VERMICOMPOSTING OF ORGANIC URBAN RESIDUES, CHARACTERIZATION OF THE PRODUCTS AND ITS CONTRIBUTION TO AMELIORATION OF SOIL FERTILITY

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1 INTRODUCTION

Low fertility of agricultural soils is a common feature in the drylands of Oaxaca (Mexico) state. The widely ancient used practice to add organic matter to the agricultural soils is now very scarce, with the obvious consequence of diminishing soil fertility. The present agronomic practice of continued addition of mineral fertilizers to agricultural soils causes an accelerated oxidation of its organic matter and concomitantly loss of structure and depress of its physical properties (Sharma et al 1998, Hati et al, 2008). This combination of agricultural practices represents an enlargement of nutrient biogeochemical cycles and a degradation of the indicators of soil health and quality (Bautista-Cruz et al., 2007).

In contrast, the production of organic residues, in urban as in rural cities and towns, continues to increase without making use of its organic matter and nutrient contents. Recycling of these materials after its stabilization by composting or vermicomposting is a promising ecological option to ameliorate soil fertility and quality, to enhance plant production and to reduce the environmental impact of its production and final disposal (Gardner, 1999).

Raw materials for composting and vermicomposting could be from various origins: feed and garden residues, used paper, waste water, manures, agroindustrial residues and subproducts, and others. Actually, only a small quantity of these materials is processed for recycling in the world. In Oaxaca (México), there is not an operative program to process organic residues and to recycling it for agricultural use or another goal. Only a small proportion of urban or rural residues is processed by small firms with the aim to use the products in gardening, Nevertheless, the compost or vermicompost production are not quality controled, so, their composition, maturity, possible phytotoxic substances or another features are unknown. Application of immature compost causes nitrogen immobilization, phosphorus fixation and decreases the oxygen concentration around root systems due to the acceleration of microbial oxidative metabolism. Unstable compost is also phytotoxic due to the production of ammonia, ethylene oxide and organic acids (Mathur et al., 1993; Tam and Tiquia, 1994, cited by Khan et al., 2009). Therefore, evaluation of compost stability prior to its use is essential for the recycling of organic waste to agricultural soils. The aim of this research was to characterize processes and products of the composting and the vermicomposting of urban organic residues, and its effects on plant germination and growth.

2 MATERIALS AND METHODS

Earthworm production. We selected two strains of *Eisenia foetida* Savigny. The first one was from the Central Valleys region of Oaxaca (1550 masl, annual rain ca. 650 mm, climate classification: warm semidry), fed with home and garden residues. The second strain was from Sierra Sur region of Oaxaca (1800 masl, annual rain ca. 2100 mm, climate classification: warm semihumid), fed with coffee pulp. Earthworm growth and reproduction, and vermicomposting and composting processes were developed according to the methods of Ferruzi (1987), De Sanzo and Ravera (2001) and Martínez (1999). Three beds 1 m wide, 3 m long and 40 cm heigh made with bricks and cement were constructed, with a difference of 5 cm between top and end sides of the bed to conduct the natural drainage. Raw material for the compost was an 80:20 mixture of home and garden residues and dairy manure.

Experimental design. We used the general linear model to establish a complete randomized design to analyze the four treatments. The first two were vermicomposting processes with the two earthworm strains, named V1 and V2. Treatments three and four were composting processes, C1 was the basic raw material plus 2% of agricultural soil as microbiota innocula; C2 was only the raw material. Each treatment was performed in an area of 0.60 m^2. The vermicomposting process began with 500 earthworm individuals.

Data record and analysis. Temperature was registered daily at 5 and 10 cm depths. pH was registered weekly in a representative sample of the fermenting mass. After six months of process the mass was dried and sieved (2 mm). A sample of each treatment was analyzed for physico-chemical characterization. Parameters and methods were: pH – potenciometric in a 1:2 rate with distillated water; Organic Carbon – Walkley and Black; extractable Phosphorus; extractable Potassium; Cationic Exchangeable Capacity – Ammonium acetate method (Ruiz and Ortega, 1979); Water Holding Capacity – gravimetric method.

