Compost - the microbial way

Introduction

Compost is food for the complex microbial populations living beneath our feet that in turn produce food for our crops. One way of making good compost is through the Controlled Microbial Composting (CMC) method that concentrates on maintaining aerobic conditions during composting. It is a widely used process globally for making high quality compost on farm quickly. In this respect it differs from many green waste composting operations.

So why are organic and non-organic growers, at the forefront of horticulture recognising the value of investing in composting? Soil is the underlying foundation for all land-based living organisms including not only ourselves but also the plants and crops grown to generate an income. As vegetables are food for us, compost is food for soil organisms that in turn feed our vegetables. Here are some of the benefits that can be achieved through using good compost:

- Nutrient provision
- Improved soil structure
- Disease suppression
- Increased pest tolerance
- Cost saving
- Elevated yields

The process of CMC comprises:

- Composting carried out in windrows
- CMC compost starter culture is added to the windrow at the start of composting
- Temperature and carbon dioxide levels are monitored regularly and windrows turned accordingly
- Windrows are covered to prevent nutrient leaching, reduce gaseous emissions and reduce heat loss

Site selection

Before choosing the materials to compost in your windrow the first thing to consider is the composting site. If using a field site to set up windrows the land should be well drained to avoid waterlogged compost. Ideally, the site should be a flat or slightly sloping concrete base (about 4 degrees) close to the main growing operation. This will allow ease of movement of machinery without damaging the soil while also preventing excessive moisture accumulation. Its close proximity helps ensure that monitoring is carried out regularly whilst reducing the time spent travelling to and from turning of the windrow.

Choosing materials
It is important to remember that the quality of your compost will depend on the quality of material put into the process. Growers should always choose organic residues from farm or horticultural sources. Farm yard manure (FYM), packhouse waste and old tomato plants are all suitable ingredients as is green waste from parks, and woodland maintenance waste. If you bring non-farm waste onto the farm for composting it is important that all the regulatory requirements are met. Contact the Environment Agency for further information.

The ratio between Carbon (C) and Nitrogen (N) and the moisture content of the starting material will have a bearing on the success of the process. The ideal C:N ratio is between 20:1 and 40:1 whilst the moisture content of the selected materials should ideally be 50 to 65 per cent.

C:N ratio and moisture content of compost ingredients

Material	**C:N Ratio**	**Moisture content (%)**
Vegetable matter	11:1 to 13:1	75
Cattle manure	11:1 to 30:1	67 to 87
Horse manure	22:1 to 50:1	59 to79
Laying hens' manure	3:1 to 10:1	62 to 75
Grass clippings	17:1	82
Hay	15:1 to 32:1	8 to 10
Straw	48:1 to 150:1	4 to 27
Paper pulp	90:1	82
Sawdust	200:1 to 750:1	19 to 65

Source: On farm composting handbook. Values are representative.

Good compost should contain the highest possible diversity of food resources to stimulate the highest possible diversity of beneficial organisms. It is crucial to add clay, as no clay humus crumb can be built without it. Application of ready-made compost (up to 10 per cent) and some soil will also help to facilitate the process and help ensure that the desired organisms are present. A microbial innoculant often referred to as a starter can be applied within two days of composting. This is a mixture of microbes to speed up the composting process. There is some debate as to whether a starter is necessary and some say that good quality compost can be made without one. If not used it is likely to add to the time required to complete the process.

Windrow design
When deciding where to situate the windrows on the composting site it is worth thinking about the most efficient way of turning the machinery and leading onto the next windrow. Windrows are usually 50 metres long and should not exceed 2.5 metres in height and 1.2 metres in width. Research has shown these dimensions to be the most effective for making good CMC. Building the windrow in the most effective way will help to develop a homogenous, well-aerated and odour-free heap. A BobCat or

front-end loader is the most efficient way of building windrows, whilst windrow turning should be performed by specialist windrow turning equipment. These tend to be self-propelled or tractor-mounted implements, the latter of which requires a creep gear box. The initial building design of the windrow will vary depending on the material used. The following can be used as a guide:

Layer	Material	Comment
1 (bottom of the pile)	Straw or wood shavings	High carbon to nitrogen material
2	FYM	Ideally not more than 30%
3	Compost	Approximately 10% if you are learning the process
4	Vegetable/green waste	Low carbon to nitrogen material
5 (top of the pile)	Soil	Small amount to add to the diversity of organisms present.
6	Starter	Microbial innoculant to get things going

The windrow should be covered with a Gore-Tex-type breathable cover, to keep rain off but allow oxygen to enter, preventing the leaching of nutrients in rainy weather and allowing carbon dioxide to disperse outwards from the windrow.

The breakdown process

After the windrows have been set up, temperatures rise and within five days can climb to 60°C or higher. If care is not taken the windrow can ignite itself! It is important that the windrow is monitored frequently with a temperature probe to ensure 65°C is not exceeded. Over this temperature valuable carbon sources can be burnt up and beneficial organisms are killed off. If the windrow is getting too hot the pile should be turned to cool it down again. During the first seven days of the process, temperatures should be maintained between 55°C and 65°C. Once this window of temperature has been met for three days, virtually all weed seeds and plant pathogens are killed. This is known as the thermophilic stage of the composting process. During the first few weeks of composting daily turning may be required but after this initial phase of about 14 days the temperature of the heap will start to drop as all organic matter is broken down.

