Humus – Compost – Mulch – Green Manure

Contents

Humus

In agriculture, humus is sometimes also used to describe mature compost, or natural compost extracted from a forest or other spontaneous source for use to amend soil. It is also used to describe a topsoil horizon that contains organic matter.

Humification

Transformation of organic matter into humus

The process of "humification" can occur naturally in soil, or in the production of compost. The importance of chemically stable humus is thought by some to be the fertility it provides to soils in both a physical and chemical sense, though some agricultural experts put a greater focus on other features of it, such as disease suppressiveness. Physically, it helps the soil retain moisture by increasing microporosity, and encourages the formation of good soil structure. Chemically, the incorporation of oxygen into large organic molecular assemblages generates many active, negatively charged sites that bind to positively charged ions (cations) of plant nutrients, making them more available by ion exchange. Biologically, it allows soil organisms (microbes and animals) to feed and reproduce. Humus is often described as the "life-force" of the soil. Yet, it is difficult to define humus in precise terms; it is a highly complex substance, the full nature of which is still not fully understood. Physically, humus can be differentiated from organic matter in that the latter is rough looking material, with coarse plant remains still visible, while once fully humified organic matter becomes more uniform in appearance (a dark, spongy, jelly-like substance) and amorphous in structure, and may remain such for millennia or more. That is, it has no determinate shape, structure or character. However, humified organic matter, when examined under the microscope without any chemical treatment, may reveal tiny but clearly identifiable plant, animal or microbial remains which have been mechanically, but not chemically degraded. This points to a fuzzy limit between humus and organic matter. In most recent literature, humus is clearly considered as an integral part of soil organic matter (SOM).

Plant remains (including those that passed through an animal gut and were excreted as faeces) contain organic compounds: sugars, starches, proteins, carbohydrates, lignins, waxes, resins and organic acids. The process of organic matter decay in the soil begins with the decomposition of sugars and starches from carbohydrates, which break down easily as detritivores initially invade the dead plant organs, while the remaining cellulose and lignin break down more slowly. Simple proteins, organic acids, starches and sugars break down rapidly, while crude proteins, fats, waxes and resins remain relatively unchanged for longer periods of time. Lignin, which is slowly transformed by white-rot fungi, is one of the main precursors of humus, together with by-products of microbial and anima activity. The humus, that is the end product of this manifold process, is thus a mixture of compounds and complex life chemicals of plant, animal, or microbial origin, which has many functions and benefits in the soil. Most humus in the soil is included in animal faeces of more or less dark color according to their content in organic matter. Earthworm humus (vermicompost) is considered by some to be the best organic manure there is.

Stability of humus

Compost that is readily capable of further decomposition is sometimes referred to as effective or active humus, though again scientists would say that if it is not stable, it is not humus at all. This kind of compost, rich in plant remains and fulvic acids, is an excellent source of plant nutrients, but of little value regarding long-term soil structure and tilth. Stable (or passive) humus consisting of humic acids and humins, on the other hand, are so highly insoluble (or so tightly bound to clay particles and hydroxides) that they cannot be penetrated by microbes and therefore are greatly resistant to further decomposition. Thus stable humus adds few readily available nutrients to the soil, but plays an essential part in providing its physical structure. Some very stable humus complexes have survived for thousands of years. The most stable humus is that formed from the slow oxidation of black carbon, after the incorporation of finely powdered charcoal into the topsoil. This process is at the origin of the formation of the fertile Amazonian Dark Earths or Terra preta de Indio.

Benefits of soil organic matter and humus

- The mineralization process that converts raw organic matter to the relatively stable substance that is humus feeds the soil population of microorganisms and other creatures, thus maintaining high and healthy levels of soil life.
- The rate at which raw organic matter is converted into humus promotes (when fast) or limits (when slow) the coexistence of plants, animals and microbes in terrestrial ecosystems.
- Effective and stable humus (see below) are further sources of nutrients to microbes, the former providing a readily available supply while the latter acts as a more long-term storage reservoir.
- Decomposition of dead plant material causes complex organic compounds to be slowly oxidized (lignin-like humus) or to break down into simpler forms (sugars and amino sugars, aliphatic and phenolic organic acids) which are further transformed into microbial biomass (microbial humus) or are reorganized (and still oxidized) in humic assemblages (fulvic and humic acids, humins) which bind to clay minerals and metal hydroxides. There has been a long debate about the ability of plants to uptake humic substances from their root systems and to metabolize them. There is now a consensus about humus as playing a hormonal role rather than a nutritional role in plant physiology.
- Humus is a colloidal substance, and increases the soil's cation exchange capacity, hence its ability to store nutrients by chelation as can clay particles; thus while these nutrient cations are accessible to plants, they are held in the soil safe from leaching away by rain or irrigation.

