organisms are much smaller, but they still play a vitally important role in the composting process. The actual species and amount will vary according to the conditions and temperature of the compost pile. Organisms in this group are:

**Bacteria**

Generally 1 million to 1 billion present per gram of compost. They are by far the largest group of microorganisms involved in composting. Most bacteria are spherical (Cocci), or rod shaped (Bacilli). Bacteria is present in all the stages of composting and breakdown the easily degradable materials. Bacteria require carbon (browns) as a source of protein and nitrogen (greens) as a source of energy.

| Bacteria Name | Shape/attribute | Habitat |
|---|---|---|
| **Alcaligenes faecalis** | Gram negative<br>Aerobic<br>Rod shaped | Intestinal tracts of vertebrates. Decaying material, dairy, water, and soil. |
| **Arthrobacter** | Gram negative | |
| **Brevibacillus brevis** | Gram positive<br>Aerobic<br>Rod shaped | Soil, air, water, and decaying matter. |
| **Bacillus species B.coagulans, circulans, lichenformis, megaterium, pumuilus, sphaericus, and subtilus** | Gram positive<br>Rod shaped<br>Obligate aerobes or facultative anaerobes | Some species are saprophytic in soil, water, and wide range of other environments. |
| **Clostridium thermocelium** | Gram positive<br>Anaerobic<br>Rod shaped (thermophilic) | Plants and animals. In digestive systems breaking down cellulose of grass. |

| Bacteria Name | Shape/attribute | Habitat |
| --- | --- | --- |
| **Escherichia coli** | Gram negative<br>Rod shaped<br>Facultative anaerobe | Human and animal guts. |
| **Flavobacterium spp.** | Gram negative<br>Rod shaped | Soil and water |
| **Pseudomonas spp.** | Gram negative<br>Rod shaped<br>Aerobic | Water, plant seeds, and a wide range of locations. |
| **Serratia spp.** | Gram negative<br>Rod shaped<br>Facultative anaerobe | Widespread |
| **Streptocuccus** | Gram positive<br>Cocci shaped | |
| **Thermus spp.** | Gram negative<br>Rod shaped<br>Meso and thermophilic | Soil, faeces, meat, sewerage, and thermal springs. |
| **Vibrio spp.** | | |



**Fungi**

Generally 100K to 100 million in a gram of compost. Fungi becomes more prominent in the latter stages with actinomycetes. Fungi form hyphae though out the compost pile (until it is turned) and the are very efficient in breaking down cellulose and lignin. Most fungi do not survive the thermophilic stage. There are heat tolerant fungi like Chaetomium thermophile, some Humicola species, Thermoascus aurantiacus that play a role in decomposing cellulose and hemicelloloses. Aspergillus fumigates is also heat tolerant but will continue to function when mesophilic organisms return.

| Fungi Name | Type | Comment |
|---|---|---|
| **Aspergillius fumigates** | Fungal mould | In soil and decaying organic matter. Grows at 50°C and can survive at 70°C. |
| **Basidiomyces** | | Degrades lignin |
| **Humicoli grisea, insolens and lanuginosa** | Thermophilic fungal mould | Found in soil and plant material |
| **Malbranchea pulchella** | Thermophilic | |
| **Myriococcum thermophillium** | Thermophilic | |
| **Paecilomycetes variotti** | | |
| **Papulaspora thermophilia** | | |
| **Peicillium spp.** | | |
| **Scytalidium** | | |
| **Termonmyces spp.** | | |
| **Trichoderma spp.** | | |

**Actinomycetes**
Generally 10K to 1 million fungal cells per gram of compost. Even though Actinomycetes are bacteria they can digest hardier compounds, survive in drier conditions they produce a chemical called geosmin that is responsible for the earthy smell of compost. They are found within 5-7 days after composting started, are mesophilic and thermophilic and found on the outer parts of the compost pile. The thermophilic actinomycetes are responsible for the degradation of lignin. Actinomycetes do not function well under wet and acidic conditions.

| Name | Attribute | Comment |
|---|---|---|
| **Streptomyces** | | Source of two thirds of clinically use full antibiotics. |
| **Frankia** | | Fixes 15% of the world's naturally fixed nitrogen. |
| **Another 14 species** | Facultative anaerobes and some are anaerobic. | Decomposers of tough plant tissues like cellulose, lignin, chitin, and hard exoskeletons of insects. |

# Benefits to the Soil From Compost

## Nutrient Supply

Studies have found that 1 - 1.5kg of sulphur, 2 - 3kg of P2O5 and 8 - 12kg elemental N is released from every 1% of OM In the soil. Elements released from organic matter help the plants with vegetative growth, amino acid production, anthocyanin formation and chlorophyll synthesis to name a few. Improving soil aggregation

## Water Holding Capacity

OM acts like a sponge and can retain up to 90% of Its own weight in water, Increasing the ability of a soil to retain more water, and saving on the cost of water and pumping the water. The water stored in organic matter Is readily plant available and plants use less energy to take this water up.

## Improve Soil Structure

Carbon derived from OM acts as the "glue" for soil aggregates, clumping them together and creating aeration in soils, Improving water infiltration and oxygen penetration. Carbon is stored in these aggregates for up to 40 years.

## Prevention of Erosion

By increasing the water infiltration rate, runoff is reduced and therefore the risk of soil erosion is decreased. Soil particles bound in aggregates provide more a more stable soil structure and particles are less prone to be washed or blown away.

## Prevention of Leaching

OM retain more nutrients inside the effective root zone, acting as a catch net to prevent nutrients, especially in sandy soils, to leach through the soil profile to become unobtainable for the roots.

## Buffer the Soil

Different plants require different pH's for ideal growing conditions. OM and specifically humus provide the ability for the plant roots to experience ideal conditions in terms of pH. Soil microbes also benefit from this buffer effect.

## Increases the Oxidation of Complex Organic Substances

When OM undergoes decomposition, it has a direct influence on the oxidation process of complex organic compounds such as the lignin-like humus, whereby OM is broken down into simple sugars, amino acids, aliphatic compounds, and phenolic acids. These compounds are further broken down into humic assemblages (humic and fulvic acids) which are important binding metal hydroxides and minerals.

## Soil Stability

Through the above mentioned factors about buffer capacity, aggregate stability, water holding capacity, drainage and microbe nutrition OM also contributes sandy and clay soils differently. In sandy soils OM helps to retain minerals and water, whereas in clay soils OM reduce the density of the clay resulting in the separation of soil particles to improve air circulation as well as water permeation.

## CEC and Soil Temperature

The ability of the soil to adsorb nutrients through chelation increases with an increase in OM due to the colloidal nature of humus. During cold times soils with OM are warmer

and benefits the activity of microorganisms, root growth and germinating seeds. On the other hand, in excessively hot soils OM buffers the temperature to enable roots and microbes to function without dying off.

# Risk Management

(Source: http://www.carryoncomposting.com/416920205)
The risks associated with infection when working with compost are small and a few simple precautions will reduce that risk to a very low level.

- Wear gloves either gardening gloves or nitrile/latex for more delicate tasks
- Wash hands and/ or use hand sanitizer if washing facilities are not available

# Handling Compost

- Moisten compost before aeration and consider wearing a dust mask (particularly if the compost smells musty).
- Do not hold your head immediately over the compost bin when aerating the compost to avoid directing aerosols or spores into the face.
- Do not store compost in the greenhouse where it will warm up during the summer allowing microorganisms to multiply.
- Shred woody material in a well-ventilated area.

# Sources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