1

Introduction

What is the secret to great flowers and more vegetables?

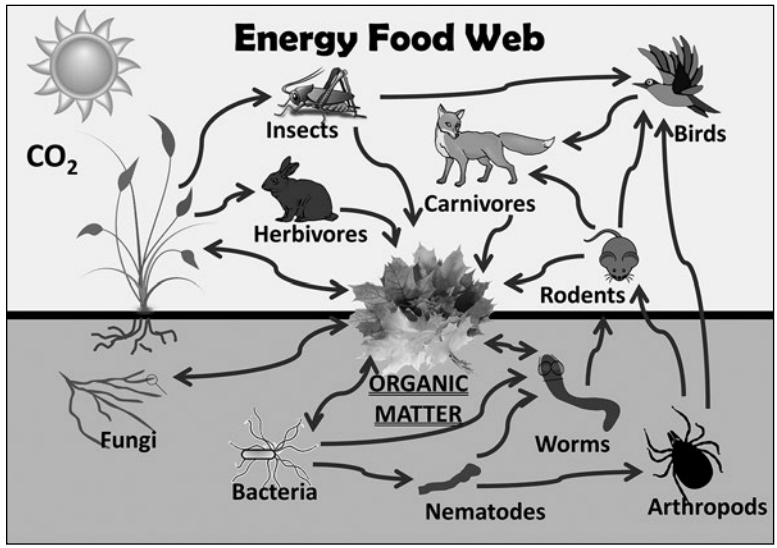
You can buy great starter plants or high-quality seeds, plant them in the right amount of sun or shade, and water correctly, but all of that has a limited effect on plant growth. The secret to great plants is the soil. Get the soil right and you can grow anything that is hardy in your location.

The obvious next question is, how do you get great soil? The answer to that question is a bit more complicated, but a key ingredient is organic matter. Adding organic matter to soil increases microbial activity, releases plant nutrients, and improves soil structure.

That nice crumbly black gold that gardeners talk about is the result of higher levels of organic matter in the soil.

Nature adds organic matter to soil all the time. Fall leaves blanket the ground, and by the following summer they have been magically incorporated into soil. Animals run through the area adding some fresh manure, and many insects die due to short life spans, adding even more organic matter. The grasses in fields set down deep roots which are constantly dying off and regenerating, all the while adding organic matter.

We see all of these processes taking place, but few of us think about the way in which organic matter is cycled around. It starts as CO_2 in the air, which is absorbed by plants and combined with sunlight to form sugars and other carbohydrates. These high carbon compounds form the basis of all organic matter.



The Energy Food Web moves carbon from the air into the soil.

When plant material falls to the ground, it becomes a carbon food source for microbes. They soon convert that plant into invisible organic matter, all the while moving it deeper into the soil.

If the plant is eaten by animals, insects, or worms, it is converted into fecal matter which is nothing more than partially digested organic matter. Some of the carbon in the food is digested and absorbed by the animal. All non-plant organisms, including microbes, animals, insects, birds, and even humans, are essentially digested organic matter that originated from plants. In the end, they are returned to the soil.

All of the processes that I have just described also happen in your garden, and you can improve on them or inhibit them. It's your choice.

Some gardeners get in the way of these natural processes. They keep their soil in pristine condition, not allowing any old vegetation from being incorporated into soil naturally. They spray for pests and reduce the number of insects that live and die in the garden. They

grow vegetables, harvest the produce, and take all of the old plant material to the curb for disposal. Fall leaves are raked and given to the city.

This makes for a very neat garden, but over time the soil has less and less organic matter, making it unhealthy.

It does not have to be that way, and many gardeners take a different approach. They do the opposite. Plant matter is left where it falls. Most insects are treasured and encouraged to use the property. Some gardeners even go so far as to collect bags of leaves from neighbors and bring them back to their garden. A big part of their gardening focus is to add more organic matter than they had when they started.

There is also a third group, the impatient gardeners. They don't want to wait for nature to incorporate yard waste and kitchen scraps into soil. They want to speed up this process. Composting is the way to do that.

Composting is nothing more than helping nature speed up the decomposition process. It takes fallen leaves, dead insects, kitchen scraps, and manure and accelerates the process of turning that material into nutrients for microbes and plants.

All of the composting methods described in this book make use of natural processes, but gardeners manipulate them so they are more efficient. The end product is essentially the same as the organic matter produced by nature.

What Is Compost?

Merriam-Webster defines compost as a mixture that consists largely of decayed organic matter and is used for fertilizing and conditioning land. This definition is not correct since the organic matter is not fully decayed.