- Humus can hold the equivalent of 80–90% of its weight in moisture, and therefore increases the soil's capacity to withstand drought conditions.
- The biochemical structure of humus enables it to moderate—or buffer—excessive acid or alkaline soil conditions.
- During the humification process, microbes (bacteria and fungi) secrete sticky gums and mucilages; these contribute to the crumb structure of the soil by holding particles together, allowing greater aeration of the soil. Toxic substances such as heavy metals, as well as excess nutrients, can be chelated (that is, bound to the complex organic molecules of humus) and prevented from entering the wider ecosystem, thereby detoxifying it.
- The dark color of humus (usually black or dark brown) helps to warm up cold soils in the spring.

Compost

Compost is plant matter that has been decomposed and recycled as a fertilizer and soil amendment. Compost is a key ingredient in organic farming. At its most essential, the process of composting requires simply piling up waste outdoors and waiting a year or more. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. Worms and fungi further break up the material. Aerobic bacteria manage the chemical process by converting the inputs into heat, carbon dioxide and ammonium. The ammonium is further refined by bacteria into plant-nourishing nitrites and nitrates.

Compost can be rich in nutrients. It is used in gardens, landscaping, horticulture, and agriculture. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover (see compost uses).

History

Composting as a recognized practice dates to at least the early Roman era since Pliny the Elder (AD 23-79) who refers to compost in his writings. Traditionally, composting was to pile organic materials until the next planting season, at which time the materials would be ready for soil application. The main advantage of this method is that little working time or effort is required from the composter and it fits in naturally with agricultural practices in temperate climates. Disadvantages (from the modern perspective) are that space is used for a whole year, some nutrients might be leached due to exposure to rainfall, and disease producing organisms, some weed, weed seeds and insects may not be adequately controlled.

Composting was somewhat modernized beginning in the 1920s in Europe as a tool for organic farming. The first industrial station for the transformation of urban organic materials into compost was set up in Wels/Austria in the year 1921. The early personages most cited for propounding composting within farming are for the German-speaking world Rudolf Steiner, founder of a farming method called biodynamics, and Annie Francé-Harrar, who was appointed on behalf of the government in Mexico and supported the country 1950–1958 to set up a large humus organization in the fight against erosion and soil degradation. In the English-speaking world it was Sir Albert Howard who worked extensively in India on sustainable practices and Lady Eve Balfour who was a huge proponent of composting. Composting was imported to America by various followers of these early European movements in the form of persons such as J.I. Rodale (founder of Rodale Organic Gardening), E.E. Pfeiffer (who developed scientific practices in biodynamic farming), Paul Keene (founder of Walnut Acres in Pennsylvania), and Scott and Helen Nearing (who inspired the back-to-land movement of the 1960s). Coincidentally, some of these personages met briefly in India - all were quite influential in the U.S. from the 1960s into the 1980s.

There are many modern proponents of rapid composting which attempt to correct some of the perceived problems associated with traditional, slow composting. Many advocate that compost can be made in 2 to 3 weeks. Many such short processes involve a few changes to traditional methods, including smaller, more homogenized pieces in the compost, controlling carbon to nitrogen (CN) ratio at 30 to 1 or less, and monitoring the moisture level more carefully. However, none of these parameters differ significantly from early writings of Howard and Balfour, suggesting that in fact modern composting has not made significant advances over the traditional methods which take a few months to work. For this reason and others, many modern scientists who deal with carbon transformations are sceptical that there is a "super-charged" way to get nature to make compost rapidly.[citation needed] They also point to the fact that it is the structure of the natural molecules - such as carbohydrates, proteins, and cellulose - that really dictate the rate at which microbial-mediated transformations are possible.

Some cities such as San Francisco and Seattle require food and yard waste to be sorted for composting.