The build up process

In the second phase known as the mesophilic stage, new groups of organisms colonise the heap, feeding on the heat-loving organisms. It is during this phase that long-chain humic acid substances develop to bind to clay particles in the heap to form the clay-humus crumb. The key measure in assessing whether the process is finished is temperature. After the initial rise, temperatures will fall before stabilising at ambient temperature. With the right combination of ingredients and regular turning, the active composting phase can be finished in six to eight weeks, between spring and autumn.

Three management indicators

Because the system shows a definite curve during the process, management moments are rather predictable. As a guideline turning may be required daily at the beginning of the process reducing to once weekly as the process nears completion. Ideally turning moments depend on results of measuring temperature, CO_2 and moisture. It is therefore essential that temperature and CO_2 probes are used. In conjunction with temperature it is also important to measure CO_2, which is released in both the thermophilic and mesophilic stage of the process. If allowed to build up it will sink to the bottom of the pile and intoxicate desired aerobic organisms and it is therefore important that CO_2 levels do not reach 20 per cent.

Controlling and maintaining the right moisture levels is a third management indicator. Water is required by the organisms in the heap to metabolise organic matter. Biological metabolic decomposition results in high heat, which in turn changes the water in the piles to steam. Protected coverings will help to retain moisture but if levels do fall below 60 per cent in the first three weeks then moisture needs to be added by spraying on to the pile during the turning process.

The final product

After the composting process is completed the compost should be:

- humified - adding to the soil's 'bank of fertility'
- similar to, and smell like, a forest soil
- biologically very active, to suppress plant diseases
- free of weed seeds
- free of human pathogens, such as *E. coli* and *Salmonella spp*
- free of plant pests, such as plant parasitic nematodes
- free of plant pathogens, such as *rhizoctonia* , *sclerotinia* and *fusarium* .

It will also contain:

- macro and micronutrients in addition to organic NPK. Compost is an especially good supplier of trace minerals such as boron, cobalt, copper, iodine, manganese, molybdenum and zinc. The more varied the materials used to make the compost, the greater the variety of nutrients the compost will provide.

Conclusion

While compost production is not a cheap operation it can be justified for high value crops, such as vegetables. Producing a consistent, high quality compost requires investment in suitable machinery and commitment of management time. Compost turning equipment ranges from about £8,000 to upwards of £100,000 and costs of breathable covers, monitoring equipment, man-hours and the creation of a concrete base (if required) also need to be considered. However, the benefits are more than worth the investment, extending beyond mere NPK input. Improved soil structure, water holding capacity and disease suppression are a few factors that alone justify and provide return on investment. There may also be potential for relationships with local councils who want to get rid of green waste and not have to pay the high costs of using landfill sites. In this respect composting could also provide a new and lucrative enterprise on the farm.

What is humus?

Humus is the end product of the decomposition and re-composition of organic matter by micro-organisms. When fresh organic matter is placed in a compost pile, rapid multiplication of micro-organisms takes place. Certain microbes (bacteria, fungi, and actinomycetes) break this raw organic matter down into smaller particles (gums, waxes, lignins) that are resistant to further decomposition, and simple organic compounds (sugars, amino acids) that are water soluble. Following the breakdown phase, a second group of microbes bind together these particles and compounds, especially lignins and microbial biomass, into more stable humic substances (fulvic acid, humic acid, humins).

Microbes attach these long-chain humic compounds to the clay particles in soil, resulting in a clay-humus crumb. The bound humus is not water soluble in the soil or compost but can become soluble through root secretions from plants only. In a healthy soil system, a natural feedback loop exists whereby plants secrete root exudates telling microbes what they need, and in response, soil microbes regulate mineralisation of the clay-humus crumb and feeding of the plants. The objective of humus management is to produce an active, quality humus in both soils and compost, thus providing a stable bank of nutrients available to be taken up by the crop as and when needed.

Soil biology

One gram of healthy soil can contain over one billion organisms, with over 10,000 different species of bacteria. We know the function of a number of these species, but for most their roles are unknown. Bacteria are the most dominant group, potentially making up 600 million organisms within one gram of soil. The function, shape and size of these bacteria vary enormously; from root nodule-forming nitrogen fixers, through to large fungi-like bacteria (*actinomycetes*), responsible for the earthy smell of healthy soil via the release of a chemical called geosmin. Soil fungi have a number of important roles; from the physical breakdown of organic matter by fungal hyphae through to providing a nutrient bridge into plant roots. Protozoa, which mainly feed on bacteria, make up around 10,000 organisms in one gram of soil, with sizes of about 1/150mm.

References

Organic Farming , Summer 2001, Issue 70. *Compost For Health, pg30-31.* Bob Baars

Organic Farming , Summer 2001, Issue 70. *Microbial Composting, pg32-33.* Kate Barnard

Further information

Soil Association technical guide: *Soil management on organic farms.* To order call the Food and Farming Department on 0117 914 2400 or email ff@soilassociation.org

For information on machinery leasing schemes visit: http://www.wrap.org.uk

The Soil Association has set up a compost demonstration farm. For further information visit: http://www.soilassociation.org

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