Wikipedia defines compost as a mixture of ingredients used to fertilize and improve soil. Compost is used to fertilize, and it does improve soil, but so do other things, like manure and wood chips, but neither of these are compost.

I define compost as partially decayed organic matter that feeds plants, feeds the soil biology, and improves soil.

Why Should Everyone Compost

If all residents composted, the annual volume of waste pickup would be dramatically reduced. The EPA said, "Food scraps and yard waste together currently make up more than 30 percent of what we throw away, and these materials could be composted instead."

Sending this organic material to landfill sites not only fills them up faster, it ends up producing a potent greenhouse gas called methane which is 25 times worse than CO_2 for global warming. Not to mention all the pollution caused by trucks running all over town collecting material.

Gardeners who compost need to buy fewer fertilizers, which is a benefit to the environment *and* their pocket book. Even non-gardeners who only have a lawn would save the expense of fertilizer.

Composting can be quite simple, and in the ideal world everyone would be required to compost or at least give their organic material to a neighbor to compost. Municipalities should not have to deal with this material.

Myths About Composting

There are a number of composting myths that might keep you from trying it. Let's dispel them right now.

Myth #1: It's too difficult.
Fact: It is as simple or complex as you want to make it. Follow my cut and drop method and it is actually easier than what you are doing right now. At the other extreme, you can become very serious and make perfect hot compost. You decide on how much effort you want to put into the process.

Myth #2: Compost piles smell.
Fact: They only smell if you do something wrong. When composting is done right, it has a very pleasant odor and smells like a walk in

the woods after a rain or, in the case of bokashi, it smells a bit like pickles.

Myth #3: It costs a lot of money.
Fact: You can spend money on it, but you can also compost for free. I made compost bins using some free skids and a bit of wire.

Myth #4: Composting attracts rodents.
Fact: Animals do live in the garden so you might have some rodents, but if you keep meat and dairy products out of the compost, rodents are rarely a problem. Bears might be a bigger problem if you compost outside.

Myth #5: It takes a lot of space.
Fact: It does take some space depending on the system you use. My cut and drop method takes no space at all. Vermicomposting can be done indoors. Some systems use very little space.

Myth #6: You need an outdoor garden.
Fact: I'll present several composting methods that work indoors.

Definitions

I like to start with definitions because they frame the discussion and ensure that we are all on the same page. In the UK and probably in other parts of the world, the word "compost" is used to describe potting soil. This is not what we are talking about here. In this book, the word "compost" refers to the end product of a composting process, which consists of taking plant material and other compostable material, piling it up, and letting it decompose into a black friable material.

Aerobic vs Anaerobic

Composting can take place in two different conditions: aerobic and anaerobic. An aerobic environment is one where oxygen is plentiful. These systems are usually open to air which is what provides the oxygen.

Anaerobic conditions are ones where there is very little oxygen. These can be created in one of two ways. Some systems are filled with water which pushes the air out and therefore keeps the oxygen levels low. Another way to create such a condition is to use a closed vessel. Decomposition uses up O_2 and produces CO_2. In a closed vessel, this results in air that has higher levels of CO_2 and very little oxygen, creating an anaerobic condition.

Why is this important? Bacteria tend to live in one or other of these conditions. Some are aerobic and some are anaerobic, but just to keep things interesting, some can live in both conditions and are called facultative anaerobes.

By controlling the amount of available oxygen, gardeners can control the type of bacteria working in the compost, and that in turn controls the type of decomposition that takes place.

What Is Organic?

Organic is a word that is used, far too frequently, to mean several different things, so it's not always clear what it means. This leads to all kinds of misunderstandings.

The term "organic" has become synonymous with the word "natural," which leads to the misconception that anything organic is good for us, our garden, and the planet. The term is used extensively to describe products, in the hope that people will buy them. In the same vein, "organic" has also come to represent non-synthetic chemicals. The reality is that many natural organic chemicals are more toxic than synthetic ones. Most drugs are synthetic and, for the most part, are safe and beneficial. Some natural organic chemicals, such as ricin, which is found in the caster bean, is one of the most toxic compounds on Earth. Organic does not mean safe.

Organic is also used to refer to agricultural produce that is grown "organically." This does not mean they are produced without pesticides or chemicals. It just means that when chemicals are used, they fall under a strict set of guidelines developed by certified organic organizations. If you follow their rules, you are organic, even

if some of the approved chemicals are synthetic or toxic. The rules become paramount and safety is secondary.