Ingredients

Composting organisms require four equally important things to work effectively:

- Carbon — for energy; the microbial oxidation of carbon produces the heat.
    - High carbon materials tend to be brown and dry.
- Nitrogen — to grow and reproduce more organisms to oxidize the carbon.
    - High nitrogen materials tend to be green (or colorful, such as fruits and vegetables) and wet.
- Oxygen — for oxidizing the carbon, the decomposition process.
- Water — in the right amounts to maintain activity without causing anaerobic conditions.

Materials in a compost pile.

Certain ratios of these materials will provide beneficial bacteria with the nutrients to work at a rate that will heat up the pile. In that process much water will be released as [evaporation|vapor] ("steam"), and the oxygen will be quickly depleted, explaining the need to actively manage the pile. The hotter the pile gets, the more often added air and water is necessary; the air/water balance is critical to maintaining high temperatures until the materials are broken down. At the same time, too much air or water also slows the process, as does too much carbon (or too little nitrogen).

The most efficient composting occurs with a carbon:nitrogen mix of about 30 to 1. Nearly all plant and animal materials have both carbon and nitrogen, but amounts vary widely, with characteristics noted above (dry/wet, brown/green). Fresh grass clippings have an average ratio of about 15 to 1 and dry autumn leaves about 50 to 1 depending on species. Mixing equal parts by volume approximates the ideal C:N range. Few individual situations will provide the ideal mix of materials at any point in time - in this respect, home composting is like horseshoes, perfect is great, but close still works. Observation of amounts, and consideration of different materials as a pile is built over time, can quickly achieve a workable technique for the individual situation.

Urine

People excrete far more of certain water-soluble plant nutrients (nitrogen, phosphorus, potassium) in urine than in feces. Human urine can be used directly as fertilizer or it can be put onto compost. Adding a healthy person's urine to compost usually will increase temperatures and therefore increase its ability to destroy pathogens and unwanted seeds. Urine from a person with no obvious symptoms of infection, is generally much more sanitary than fresh feces. Unlike feces, urine doesn't attract disease-spreading flies (such as house flies or blow flies), and it doesn't harbor the most hardy of pathogens, such as parasitic worm eggs. Urine usually does not stink for long, particularly when it is fresh, diluted, or put on sorbents.

Urine is primarily composed of water and urea. Although metabolites of urea are nitrogen fertilizers, it is easy to over-fertilize with urine creating too much ammonia for plants to absorb, acidic conditions, or other phytotoxicity.

Micro-organisms

With the proper mixture of water, oxygen, carbon, and nitrogen, micro-organisms are allowed to break down organic matter to produce compost. The composting process is dependent on micro-organisms to break down organic matter into compost. There are many types of microorganisms found in active compost of which the most common are:

- Bacteria- The most numerous of all the microorganisms found in compost.
- Actinomycetes- Necessary for breaking down paper products such as newspaper, bark, etc.
- Fungi- Molds and yeast help break down materials that bacteria cannot, especially lignin in woody material.
- Protozoa- Help consume bacteria, fungi and micro organic particulates.
- Rotifers- Rotifers help control populations of bacteria and small protozoans.

In addition, earthworms not only ingest partly composted material, but also continually re-create aeration and drainage tunnels as they move through the compost.

A lack of a healthy micro-organisms community is the main reason why composting processes are slow in landfills with environmental factors such as lack of oxygen, nutrients or water being the cause of the depleted biological community.

Uses of compost

Compost is generally recommended as an additive to soil, or other matrices such as coir and peat, as a tilth improver, supplying humus and nutrients. It provides a rich growing medium, or a porous, absorbent material that holds moisture and soluble minerals, providing the support and nutrients in which plants can flourish, although it is rarely used alone, being primarily mixed with soil, sand, grit, bark chips, vermiculite, perlite, or clay granules to produce loam.

Generally, direct seeding into a compost is not recommended due to the speed with which it may dry and the possible presence of phytotoxins which may inhibit germination, and the possible tie up of nitrogen by incompletely decomposed lignin.[8] It is very common to see blends of 20–30% compost used for transplanting seedlings at cotyledon stage or later.

Destroying pathogens, seeds, or unwanted plants

Composting can destroy pathogens or unwanted seeds. Unwanted living plants (or weeds) can be destroyed by covering with mulch/compost.