Biological assays. Two experimental assays were performed to analyze phytotoxic residues in the compost products and another to record their effects on the growth of two regional plant species, tomato (*Lycopersicon esculentum*) and "chile de agua" (*Capsicum annum*). In the first experiment, 50 radish (*Raphanus sativus*) and lettuce (*Lactuca sativa*) seeds were placed on filter paper in the bottom of Petri dishes. The paper was moistened with a compost aqueous extract (5%), the dish sealed with parafilm and placed in a dark and fresh site. Every 24 h the germination was registered. Another experiment with the same aim was performed. A thin layer (1 cm) of compost was placed in square salvers, on the surface 50 seeds of same species were uniformly distributed. The compost was moistened with distilled water and the salver was covered with plastic and placed in a dark and fresh site. 72 h later, the numbers of emerged seedlings were recorded. All treatments were in triplicate. Plant growth was followed in an assay using agricultural soil (sandy, pH 7.4, poor in organic matter, available N and P) in pots. A completely randomized experimental design was used with four replicates. The factor analyzed was the compost type (V1, V2, C1, C2 and Control) and the model plant species were *L. esculentum* and *C. annum*. The experiment was cultured for eight weeks. Plant height, number of leaves and shoot diameter were recorded weekly. At harvest, shoot and root dry weight were recorded and N, P and K concentrations in shoot were determined.

Statistical analysis. Data expressed as percentage were arcos transformed to cover the variance homogeneity demand of the model. Analysis of variance was applied to the data, when statistical significant differences were encountered, a multiple range test (Tukey HSD $P < 0.05$) was used (Steel and Torrie, 1988).

3 RESULTS AND DISCUSSION

Temperature at 10 cm depth was slightly but not significantly different to that at 5 cm (Figure 1). This difference may be due to the freeze capacity of the air exchange with the surrounding environment. There were no differences between composting and vermicomposting processes for this variable at either depths. The thermal behavior of the processes indicates that these are thermophilic, characteristic of the aerobic fermentation.

Organic C was significantly greater in compost that in vermicompost (Figure 2). We hypothesized that earthworm consumption of organic matter diminished the organic C in the vermicompost at a greater rate than the microbiota acting on the same materials. This C was incorporated into the earthworm biomass, causing a net loss of C in the organic matter processed. The pH values were medium alkaline with no significantly differences between processes (Figure 2). According to some authors, an alkaline value of pH indicates that the process is finished and the products have reached the maturity (Díaz-Burgos, 1990; Renalli et al., 2001).

The nutrient concentrations of vermicompost and compost products are recorded in Figure 3. The mean N concentration was the same in both types of products. The P concentration was significantly greater in compost that in vermicompost, but no significant differences was recorded between V1 and V2 or C1 and C2. In contrast, K concentrations were greater in vermicompost than in compost products, nevertheless there were no significant differences between V1 and V2 or C1 and C2. These data show us the potential value of the products for agricultural use as source of macronutrients. Comparison with other types of organic products used in agriculture, like manures (dairy, poultry, goat) establish these compost products as "medium" in richness of macronutrients concentration (Trinidad, 1987; Mitchel and Donald, 1995).

In the phytotoxicity assays, both types of products showed toxic effects for both plant species, with the greater effect on lettuce. For both plant species V1 has the lowest and C2 the highest toxic effect (Figure 4). The exact identity of the phytotoxic substances is unknown. Costa (1991) suggested the main germination inhibitors were the polyphenols and the low molecular weight organic acids neo-synthesized o recalcitrant to the fermentation process.