To a chemist the word "organic" means something completely different. An organic chemical is any chemical that contains carbon and is not a salt. All sugars, carbohydrates, proteins, and most pesticides contain carbon and are organic, even if they are man-made.

This book will use the chemist's definition of organic and the term "certified organic" to refer to organic agriculture.

I'll use the term "organic matter" in a very general sense to refer to any dead flora, fauna, or microbe. This could be recent dead material such as wood chips and manure, or a highly decomposed form such as compost or humus. Composting starts with organic matter, and at the end of the process, you still have organic matter. Composting changes its characteristics, but finished compost is still organic matter.

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The Role of Compost in Soil

Compost is critical for developing soil structure and feeding plants. This chapter will help you understand it better and explore the impact it has on soil.

The word "compost" is used in a very general way in this book. It refers to plant and animal material that has undergone extensive decomposition so that the original material is no longer recognizable. It is normally dark in color, quite friable, and smells good and earthy.

Composting is the process of making compost. The more traditional way of doing this is to pile up the organic matter and let it rot. Over time the natural microbial biology converts the starting organic matter into compost.

As you will see in this book, there are many ways to make compost, and there are many types of starting material. But that does not mean there are many types of compost.

We don't look like plants, but on a molecular basis, and even at the cellular level, we are not that different. In fact 50% of our DNA is the same as a plant's DNA. That number is a bit misleading since a lot of that is not active, but the point is valid. Chemically, plants and animals have a lot of similarities.

When cells are decomposed, they produce proteins, carbohydrates, vitamins, hormones, and fats (oils). Further decomposition degrades these large molecules even more into simple compounds like amino acids, simple sugars, and nutrients. At this point in the

decomposition process, there is virtually no difference between you, me, or a banana.

The majority of all living organisms are made up of carbon, hydrogen, and oxygen. When this composts fully, it forms humus.

The reason all compost is basically the same is that once all of this decomposition has taken place, we are left with the simple molecular building blocks that are used in all forms of life. Compost can have more or less water in it, it can have higher or lower nutrient levels, but the similarities are far greater than the differences.

Gardeners commonly ask which compost is best. They go to the store and see piles of composted cow manure and composted horse manure, so they naturally wonder which one is better? The answer is, they are the same. It's all compost.

The best compost is the one you can get in larger quantities and at a low price. This almost always means it is transported the shortest distance, which is good for your pocket book as well as the environment.

The very best compost is the one you make yourself. It is mostly free, reduces material going to landfill, and you know exactly how it was made.

Benefits of Composting

Compost has many benefits for the gardener. This section is an overview of these benefits, which are discussed in more detail throughout the book.

Compost as a Mulch

Used as mulch, compost provides most of the benefits of other types of mulches. It keeps the soil cool, which plant roots love, and it reduces evaporation, which keeps the soil moisture more constant and reduces watering frequency.

It may or may not help with weeds. It will keep seeds at the soil surface dark, preventing them from germinating. Unfortunately, any new seeds that land on top of the compost will find a perfect place to grow. Some compost can also contain viable seeds, in which case they will easily germinate in the mulch.

Compost as a Fertilizer

Compost contains a good supply of plant nutrients including all of the micronutrients. It also releases these nutrients over time, acting like a slow-release fertilizer. It is perfect in areas where you want a low but steady long-term feed, like most ornamental beds.

Cation exchange capacity (CEC) is a measure of the soil's ability to hold nutrients. A higher CEC means that the soil can hold more, which is good for soil fertility. Soil with a low CEC holds fewer nutrients and results in poor plant growth.

Compost has a high CEC which means nutrients stick to it and are more slowly leached away. This is especially important for sandy soil that is unable to hold on to nutrients.

Compost as a Soil Builder

Compost is the best option for improving soil. If you have ever gone into the woods and felt the black crumbly soil you find there, you'll know what good soil is—what we gardeners call black gold. That soil is the result of natural compost being added over hundreds or even thousands of years.

Compost helps build aggregation and improves the structure of both sandy soil and clay soil. Nothing improves soil better than compost.

Compost Retains Water

Compost holds a lot of water, keeping it near the soil surface where plant roots can get to it. It helps maintain an even moisture level thereby reducing watering needs.

A 5% increase in organic material quadruples the soil's ability to hold water. Compost holds water equal to 200% of its own dry weight.

Compost Removes Toxins

It's like a sponge for heavy metals like lead and cadmium. Compost grabs hold of them as they float by in the soil solution and holds on to them so that plants are exposed to lower levels.

Compost can also hold onto other toxins, like pesticides.

Compost Buffers pH

Both acidic and alkaline soils are neutralized, bringing the pH level closer to the optimum range for plants (6 to 7).