The "microbial pesticides" in compost may include thermophiles and mesophiles, however certain composting detritivores such as black soldier fly larvae and redworms, also reduce many pathogens. Thermophilic (high-temperature) composting is well known to destroy many seeds and nearly all types of pathogens (exceptions may include prions). However, thermophilic composting requires a fair amount of material, around a cubic meter.

The sanitizing qualities of (thermophilic) composting are desirable where there is a high likelihood of pathogens, such as with manure. Applications include humanure composting or the deep litter technique.

Types

Compost tea

Compost tea is a liquid solution or suspension made by steeping compost in water. It is used as both a fertilizer and in attempts to prevent plant diseases.The liquid is applied as a spray to non-edible plant parts, or as a soil-drench (root dip), such as seedlings, or as a surface spray to reduce incidence of harmful phytopathogenic fungi in the phyllosphere.

Vermicompost

Vermicompost is the product of composting utilizing various species of worms, usually red wigglers, white worms, and earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast. Vermicast, also known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by species of earthworm.[17]

The earthworm species (or composting worms) most often used are Red Wigglers (Eisenia foetida or Eisenia andrei), though European nightcrawlers (Eisenia hortensis) could also be used. Users refer to European nightcrawlers by a variety of other names, including dendrobaenas, dendras, and Belgian nightcrawlers.

Containing water-soluble nutrients, vermicompost is a nutrient-rich organic fertilizer and soil conditioner.

Bokashi composting

Bokashi is a method of intensive composting. It can use an aerobic or anaerobic inoculation to produce the compost. Once a starter culture is made, it can be used to extend the culture indefinitely, like yogurt culture. Since the popular introduction of effective microorganisms (EM), Bokashi is commonly made with only molasses, water, EM, and wheat bran.

In home composting applications, kitchen waste is placed into a container which can be sealed with an air tight lid. These scraps are then inoculated with a Bokashi EM mix. This usually takes the form of a carrier, such as rice hulls, wheat bran or saw dust, that has been inoculated with composting micro-organisms. The EM are natural lactic acid bacteria, yeast, and phototrophic bacteria that act as a microbe community within the kitchen scraps, fermenting and accelerating breakdown of the organic matter. The user would place alternating layers of food scraps and Bokashi mix until the container is full.

Hugelkultur

The practice of making raised beds filled with rotting wood. It is in effect creating a Nurse log though covered with dirt. The buried decomposing wood will give off heat, as all compost does, for several years. This effect has been used by Sepp Holzer for one to allow fruit trees to survive at otherwise inhospitable temperatures and altitudes.

Alternative to landfilling

As concern about landfill space increases, worldwide interest in recycling by means of composting is growing, since composting is a process for converting decomposable organic materials into useful stable products. Industrial scale composting in the form of in-vessel composting, aerated static pile composting, and anaerobic digestion takes place in most Western countries now, and in many areas is mandated by law. There are process and product guidelines in Europe that date to the early 1980s (Germany, Holland, Switzerland) and only more recently in the UK and the US. In both these countries, private trade associations within the industry have established loose standards, some say as a stop-gap measure to discourage independent government agencies from establishing tougher consumer-friendly standards.The USA is the only Western country that does not distinguish sludge-source compost from green-composts, and by default in the USA 50% of states expect composts to comply in some manner with the federal EPA 503 rule promulgated in 1984 for sludge products.Compost is regulated in Canada and Australia as well.

Mulch

In agriculture and gardening, mulch is a protective cover placed over the soil to retain moisture, reduce erosion, provide nutrients, and suppress weed growth and seed germination. Mulching in gardens and landscaping mimics the leaf cover that is found on forest floors.

Materials

- Materials used as mulches vary and depend on a number of factors. Use takes into consideration availability, cost, appearance, the effect it has on the soil — including chemical reactions and pH, durability, combustibility, rate of decomposition, how clean it is — some can contain weed, seeds or plant pathogens.
- A variety of materials are used as mulch:
- Organic residues: grass clippings, leaves, hay, straw, kitchen scraps comfrey, shredded bark, whole bark nuggets, sawdust, shells, wood chips, shredded newspaper, cardboard, wool, but also animal manure, etc. Many of these materials also act as a direct composting system, such as the mulched clippings of a mulching lawn mower, or other organics applied as sheet composting.
- Compost: This should be fully composted material to avoid possible phytotoxicity problems, and the weed seed must have been eliminated, otherwise the mulch will actually produce weed cover.
- Rubber mulch: made from recycled tire rubber.
- Plastic mulch: crops grow through slits or holes in thin plastic sheeting. This method is predominant in large-scale vegetable growing, with millions of acres cultivated under plastic mulch worldwide each year (disposal of plastic mulch is cited as an environmental problem).
- Rock and gravel can also be used as a mulch. In cooler climates the heat retained by rocks may extend the growing season.

