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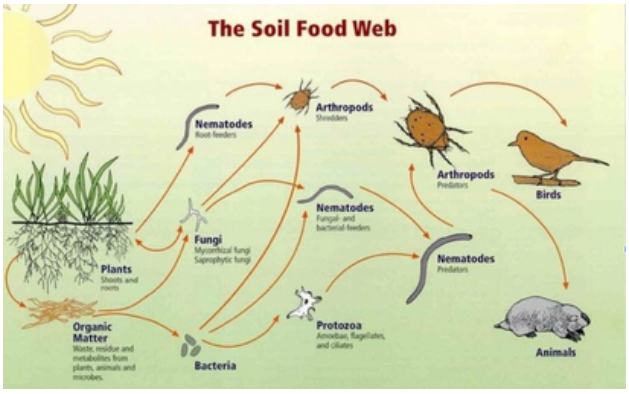
Tending to Soil



Soil Food web graphic food web Image Credit, USDA, 2016

THE SOIL FOOD WEB

The **soil food web** is the **community of organisms living in the soil**, including plants, insects, worms and microorganisms. **Food webs** describe the **transfer of energy between species** in an ecosystem.

First Trophic Level
Plants use the sun's energy to turn carbon dioxide and minerals into carbon rich substances like sugars, by photosynthesis. Much of these substances are used for plant growth. However plants send some of these substances down through their roots and use them to attract fungi and bacteria. It is well known that many fungi and bacteria feed on decaying organic matter like dead leaves to provide them with the energy they need to survive, but they also feed on these carbon rich, energy dense 'plant exudates'. In return, they begin a process that ensures that plants can access important minerals like nitrogen, calcium and phosphorus that they scavenge from the soil. The microbes also protect plant roots from pests and predators so that their food supply from the plants is not disrupted!

Second trophic level
Most bacteria and fungi do not directly give plants the nutrients they have scavenged from the soil. They must first be eaten, digested and excreted by predators close to plant roots. The predator poo and decaying microbe bodies are rich in nutrients, in forms easily absorbed by plants. These predators are protozoa, microarthropods (small arthropods) and nematodes.

Bacteria are eaten by protozoa and fungi are eaten by fungal feeding nematodes and micro-arthropods.

Higher Level Predators
These include larger arthropods (eg. Spiders, springtails, beetles, spiders, ants), larger nematodes and worms. At the highest level there are birds and mammals. They keep the lower level predators in check so that the soil food web remains balanced.

Many organisms in the soil food web serve other functions too. Arthropods are also great at shredding plant material, helping it break down faster, and even eat weed seeds!

In the first tropic level there are some specific microbes that live on or in plant roots and exchange minerals with them for these exudates. These include rhizobium bacteria which provide legumes with nitrogen they fix from the atmosphere and mycorrhizal fungi which form relationships with a huge variety of plants, creating vast connective networks throughout the soil, transporting minerals and water to where they are needed most.

SOIL HEALTH PRINCIPLES

1. Keep living roots in the ground for as long as possible. Root exudates are the favourite food of soil microbes, so they are the foundation of the soil food web. Living roots also help to hold soil together, fight soil compaction and absorb water in times of high rainfall. When the roots die, they create channels supporting movement of air, water and soil organisms throughout the soil.

2. Cover the soil with plant residue or living plants. This helps to keep the soil warm in winter, prevents it from drying out in the heat, and limits compaction by providing a protective shield against rainfall. It also provides food for soil life!

3. Minimise digging and walking on the soil as this creates soil erosion and compaction, destroying the homes and food sources for soil organisms. Compacted soil is also prone to waterlogging and creates difficulties for roots and soil organisms to move through the soil.

4. **Maximise diversity in crop rotations and plantings.** Diverse plantings support a diversity of species above and below ground, creating checks and balances against pests and diseases. Having lots of different plant structures and leaf shapes also maximises access to light and therefore photosynthesis. Plant leaves are like little solar panels harvesting energy from the sun's light and sending it down in the form of sugars to feed the soil food web below.