Compost Increases Microbes in Soil

The secret to healthy soil are the microbes. More microbes translate into better soil, which results in better plants. Compost not only provides food for microbes but it also gives them a place to hide.

Compost Helps the Environment

Composting uses organic waste material that would normally end up in landfill. This reduces the amount of material going to landfill while at the same time reducing greenhouse gases like methane.

The Microorganism Myth

Microorganisms (microbes) are responsible for improving the structure of soil. They also decompose organic matter to release nutrients that plants can use. They are critical for the health of soil and plants.

One way of determining soil health is to measure the number of microbes. The more microbes in soil, the healthier the soil.

Knowing this fact, people automatically assume that adding more microbes to soil will improve it, and most information online or in books supports this idea. Manufacturers even sell bottled microbes to make it easy to "improve soil." The sad fact is that this is all a big myth.

Adding microbes to soil does not increase the number or diversity of microbes living in soil.

You might be sitting there shaking your head thinking that can't be true. If you add more, you obviously have more, which is actually true for a short while. However, in a matter of hours, the number of microbes will be back to the level you had before you added them.

Think of soil as being a football stadium. It has 50,000 seats and every seat is full. Another 5,000 sport fans arrive looking for seats, but they are all full, so the latecomers can't stay.

If you have crappy soil, your stadium may only hold 10,000 seats, but they are always full. Good soil has 80,000 seats, and they are always full too.

Microbes multiply very quickly, with some species doubling in number every 20 minutes. The number of microbes in soil at any given time depends on moisture, temperature, air, and available food. Of these, food is the most important parameter controlling populations. If available food increases, the population explodes. As food levels drop, microbes die off.

The key point is that at any given point in time, the population is at a maximum level for the current food, air, temperature, and moisture levels. The available seats are always full.

Improving any of the four parameters will result in a higher number of microbes, but just adding more microbes will have no effect.

What happens when compost is added to soil? It contains microbes and microbe food, the organic matter. Just like soil, the compost also has all of its seats filled with microbes. Adding this to soil does increase the total number of microbes but only to the extent that the organic matter can support them.

What Is Soil Health?

The term is used a lot but what does it really mean? Depending on your interest, it can mean different things. A climate scientist might define "healthy soil" as one where the amount of sequestered carbon is increasing. A farmer might define it as soil that produces a good yield. A microbiologist may be measuring microbe population and diversity.

Gardeners look at plant health. If a plant is growing well, flowering a lot, and has no diseases, the soil must be healthy or at least healthy enough to grow good plants. Some plants grow well in nutritious soil, while others grow much better in sandy, lean soil. The definition of soil health depends very much on the type of plant you are growing.

I am not going to provide a specific definition, but for the purpose of this book, healthy soil is one that grows a wide range of

plants, has good aggregation, has a good amount of organic matter, and supports a high number of microbes. Admittedly, that is a squishy definition, but it is good enough for our purpose.

Aggregation is a measure of how well the base ingredients of soil—sand, silt, clay, and organic matter—are clumped together to form larger soil particles. You can see and feel good aggregation by handling soil from an undisturbed forest or meadow. It's easy to dig, consists of larger crumbly pieces of soil that allow a lot of air to get in, and the spaces between the particles are large enough for root growth.

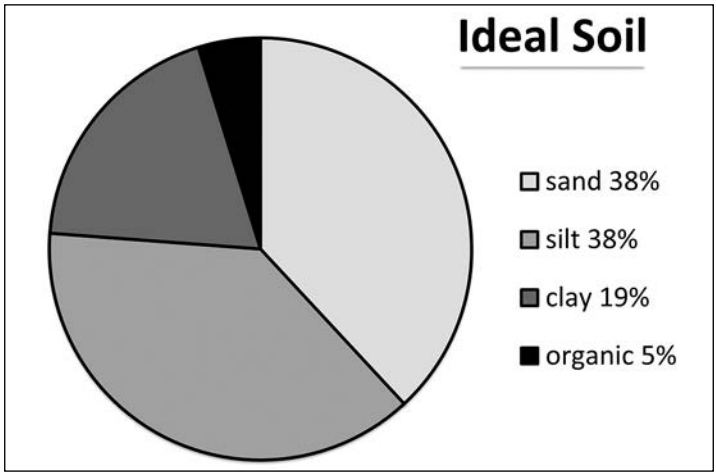
What Is Soil?

As you can see from the above list of benefits, compost plays a huge role in soil development. In order to understand this in more detail, it is important to have a better understanding of soil. This section will introduce a number of soil topics, but due to limited space, it can't cover all of the things gardeners should know. If you want to know more about soil, have a look at my other book, *Soil Science for Gardeners*.