Organic mulches

Organic mulches decay over time and are temporary. The way a particular organic mulch decomposes and reacts to wetting by rain and dew affects its usefulness.

Organic mulches can negatively affect plant growth when they are decomposed rapidly by bacteria and fungi, which require nitrogen that they remove from the surrounding soil. Organic mulches can mat down, forming a barrier that blocks water and air flow between the soil and the atmosphere. Some organic mulches can wick water from the soil to the surface, which can dry out the soil.

Commonly available organic mulches include:

- Leaves from deciduous trees, which drop their foliage in the fall. They tend to be dry and blow around in the wind, so are often chopped or shredded before application. As they decompose they adhere to each other but also allow water and moisture to seep down to the soil surface. Thick layers of entire leaves, especially of Maples and Oaks, can form a soggy mat in winter and spring which can impede the new growth lawn grass and other plants. Dry leaves are used as winter mulches to protect plants from freezing and thawing in areas with cold winters, they are normally removed during spring.
- Grass clippings, from mowed lawns are sometimes collected and used elsewhere as mulch. Grass clippings are dense and tend to mat down, so are mixed with tree leaves or rough compost to provide aeration and to facilitate their decomposition without smelly putrefaction. Rotting fresh grass clippings can damage plants; their rotting often produces a damaging buildup of trapped heat. Grass clippings are often dried thoroughly before application, which mediates

against rapid decomposition and excessive heat generation. Fresh green grass clippings are relatively high in nitrate content, and when used as a mulch, much of the nitrate is returned to the soil, but the routine removal of grass clippings from the lawn results in nitrogen deficiency for the lawn.

- Peat moss, or sphagnum peat, is long lasting and packaged, making it convenient and popular as a mulch. When wetted and dried, it can form a dense crust that does not allow water to soak in. When dry it can also burn, producing a smoldering fire. It is sometimes mixed with pine needles to produce a mulch that is friable. It can also lower the pH of the soil surface, making it useful as a mulch under acid loving plants.
- Wood chips are a byproduct of the pruning of trees by arborists, utilities and parks; they are used to dispose of bulky waste. Tree branches and large stems are rather coarse after chipping and tend to be used as a mulch at least three inches thick. The chips are used to conserve soil moisture, moderate soil temperature and suppress weed growth. The decay of freshly produced chips from recently living woody plants, consumes nitrate; this is often off set with a light application of a high-nitrate fertilizer. Wood chips are most often used under trees and shrubs. When used around soft stemmed plants, an unmulched zone is left around the plant stems to prevent stem rot or other possible diseases. They are often used to mulch trails, because they are readily produced with little additional cost outside of the normal disposal cost of tree maintenance.
- Bark chips, of various grades are produced from the outer corky bark layer of timber trees. Sizes vary from thin shredded strands to large coarse blocks. The finer types are very attractive but have a large exposed surface area that leads to quicker decay. Layers two or three inches deep are usually used, bark is relativity inert and its decay does not demand soil nitrates.
- Straw mulch or field hay or salt hay are lightweight and normally sold in compressed bales. They have an unkempt look and are used in vegetable gardens and as a winter covering. They are biodegradable and neutral in pH. They have good moisture retention and weed controlling properties but also are more likely to be contaminated with weed seeds. Salt hay is less likely to have weed seeds than field hay.
- Cardboard or newspaper can be used as mulches. These are best used as a base layer upon which a heavier mulch such as compost is placed to prevent the lighter cardboard/newspaper layer from blowing away. By incorporating a layer of cardboard/newspaper into a mulch, the quantity of heavier mulch can be reduced, whilst improving the weed suppressant and moisture retaining properties of the mulch.However, additional labour is expended when planting through a mulch containing a cardboard/newspaper layer, as holes must be cut for each plant. Sowing seed through mulches containing a cardboard/newspaper layer is impractical. Application of newspaper mulch in windy weather can be facilitated by briefly pre-soaking the newspaper in water to increase its weight.

