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Introduction

Compost is organic fertilizer used for plant growth. For organic matter to become compost it must go through a decomposition process during which microorganisms digest the organic matter and leave it in a form of humus that has become relatively enriched by nitrogen and other minerals. During the decomposition a part of the organic matter will evaporate as carbon dioxide. Since plants absorb carbon as CO_2 from the air, high carbon content in fertilizer is redundant.

Compost is structurally a good substrate for plant growth because it has a good balance between water holding capacity and drainage. In addition, compost has a high cat ion exchange capacity (CEC), i.e. good as fertilizer. Any type of organic material can be made into compost. However, decomposition rate and nutrient value varies with base material (e.g. lignified wood and nitrogen rich manure) and decomposition conditions (temperature, water, oxygen).

The art of compost making is a very old practice (e.g. several thousand years in China) but has developed rapidly during the last few decades, thanks to concern about resource demand, price of inorganic (mineral) fertilizer and accumulation of vast amount of organic material close to consumers (towns) and away from production soil (farmers). Whether mineral fertilizer is available or not, compost can have huge advantages.

In nurseries we use compost primarily in connection with potting soil, partly as fertilizer, partly to improve structure by adding the properties of organic material.

Since decomposition under tropical conditions is fast as compared to decomposition under cooler climates, a challenge is often to reduce decomposition rate.

Organic debris

Organic matter is any natural, solid and dead material that contains carbon (C). Organic matters contain energy built up during the growth of the organism. The chemical C atoms form chains and rings in chemical structures. Often other compounds are attached to the carbon structures e.g. nitrogen (N) phosphorus (P) and potassium (K). Where the carbon chains are short and simple, they easily break down (e.g. sugar). Where they are long chains and with complex structures, breaking them can take long time (e.g. cellulose and lignin in wood). Further, inorganic groups such as nitrogen can influence decomposition rate.

Fig. 1: Decomposition happens in well balanced environment

Sugar and fat belong to the simple organic material that easily breaks down. Most proteins break down rather fast, but there are also quite complex proteins. Plants have no skeleton, so they use primarily complex carbon structures to build strong structures such as stems and trunks. These contain almost only carbon and hydrogen (H) and can be very complex. Animals are, for various reasons, normally not used as organic material for compost.

The best decomposition rate is obtained and the best humus produced, if there is a good initial ratio between carbon and nitrogen. Tropical plant material usually contains much carbon, - hence adding nitrogen-rich organic material is often necessary. The C:N ratio should be about 30-40:1 (=30-40 times more carbon than nitrogen). Nitrogen enrichment may be done by adding cow dung, chopped up green manure (legume crop) or dissolved mineral fertilizer (e.g. urea).

Decomposition and decomposers

Decomposition is the inverse of growth. In its simplest form: photosynthesis builds up, respiration break down. Decomposition break complex matters into

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simple matters. Eventually individual chemical components are released, which can then be re-cycled through absorption by plants. Digestion of plant material by animals is a decomposition process. The waste from digestion, dung, has a higher content of e.g. nitrogen than undigested material. Therefore dung is good as fertilizer, either fresh or after decomposition. Nitrogen can also be applied as mineral fertilizer e.g. urea. However, dung from ruminants has an addition attractive property,- it contains ruminant microorganisms, which are specialized in breaking down difficult decomposable matters such as straw and leaves. During decomposition, decomposers use the energy stored in the organic matters by breaking it down. The energy in that form is not important for plant fertilizer since plants get their energy directly from the sun. Therefore, the less organic energy and the lower the organic matter content, the more concentrated is the mineral content. However, some organic matter is necessary to bind the minerals, so they don't evaporate or leach out. Humus as in compost has the property of maintaining plant minerals while at the same time making it available to plants (high CEC)

The most important decomposers of organic material are bacteria, and the most suitable types of bacteria for compost making are those that use oxygen, i.e. aerobe bacteria.