Soil consists of mineral components and organic matter. The mineral components include sand, silt, and clay. You can think of sand as being small stones and silt as extremely small stones. Sand is much larger than silt, but both particles have the same physical and chemical properties. Neither one holds water or nutrients very well.

Clay is made up of very small particles, much smaller than silt. These particles have electrical charges on them that hold onto nutrients. The spaces between particles are also very small, and they easily fill with water. That water is very slow to drain away. That is why clay soil tends to stay wet while sandy soil dries quickly.

Most gardeners know that organic matter is important to soil, but they are surprised to learn that good soil only contains about 5% organic matter. In fact, most soil at newer homes, and agricultural soils, have much less than this. The value is even lower in sandy soil, which is usually closer to 1%.



Components of ideal soil.

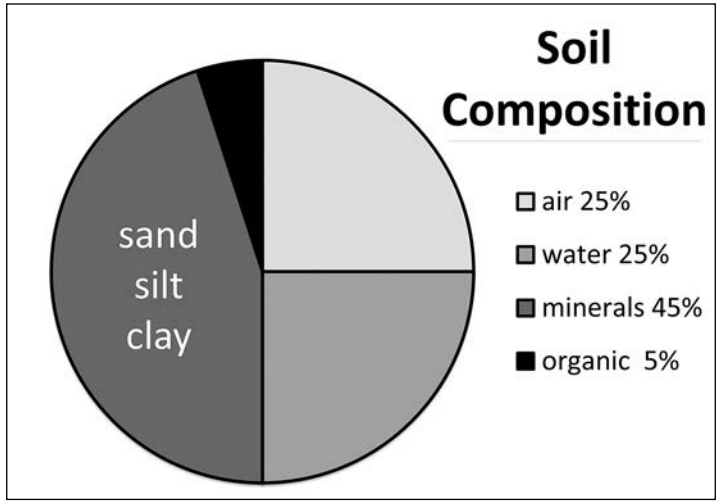
The diagram above shows the amount of sand, silt, clay, and organic matter in ideal soil. It is important that you realize nobody has ideal soil, and it is not your job to create ideal soil. You are stuck with the sand, silt, and clay in your garden, and you have to make the best of it. You can, however, increase your organic matter, and this book shows you how to do that. Even a change of less than 1% can make a big impact on the health of your soil.

Air and Water

Air and water are critical for proper plant growth, and they make up about 50% of soil. The actual amount depends on several factors such as soil texture, the amount of organic material, and the degree of compaction, but ideal soil contains about 25% air and 25% water.

Immediately after a heavy rain, much of the air has been forced out and replaced with water. Gravity, evaporation, and plants will then reduce the level of water, which is replaced with air. Perfectly dry soil will have no water and 50% air. Such dry soil is rare and is mostly found in laboratories. Soil normally holds some water even if plants are no longer able to get any of it.

Evaporation is the process where liquid water turns into water vapor and escapes into the air. This happens mostly at the surface of



Soil composition.

the soil, and that is why the top layer of soil can be quite dry while, a few inches down, the soil is still quite wet.

As evaporation takes place, more water will be drawn to the surface by capillary action. Over time this process slowly dries out the soil. Mulch slows down evaporation, keeping the soil moist for a longer period of time.

Gravity is also at work, and it pulls water deeper into the soil. Eventually water is pulled down far enough to enter reservoirs deep in the ground, or depending on topography, it might flow into a river or lake.

Plant roots are constantly absorbing water and transferring it to their leaves, where much of it evaporates through leaf openings called stomata. Water is also used in chemical processes like photosynthesis. Removal of water by plants can be significant. A large tree can remove up to 100 gallons (400 liters) of water a day, and discharge it into the air as water vapor.

Organic matter plays a critical role in this water-air cycle by slowing down both evaporation and water loss due to gravity. It does this by holding on to the water molecules more tightly than soil, thereby slowing its movement both up and down.

Organic matter is full of tiny pores that hold lots of air and

water. When it is added to clay soil, it increases the amount of air in the soil allowing it to dry faster. In sandy soil it holds water longer, keeping the soil from drying out.

Compost is a perfect form of organic matter, and even small amounts can improve the water-air cycle to benefit plants and microbes.

Aggregation and Soil Structure

So far we have looked at soil on a microscopic level, but soil is much more than that. If you pick up some good soil, you will notice that it does not look like a bunch of sand, silt, and clay. What you see is larger crumbly pieces which are dark in color. The space between particles is quite large. The soil is fluffy with lots of air pockets of all different sizes.