Application

In temperate climates, the effect of mulch is dependent upon the time of year at which it is applied as it tends to slow changes in soil temperature and moisture content. Mulch, when applied to the soil in late winter/early spring, will slow the warming of the soil by acting as an insulator, and will hold in moisture by preventing evaporation. Mulch, when applied at the time of peak soil temperatures in mid-summer, will maintain high soil temperatures further into the autumn (fall). The effect of mulch upon soil moisture content in mid-summer is complex however. Mulch prevents sunlight from reaching the soil surface, thus reducing evaporation. However, mulch can absorb much of the rainfall provided during light rainfall, which will later quickly evaporate when exposed to sunlight, thus preventing absorption into the soil, whilst heavy rainfall is able to saturate the mulch layer, and reach the soil below.

In order to maximise the benefits of mulch, whilst minimising its negative influences, it is often applied in late spring/early summer when soil temperatures have risen sufficiently, but soil moisture content is still relatively high. Furthermore, at this point in the growing season, plants should be well enough established to be able to cope with the increase in the numbers of slugs and snails owing to the habitat provided for them by the mulch.

Plastic mulch used in large-scale commercial production is laid down with a tractor-drawn or standalone layer of plastic mulch. This is usually part of a sophisticated mechanical process, where raised beds are formed, plastic is rolled out on top, and seedlings are transplanted through it. Drip irrigation is often required, with drip tape laid under the plastic, as plastic mulch is impermeable to water.

In home gardens and smaller farming operations, organic mulch is usually spread by hand around emerged plants. For materials like straw and hay, a shredder may be used to chop up the material. Organic mulches are usually piled quite high, six inches (152 mm) or more, and settle over the season.

In some areas of the United States, such as central Pennsylvania and northern California, mulch is often referred to as "tanbark", even by manufacturers and distributors. In these areas, the word "mulch" is used specifically to refer to very fine tanbark or peat moss.

Mulch made with wood can contain or feed termites, so care must be taken about not placing mulch too close to houses or building that can be damaged by those insects. Some mulch manufacturers recommend putting mulch several inches away from buildings.

Anaerobic (sour) mulch

Mulch should normally smell like freshly cut wood, but sometimes develops a toxicity that causes it to smell like vinegar, ammonia, sulfur or silage. This happens when material with ample nitrogen content is not rotated often enough and it forms pockets of increased decomposition. When this occurs, the process may become anaerobic and produce these phytotoxic materials in small quantities. Once exposed to the air, the process quickly reverts to an aerobic process, but these toxic materials may be present for a period of time. If the mulch is placed around plants before the toxicity has had a chance to dissipate, then the plants could very likely be damaged or killed depending on their hardiness. Plants that are predominantly low to the ground or freshly planted are the most susceptible, and the phytotoxicity may prevent germination of some seeds.

If sour mulch is applied and there is plant kill, the best thing to do is to water the mulch heavily. Water dissipates the chemicals faster and refreshes the plants. Removing the offending mulch may have little effect, because by the time plant kill is noticed, most of the toxicity is already dissipated. While testing after plant kill will not likely turn up anything, a simple pH check may reveal high acidity, in the range of 3.8 to 5.6 instead of the normal range of 6.0 to 7.2. Finally, placing a bit of the offending mulch around another plant to check for plant kill will verify if the toxicity has departed. If the new plant is also killed, then sour mulch is probably not the problem.

Groundcovers (living mulches)

Groundcovers are plants which grow close to the ground, under the main crop, to slow the development of weeds and provide other benefits of mulch. They are usually fast-growing plants that continue growing with the main crops. By contrast, cover crops are incorporated into the soil or killed with herbicides. However, living mulches also may need to be mechanically or chemically killed eventually to prevent competition with the main crop.

Some groundcovers can perform additional roles in the garden such as nitrogen fixation in the case of clovers, dynamic accumulation of nutrients from the subsoil in the case of creeping comfrey (Symphytum ibericum), and even food production in the case of Rubus Tricolor.