5. Feed Soils with organic matter like compost or crop residues. This is important, especially if you are continually harvesting from a vegetable bed. Each time you harvest you remove organic materials that would otherwise fall to the ground and feed soil organisms.

6. Minimise Use of Chemicals. Soluble plant nutrients in fertilisers may feed plants in the short term but they disrupt the mutually beneficial relationship between plants and the rest of the soil food web. Since chemically grown plants don't need bacteria and fungi to harvest minerals for them, they stop producing root exudates, leaving these microbe populations unsupported. With the soil food web disrupted, these plants become dependent on fertiliser applications for their survival. Plants produced with synthetic fertilisers are often much less nutrient dense than organically grown plants. Nitrogen, Phosphorus and Potassium, the 3 main fertilisers used in industrial agriculture may produce large vegetables, but they will be deficient in the myriad of other minerals that would have been present, had they been produced through natural processes in a living soil!

Pesticides kill soil organisms, killing the bad guys and their natural predators. Like with fertilisers, the disruption of the soil food web, leaves plants dependent on continued applications of pesticides to keep crops alive, destroying ecosystems, and harming human health.

GREEN MANURES & COVER CROPS

Green manures are plants grown for the beneficial effect they have on soil. Cover crops are similar to green manures, but they serve an additional important function of covering the soil over winter to prevent soil erosion, nutrient leaching and compaction from heavy rains and to provide habitat for a diversity of wildlife over winter. Here are some options to suit your soils needs:

Compacted soils: fodder radish, phacelia, chicory

Undersowing: For sowing beneath taller plants to suppress weeds and feed the soil: yellow trefoil, red clover and crimson clover

Sowing on paths: Persian, Egyptian and crimson clover are good for suppressing weeds and fixing nitrogen between vegetable beds

For late autumn sowing to cover the soil over winter: vetch, rye, field beans, fodder radish, Austrian winter peas

For quick growing green manures in spring and summer: phacelia and buckwheat are a good choice.

Think about how you will kill your green manure when you want to use the space again for crops. You can mow, crimp, dig in your cover crops or cover them with black plastic for a period to kill them. Or if growing over winter, choose a type that will perish in cold temperatures or winter frosts.

Cover crops at East Neuk Market Garden, Image credit: King, 2024

MAKING GREAT COMPOST!

Compost is a great soil amendment, that if made correctly improves soil structure, nutrient availability and microbial diversity of your soil. You can add compost to pots, add it as a mulch layer to the top of garden beds, or mix it with water to make compost extracts which can be sprayed on plants or used as a soil drench.

Compost ingredients

Carbon rich materials (browns) are mature plant materials eg. hay, straw, dead leaves, woodchip from young branches, shredded paper and cardboard & sunflower stems. Woodchip from mature trees can be used, but it will have a very high carbon content and take much longer to decompose. Soaking it in water before adding to the pile will aid decomposition.

Nitrogen rich materials (greens) are immature leafy materials taken from plants that were actively growing, eg. weeds, grass clippings, animal manure, veg scraps, coffee grounds

To make great compost, your pile should be made up of 3 parts carbon to 1 part nitrogen rich materials

But why? Microbes that digest organic matter need carbon for energy (just like us!) while they use nitrogen to build proteins which form their bodies, support their reproduction and form the enzymes that they use to decay organic material. Microbes require approximately 25 times more elemental carbon than nitrogen for these processes.