What you are looking at is the macro structure of good soil. The smaller pieces of sand, silt, and clay have been mixed with organic matter to form larger structures called aggregates. My woodland soil has aggregated particles of one-quarter inch (six millimetres) in size and many can be a full inch in diameter.

Aggregation is not well understood by gardeners, but it is a very critical part of soil health. When soil has it, you have good soil that will grow lots of plants. When aggregation is lacking, the soil performs poorly. Creating good soil is all about improving aggregation.

The key to aggregation is a special binding agent that consists of many different kinds of chemicals produced by living organisms. Think of them as life juices. Plants, bacteria, fungi, earthworms, and small insects all excrete juices, and some of these chemicals work great as a glue. Fungi and actinomycetes make even larger aggregates by using their mycelium to knit smaller particles together.

Organic matter is the food for all of these organisms. A higher level of organic matter in soil translates into a higher microbe population which results in more glue and better aggregation.

Why are aggregates so important? Clay and silt are very small particles, and the spaces between them are too small for roots to penetrate. As soil aggregates into larger particles, the spaces between particles gets larger, which makes it easier for plant roots to

grow. The small pores inside each aggregate are also perfect for bacteria to hide from larger organisms that want to eat them.

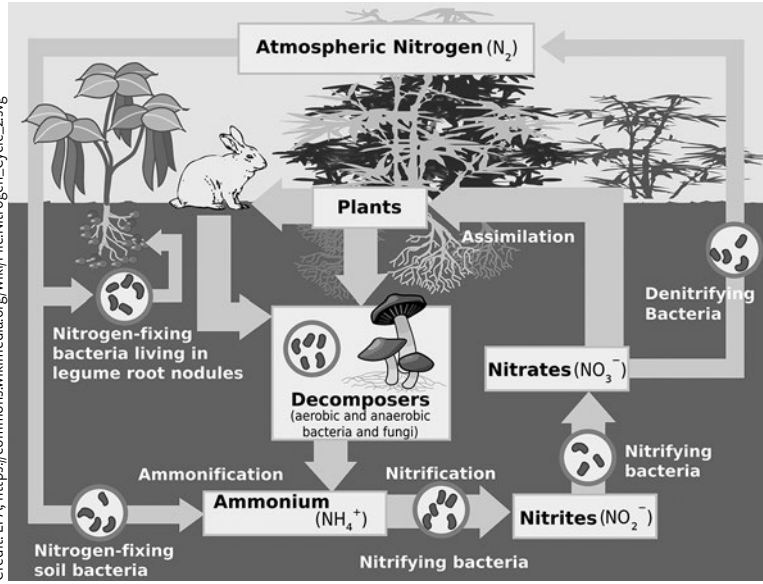
Aggregation is a continuous process that is either improving or getting worse. The natural binding agents slowly decompose and need to be continually replaced by microbe activity. An annual addition of compost ensures that aggregation is always improving.

Plant Nutrients

Gardening is all about growing plants, and as plants grow, they absorb nutrients from air and soil to form larger molecules and cellular structures. Composting is the opposite. Composting takes the complete plant, or animal, and decomposes them back to basic nutrients. This is called the nutrient cycle.

Plant nutrients can be broken down into two main categories: mineral nutrients (originating from minerals) and non-mineral nutrients.

The non-mineral nutrients make up 96% of a plant and consist of oxygen, hydrogen, and carbon. The plant absorbs CO_2 from



Credit: EPA, https://commons.wikimedia.org/wiki/File:Nitrogen_Cycle_2.svg

Nutrient cycle for nitrogen.

the air which provides most of the carbon and some of the oxygen. They also absorb water and oxygen through the roots. The water is transported to leaves where it is broken down into oxygen and hydrogen. A properly watered plant has no problem getting all of the non-minerals it needs.

The mineral nutrients only account for 4% of a plant's weight and include things like nitrogen, phosphorus, and potassium. Although they make up a small part of a plant, the mineral nutrients are vital to its growth.

Both soil particles and organic matter contain mineral nutrients, but plants can't use them until they are released in a plant-available form called ions. Once in the form of ions, they dissolve in the soil solution (the water in the soil) and are available to plants.

Ions

You probably recognize the names of many micronutrients such as iron, zinc, potassium, calcium, and magnesium, but what you may not know is that these are all metals. For example, pure calcium is a dull silvery-gray color and looks a lot like iron.