On-site mulch production

Owing to the great bulk of mulch which is often required on a site, it is often impractical and expensive to source and import sufficient mulch materials. An alternative to importing mulch materials is to grow them on site. This can be carried out using the following systems:

Dedicated "mulch garden": an area of the site dedicated entirely to the production of mulch which is then transferred to the growing area. Mulch gardens should be sited as close as possible to the growing area so as to facilitate transfer of mulch materials.[6]

Integrated mulch production: Mulch bearing plants are grown alongside crops and are "chopped and dropped" when needed. This completely avoids transporting mulch materials.

Species suitable for bulk mulch production

Miscanthus giganteus: A grass growing to around 3.5 m (11.5 ft) [7] which is commonly grown in the EU as a biomass crop. Owing to the large bulk of organic material which it produces, it is likely to be an ideal species for mulch production.

Panicum virgatum: A grass, native to North America, growing somewhat shorter than Miscanthus Giganteus which is grown as a biomass crop in the US. This species is likely to perform well in its native range, but biomass cultivars are not easily available in Europe in 2010.[3] Owing to its fibrous rooting habit, it is particularly suited to sites at risk of erosion.[8]

Nitrogen fixing species suitable for mulch production

Lupinus polyphyllus: A large perennial herbaceous nitrogen fixer. Whilst this species is not able to provide the bulk of mulch material which the above two species are able to, it is able to fix nitrogen and grow on poor, sandy soils. Furthermore, low-alkaloid cultivars have been developed which can be used as an animal feed[9] It therefore holds promise as a combined fertility/mulch/livestock feed producing plant.

Co-planting of bulky mulch producing plants with nitrogen fixing mulch producing plants is likely to result in overall higher yields of mulch materials owing to higher soil nitrogen levels.

Mulching (composting) over unwanted plants

Sufficient mulch over plants will destroy them, and may be more advantageous than using herbicide, cutting, mowing, pulling, raking, or tilling. The higher the temperature that this "mulch" is composted, the quicker the reduction of undesirable materials. "Undesirable materials" may include living seed, plant "trash", as well as pathogens such as from animal feces, urine (e.g. hantavirus), fleas, lice, ticks, etc.

In some ways this improves the soil by attracting and feeding earthworms, and adding humus. Earthworms "till" the soil, and their feces are among the best fertilizers and soil conditioners.

Green manure

In agriculture, a green manure is a type of cover crop grown primarily to add nutrients and organic matter to the soil. Typically, a green manure crop is grown for a specific period, and then plowed under and incorporated into the soil.

Functions

Green manures usually perform multiple functions that include soil improvement and soil protection:

- Leguminous green manures such as clover and vetch contain nitrogen-fixing symbiotic bacteria in root nodules that fix atmospheric nitrogen in a form that plants can use.
- Green manures increase the percentage of organic matter (biomass) in the soil, thereby improving water retention, aeration, and other soil characteristics.
- The root systems of some varieties of green manure grow deep in the soil and bring up nutrient resources unavailable to shallower-rooted crops.
- Common cover crop functions of weed suppression and prevention of soil erosion and compaction are often also taken into account when selecting and using green manures.
- Some green manure crops, when allowed to flower, provide forage for pollinating insects.
- Historically, the practice of green manuring can be traced back to the fallow cycle of crop rotation, which was used to allow soils to recover.

Green manure crops

Average biomass yields and nitrogen yields of several legumes by crop:	Biomass tons acre	N lbs acre
Sweet clover	1.75	120
Berseem clover	1.10	70

Crimson clover	1.40	100
Hairy vetch	1.75	110

- Winter cover crops such as oats or rye have long been used as green manures.
- Fava beans
- Mustard
- Clover
- Vetch (Vicia sativa)
- Buckwheat in temperate regions
- Lupin
- Fenugreek
- Sunn hemp, a tropical legume
- Alfalfa, which sends roots deep to bring nutrients to the surface.
- Velvet bean (Mucuna pruriens), common in the southern US during the early part of the 20th century, before being replaced by soybeans, popular today in most tropical countries, especially in Central America, where it is the main green manure used in slash/mulch farming practices
- Tyfon, a Brassica known for a strong tap root that breaks up heavy soils.
- Ferns of the genus Azolla have been used as a green manure in southeast Asia.

Use in organic farming

Organic farming relies on soil health and cycling of nutrients through the soil using natural processes. Green manures perform the vital function of fertilization, in concert with the addition of animal manures if those are used.