Fig. 2: 'Chimneys' or air pipes helps bringing in oxygen and remove heat during decomposition

Decomposers 'attack' material from the surface. Therefore: the larger the relative surface area, the faster the decomposition. Decomposition rate can be accelerated by chopping or grinding large size material into smaller units. Doing that also assures a more uniform decomposition and structure of the compost.

The activity level of decomposers depends on temperature. Most bacteria have a temperature optimum between 30 and 50^{o} C. Since decomposition releases energy, temperature will increase during decomposition. If temperature reaches > 55^{o}C, efficiency of the bacteria declines and >60^{o}C may cause death of the bacteria. Hence, temperature should be held under 55^{o}C. If temperature reach a critical level, turnover (re-shoveling/mixing) may be necessary.

Oxygen is consumed during the chemical process of decomposition. Initially there are adequate oxygen as air pocket and pores in the organic matter. However, during decomposition the structure break down leaving less air-space, and oxygen may be depleted. Inserting 'chimneys' into compost heaps helps delay oxygen deficiency. However, it is usually advisable to overturn (re-shovel) compost heaps at least once during decomposition.

No decomposition can take place without water. However, water tends to replace oxygen so that over-wetted compost heaps may suffer from lack of oxygen. Under wet tropical conditions it is advisable to keep compost heaps under cover as water may easy evaporate during hot days and heaps may get over-wetted during heavy rain; both extremes interfere with decomposition.

Compost heap location and design

In addition to easy access, location should be chosen, where there is adequate shade to prevent over-heating. Shading trees give a good microclimate.

Some organic material may be attractive to animals e.g. pigs and rats, therefore compost heaps should be fenced or covered, or alternatively made in firm structures of concrete, wire mesh or other lasting material. If composting is uncovered, it must be provided with good drainage, especially in high rainfall areas. Moisture is easier to regulate if composting material is under roof

Compost making

Exact procedure of compost making must be adjusted according to base material, availability of additives, location and access to material. Following guideline is thus subject to variation.

1. Chop or ground the plant material into pieces of max 1 cm length. The best chopping is done by using compost grinders.
2. Sieve the material on a sieve with mesh size about 10 mm
3. Mix the material to a homogenous mix, or if different material is used, pile up in layers, max 5 cm thick. Adding some compost to material will serve as to inoculate with decomposition bacteria. Insert possibly PVC-tubes or other 'chimneys' for oxygen supply and heat release
4. Mix old compost with dung from ruminants and dilute in water. Pour the solution over the compost pile regularly while making the pile.

5. If needed spray water over the material to make it moist, - not wet. Water content in compost should be around 30%. Rule of thumb: the material shouldn't 'drip,' but water can be squeezed out by hand.
6. Cover the material with a layer of soil or grass to prevent over-heating
7. Leave compost to decompose for 2-3 weeks. Check regularly on temperature (digit thermometer with cable insertion) and moisture (take out samples – check by hand, water should come out if firmly squeezed).
8. Turn-over / re-shovel into a new heap. Cover and leave for 2-3 weeks.
9. The compost is ready for use when it has a uniform structure without any major visible plant structures. It should be dark brown and look a bit like coarse grinded coffee.
10. Compost can be stored in bags or heaps. Decomposition will still take place as long as there is organic material. However, the rate of decomposition will be low and heat should not develop.

Tools and accessories

Decomposition is accelerated if the material is chopped into smaller pieces. It may be done manually or by the help of a compost grinder. A sieve is practical to separate very large pieces of material that need to be grinded. A thermometer is useful to monitor that the decomposition happens at the right temperature, and guide whether there should be more or less ventilation to accelerate decomposition.

Fig. 3. Equipment for compost making. Compost grinder to chop up material, sieve, mesh size about 0.5 cm. to remove large debris, shovel for mixing and turning over, thermometer to control decomposing temperature

Fig. 4: Different compost container designs. The material must be kept moist. Therefore, sides should be closed to avoid desiccation and a uniform decomposition. The sides, or at least one of them, should be easy to open or remove to ease turning over and eventually removing the compost. The sides also serves as to prevent rodents from entering.

Selected readings:

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