We talk about plants using iron, calcium, and magnesium, but the truth is that plants can't use any of these. Putting an iron nail in soil does nothing to feed plants, so it can't solve nutrient deficiencies, although that myth is common in social media. Plants are only able to use these metals once they are converted into ions.

When calcium is exposed to air, it reacts with the oxygen to form a type of rust. This chemical reaction produces a white powder called calcium oxide which contains one molecule of calcium and one molecule of oxygen (CaO). When calcium oxide dissolves in water, something special happens. The calcium and oxygen separate into electrically charged particles called ions. The calcium ion has a positive charge (a cation), and the oxygen ion has a negative charge (an anion).

Once the calcium is in the form of an ion, plants are able to absorb it through the roots and use it inside the plant. We talk about plants using calcium, but what they really use are calcium ions. This

Ionic Forms of Plant Nutrients

Nutrient name	Chemical symbol	Ion form	Ion name
Carbon	C	none	
Hydrogen	H	H^+	
Oxygen	O	O^{-2}	
Nitrogen	N	NO_3^-, NH_4^+	Nitrate, ammonium
Phosphorus	P	HPO_4^{-2}, $H_2PO_4^-$	Phosphate
Potassium	K	K^+	
Calcium	Ca	Ca^{+2}	
Magnesium	Mg	Mg^{+2}	
Sulfur	S	SO_4^{-2}	Sulfate

may seem like unimportant semantics, but it is critical for understanding how nutrients behave in soil, and how they become available to plants.

All of the mineral nutrients used by plants form some type of ion. Some are a bit more complex than the above calcium example, but the principles are exactly the same. This table shows a list of the macronutrients and their ion forms.

In the early stages of composting, you find big pieces of organic matter, a whole leaf or an apple core. These all contain nutrients, but they are tied up in the form of large molecules and complete cells. None of these nutrients are available to plants.

As decomposition takes place, cells and large molecules are broken down into smaller and smaller pieces until ions are released. *It is only then that plants can use these nutrients*.

What Is Salt?

The general public uses the term "salt" to mean table salt, which is sodium chloride. Chemists, soil scientists, and this book use the term to refer to any compound that is made up of ions.

Compost Myth: Salt Kills Soil Microbes

Many believe that the salts in synthetic fertilizer harm soil life, but that is not true. The salts in fertilizer dissolve in water, forming ions. These ions are exactly the same as the ions released from organic material like manure or compost. They are essential for the growth of microbes and plants.

Any chemical, no matter how useful, can become toxic at high levels. Even too much water will kill you. Provided fertilizers (i.e., salts) are used in appropriate amounts, they do not harm soil life.

Sodium chloride is one of many different types of salt. In water, it breaks up into sodium ions (Na^+) and chloride ions (Cl^-).

The calcium oxide discussed above is also a salt. Compounds such as ammonium nitrate and potassium phosphate, found in synthetic fertilizer, are also salts. Urea fertilizer is an organic molecule made up of carbon, hydrogen, oxygen, and nitrogen, and since it does not form ions in water, it is not a salt.

Table salt or road salt releases sodium ions in water. All life, including plants, need some sodium, but as the amount of sodium in soil increases, it can quickly become toxic to plants and microbes. It is best to keep sodium out of the garden.

Movement of Nutrients in Soil

Sand and silt particles have almost no electrical charge on their surface so ions don't stick to them very well. When nutrient ions come in contact with these particles, they just keep moving along with the water. This is the reason why rain easily washes nutrient ions out of sand and silt into the subsoil layers, and explains why such soils have low natural fertility.

Clay and organic matter have charges on them that act like little magnets. These magnets attract both anions and cations and hold them tightly, preventing water from washing them away.

Compost Myth: Organic Nutrients Are Better

This is a very common myth that is promoted by the organic movement. They believe that nutrients from organic sources are much better for plants than nutrients from synthetic fertilizer. This concept is completely wrong.

Synthetic fertilizer usually consists of simple salt compounds. Good examples are ammonium nitrate, calcium carbonate, and potassium phosphate. When these compounds dissolve in water, they separate into ions, namely ammonium, nitrate, calcium, carbonate, potassium, and phosphate. Plant roots can absorb all of these.

When an organic source, like manure or compost, is added to soil, it slowly decomposes into the same ions found in synthetic fertilizer. The nitrate ion from an organic source is exactly the same as a nitrate ion from a synthetic fertilizer. Neither labs, nor plants, nor microbes can tell the difference between the two sources, once the ion has been released into water.

Once you understand this, it becomes clear that both sources result in exactly the same nutrients. Nutrient ions can originate from an organic source, but they can't be any more organic than the ones from fertilizer. They are all inorganic.