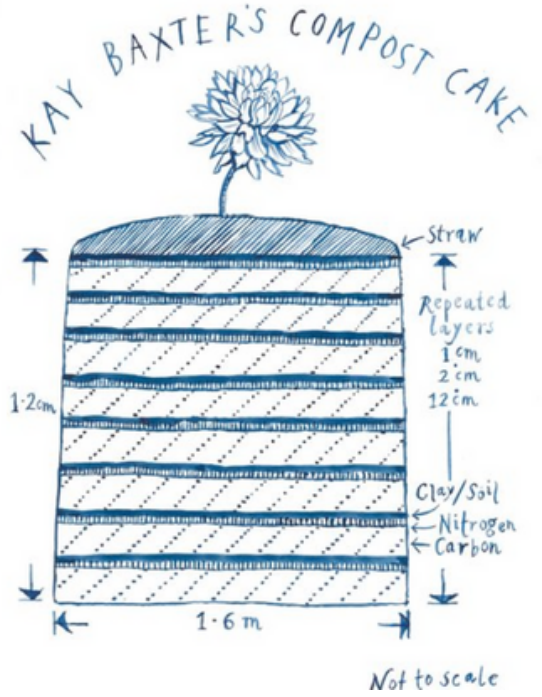
With too much nitrogen rich materials in a pile, much of the nitrogen will be lost to the atmosphere as ammonia gas, which is harmful to worms and can form nitrous oxides, powerful greenhouse gases. A pile will also become soggy and smelly creating the perfect environment for harmful anaerobic bacteria. A pile too rich in carbon limits decomposition since there is not enough relative nitrogen for microbes to grow, reproduce and digest organic material.

When creating a compost pile, layer up nitrogen and carbon rich materials like a lasagne, or thoroughly mix them all together before piling them up. These methods ensure you get a good mixture of materials throughout the pile.

Microbes need a **moist environment** to survive and thrive! Your compost pile should be moist but not wet, so that a drop or two of water can be squeezed from the material in your hands. If too wet, mix in some wood chips or leaves. In our rainy climate it is best to shelter your pile with a plastic sheet cover, or a roof. If too dry, water the pile with non chlorinated water (chlorine kills microbes!), like rain water, or tap water that has been left to sit in daylight for 24 hours. You can also mix in some nitrogen rich materials with a high moisture content.

Hot composting is a form of aerobic composting made by collecting enough carbon and nitrogen rich materials over a 2 week period to make a pile at least one cubic metre in size. The size of the pile and the freshness of the materials helps it to heat up. The pile must reach 58 degrees C to kill pathogens and weed seeds. Regular turning over the first 2 weeks will help to maintain high temperatures, but turning and watering also helps to stabilise temperatures if they exceed 65 degrees C, the upper limit at which beneficial microbes can survive. After about 2 weeks temperatures will begin a steady decline and you can stop turning the pile. After ambient temperatures are reached at about 12 weeks, you can use the compost.

The **Compost Cake** developed by Kate Baxter produces well humified nutrient and microbe rich compost in 6 months without turning. Simply layer up your pile in a 'cake' which is held together by placing bamboo or hazel stakes in a circle of 1.6m diameter.



Compost Cake Diagram, Image credit: Soil To Table, Elworthy & Courtauld, 2024

Cold composting is similar to hot composting, but you don't need to collect such a large volume of materials. Instead you just build the pile over time, as and when your materials become available. It will not heat up, meaning that weed seeds, and pathogens may not be killed. However many people prefer this method as it is much less labour intensive and can contain a more diverse mix of microbes as it never gets too hot. Turning is not necessary in this method.

Worm composting is a type of cold composting using composting worms E.fetida (red wigglers), that you can purchase online. It is great for dealing with food waste and can produce compost known as vermicast in 3 months. Be sure to mix enough carbon rich material in there or it will become soggy and anaerobic. Do not use the brown liquid that drains from a worm bin, this is a sign of too much moisture in your bin, and can contain diseases, harmful bacteria and nitrates.

Bokashi is great for decomposing food scraps, and is ideal for small households. It can take as little as 6 weeks to produce a finished product. Bokashi is a way of fermenting your waste rather than composting it. Unlike with aerobic composting, the fermentation takes place in the absence of oxygen and you can use it to break down meat, dairy and cooked food. It requires the addition of an inoculated bran, or solution of microorganisms (known as Effective microorganisms or EM). You can buy these or culture the microbes yourself! Once you have fermented your waste, add it to your compost pile or bury it in your garden where it will decompose aerobically in a matter of weeks.