Composting of coffee pulp

Composting can be defined as the biological decomposition and stabilization of organic residues by microorganisms. The temperatures during composting are increased above 50°C because of the microbiological activity resulting in a stable product, rich in humic substances, which can be used as organic fertilizer for conditioning soils without causing negative impact on the environment. Composting is also an ecological practice because it allows the return of the organic matter to the soils.

Composting is a dynamic process that involves the combined activity of several types of microorganisms: bacteria, fungi, actinomycete and other biological populations, that participate in different stages of the decomposition of the substrate (Rodale, 1971 – *see: Selected bibliography under Section 3*). In several investigations it has been demonstrated that the bacteria initiate the decomposition causing an increase in temperature, and the breakdown of organic molecules of complex structures such as proteins (Leon, 1982 – *see: Selected bibliography under Section 3*).

The high temperatures generated during composting also cause the breakdown of the cellular membrane of fungi, and therefore some internal components of the cell (e.g. antibiotics, fitohormones, fitoauxins, and citoquinines) are inactivated, giving a compost with an acceptable level of humic acids, but without biostimulants (Compagnoni, 1988 – *see: Selected bibliography under Section 3*).

Composting by earthworms can be considered as a special process where worms and microorganisms are involved in the decomposition process. The red worm (*Eisenia fetida)* is usually used for this process. The product 'vermicompost' consists of the dung material of the worms which can be used as a biological fertilizer and also of the biomass of worms, which can be used for new vermicultivation, or as protein source for animal feeding (Gómez, 1994 - *see: Selected bibliography under Section 3*). In earthworm composting biostimulants remain because the destruction of fungi cells occurs in the enteric tube of the worms and therefore the inactivation of these compounds is avoided (Compagnoni, 1988).

While composting can be considered as a technique for treatment of organic residue on a large scale, earthworm composting is a relatively recent technique, developed on a smaller scale (Mustin, 1987 - *see: Selected bibliography under Section 3*).

Coffee processing results in by-products such as pulp and mucilage that constitute around 60% of the wet weight of the fresh fruit (Calle, 1977 - *see: Selected bibliography under Section 3*). Because of their abundance, chemical composition and physical characteristics, these residues should be handled in an appropriate way in order to avoid environmental pollution. It has been shown that the pulp and husk are often highly contaminated with OTA producing fungi (Bucheli et al, 2002 - *see: Selected bibliography under Section 1 'Putting the OTA problem in context', specifically the section on 'Ochratoxin A producers'*). If poorly managed, they could become sources of mould contamination for coffee beans.

In Colombia, annual coffee pulp production is approximately 2 million tons (Rodríguez, 2003 - *see: Selected bibliography under Section 3, specifically the section on 'Composting'*). On large coffee farms the pulp is treated by composting and later used in the field as an organic conditioner of soils, thus reducing some of the cost of coffee production when compared to chemical fertilization. On small coffee farms composting by earthworms is more widely used.

Fresh coffee pulp contains a vast microbial population of bacteria, fungi and yeast. During composting of pulp, an increase of mesophile and actinomycete populations has been observed (Blandón, Rodríguez; Dávila, 1998 - *see: Selected bibliography under Section 3, specifically the section on 'Composting'*). Fungi play an important role in the initial steps of composting because of their saprophytic activity and the attack of lignin and cellulose transforming them into simple carbohydrates (Compagnoni, 1988; Mustin, 1987; Leon, 1982).

According to common Colombian practice, coffee pulp is stored in rooms made from bamboo with cement floor, and zinc roofs[1]. The mass is turned every 15 days in order to increase the ventilation and to speed transformation of substances - composting takes between four to five months.

For earthworm composting red worms[2] are placed in layers of approximately 10 to 15cm thickness. Beds can be made from bamboo or brick, 1m wide, 0.4m height and of a variable length; the floor should be constructed from cement or be covered with plastic to isolate the culture from ground. It is also recommended to build a roof for isolation of the culture from direct rain (Dávila and Ramírez, 1996 - *see: Selected bibliography under Section 3, specifically the section on 'Composting'*).

The vermicultivation is fed with coffee pulp that has been stored in rooms for at least one week. Then pulp is placed in the beds, with a maximum layer thickness of 4cm to avoid a rapid increase in temperature, and at the same time to facilitate ventilation of the culture and therefore to obtain an efficient transformation. Every three days dampened pulp is added to the beds.

[1] Photo of composting of coffee pulp (right) courtesy of CENICAFE.
[2] Photo of composting of coffee pulp using worms (left) courtesy of CENICAFE.

Worms are separated from vermicompost two or three times a year. Earthworm composting takes about three months.

Diverse microorganisms and minerals have been found in the vermicompost after three months such as: *Aeromonas hydrophila*, *Citrobacter* sp., *Chromobacterium* sp., *Enterobacter* sp., *Escherichia* sp., *Flavobacterium meningosepticum*, *Klebsiella oxytoca*, *Providencia* sp, *Pseudomona paucimobilis, Pseudomona cepacea, Xantomona* sp., *Aspergillus* sp., *Cladosporium* sp., *Fusarium* sp., *Geotrichum* sp., *Penicillium* sp., *Actinomadura* sp., and *Streptomyces* sp.

For quality assurance of the composting process, it is important to bear in mind that the appearance and texture of the final product should be as soil, the relationship C/N should be between 10 and 12 and pH values between 6 and 8 in order to be considered as a balanced humus. Actinomycetes have been always present in the compost and are predominant.

In general yields between 35 to 40% w.b. are obtained in the production of vermicompost from pulp (Dávila and Ramírez, 1996 - *see: Selected bibliography under Section 3, specifically the section on 'Composting'*). Compost obtained from coffee pulp is one of the best residues from vegetal origins, but it can not be considered as a complete fertilizer, as it does not contain all the necessary nutrients for a coffee plantation. However, vermicompost contains several compounds, and, by some measures, has better physical characteristics when compared to chemical fertilizers. (Aranda, 1995 - *see: Selected bibliography under Section 3, specifically the section on 'Composting'*).

Yields in coffee production are the same (or improved) when compost from coffee pulp is used compared to traditional chemical fertilization. It is recommended to use doses of 6kg/pulp/plant/year on the surface of the soil. In the case of vermicompost from coffee pulp,0.5kg/plant/year may be used (Sadeghian, 2002 - *see: Selected bibliography under Section 3, specifically the section on 'Composting'*).

Further investigations on composting:

Composting trials under the FAO/CFC/ICO project are under way in India during the 2004/05 harvest season to investigate the impact of various composting conditions on survival of OTA-producing mould present in coffee waste. Results from these trials should be available during 2005.