When rain flows through clay soil or soil that contains a lot of organic matter, it does dislodge some nutrients and moves them deeper in the soil, but the effect is minor. Most nutrients remain stuck in place. The net effect is that nutrients move much more slowly in these soils than in sandy soil.

Soil that contains more organic matter holds mineral nutrients better, making these soils more nutritious.

Tilling

The organic level in soil is constantly changing. Adding compost to soil will increase the level and, as you have seen, that has a positive effect on soil health. Gardeners can also do things to decrease the organic level, and one of the most controversial is tilling.

Tilling has historically been a standard practice. Each spring the vegetable garden is tilled to remove weeds and get the soil nice and fluffy, ready for planting seeds. Unfortunately this practice has some downsides. It destroys aggregation, which in turn makes surface crusting worse. It also brings weed seed from deeper in the soil up to the surface, creating more weed problems.

For a number of years, it was also believed that tilling reduces the level of organic matter in soil. Tilling adds more air to soil. With access to more air, microbe numbers start to grow and they break down the organic matter faster, and this has been confirmed through testing. However, more recently scientists have looked at deeper soil profiles and found the story is more complex.

Tilling does reduce the organic matter in the top 6 inches (15 cm) of soil, but it increases the level below the 6-inch mark. The total amount of organic matter in the top foot (30 cm) of soil is not changed with tilling. It could be that tilling moves more organic matter to lower levels, or it might be due to plants being able to grow deeper roots in tilled soil.

The addition of air to soil during tilling is also not as significant as first thought. Air is added for a short period after the tilling event, but over a period of months or years, this effect is insignificant compared to other processes.

Tilling is not as bad as originally thought, or as claimed by some fringe groups, but it is a practice that most gardeners can stop. Use mulch to keep weeds down, and make smaller beds so you don't have to walk on the planting surface. Combining these two techniques eliminates the need for tilling in established beds.

Mulching

Mulch is any material that covers the ground between plants. It will retain moisture, suppress weeds, keep the soil cool, and some feel it makes the garden look better. It can be either organic or inorganic, but organic material has the added bonus of improving the soil as it decomposes. The advantage of inorganic material is that it does not need to be replaced.

Effect of Fertilizer and Mulch on Soil Properties

	Fertilizer	Compost	Wood chips
Density	Lower +	Lower ++	Lower ++
Moisture	Same	Up +	Up ++
Organic matter	Same	Up ++	Up +
Respiration	Up +	Up ++	Up ++
pH	Same	Up ++	Up +
Nitrogen	Same	Up ++	Up +
Phosphorus	Up +	Up +++	Up +
Potassium	Same	Up +++	Up ++

Credit: GardenMyths.com based on data by Bryant C. Scharenbroch and Gary W. Watson

Compost Myth: There Is No Such Thing as Too Much Compost

Compost is organic and slowly provides nutrients to the garden. Since it is good for the garden, many people feel that more is better, but that is not true.

The problem lies with the nutrient ratios in compost compared to the nutrients used by plants. Plants use nitrogen, phosphorus, and potassium (NPK) in a ratio of about 3-1-2. They use three times as much nitrogen as phosphorus. Compost generally has an NPK ratio of 1-1-1, namely, equal amounts of each nutrient.

If you supply a plant with the correct amount of phosphorus using only compost, it will be lacking in nitrogen. If you use more so that the plant has enough nitrogen, you will be supplying way too much phosphorus, and this is what people tend to do. After a few years, their soil becomes toxic due to a high level of phosphorus.

Small amounts of compost (one inch a year) are good for the garden and will avoid toxic phosphorus levels.

As organic mulch decomposes, it has a significant effect on the soil. A five-year study[1] compared fertilizer, compost, and wood chip mulch, by measuring density (i.e., compaction), moisture, organic matter, respiration (microbe activity), pH, nitrogen, phosphorus, and potassium. It found that wood chip mulch increased the organic matter in soil, decreased compaction, increased microbial activity, and increased nutrient levels. These changes lead to better aggregation and better plant growth.

Mulch also reduces crusting, increases rain infiltration, and reduces runoff. Raindrops can no longer hit the surface of the soil, eliminating the crusting problem. The mulch also disperses raindrops, allowing it to more slowly percolate down to the surface of the soil, where it is easily absorbed.

Compost is very good mulch, one that provides a lot of nutrients and is very effective at improving the quality of soil. It is generally applied as a thin layer of about one inch and, as such, is not great for reducing weed growth. However, it is better to apply compost as mulch than to dig it into the soil.