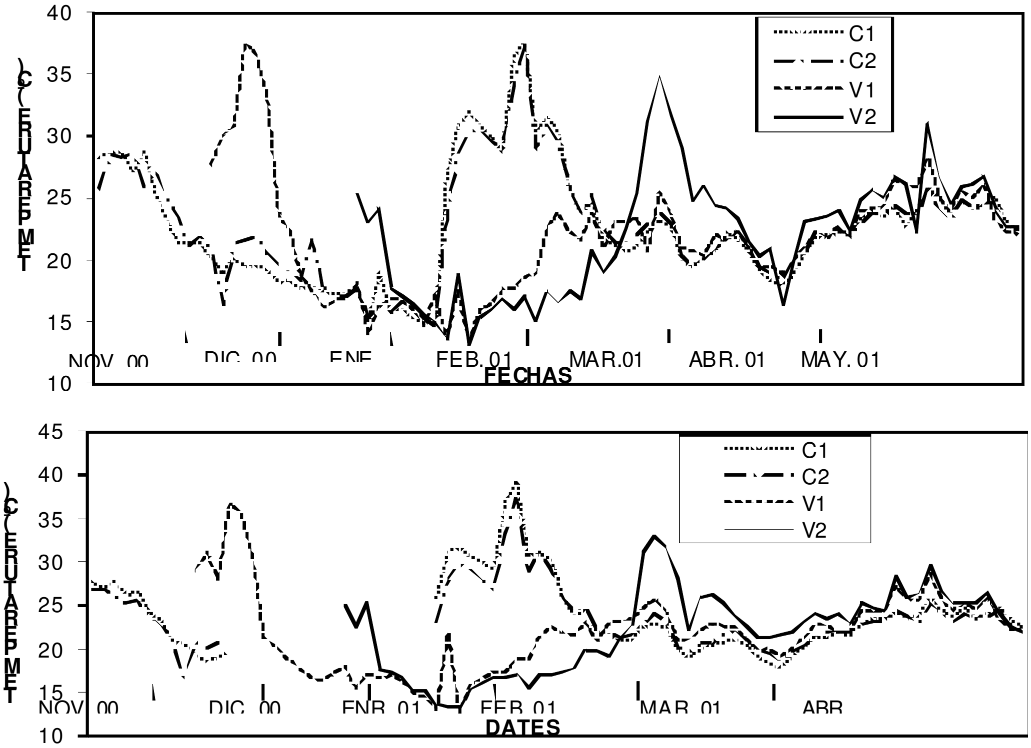

FIGURE 1 **Thermal perform of the composting (C1, C2) and vermicomposting (V1, V2) processes at 5 and 10 cm of the mass deep.**

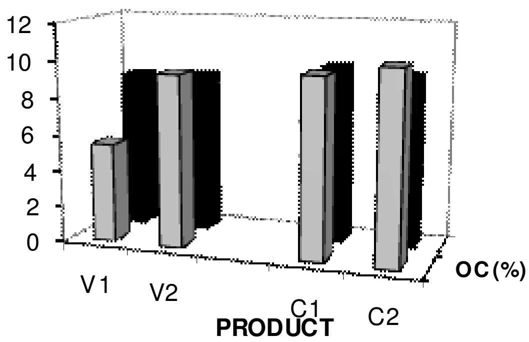

FIGURE 2 **pH and OC (%) values for two vermicompost (V) and two compost (C) products**

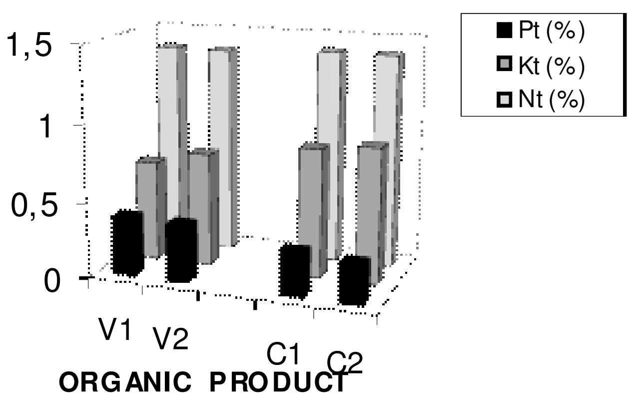

FIGURE 3 **Total Nitrogen, Phosphorus and Potassium concentrations in vermicompost (V) and compost(C) products.**

With respect to the control (without addition of organic or mineral products), both V or C products act as plant growth promoters (Figure 5), mainly due to their nutrient content and perhaps also by the existence of plant hormones or plant growth promoter substances.

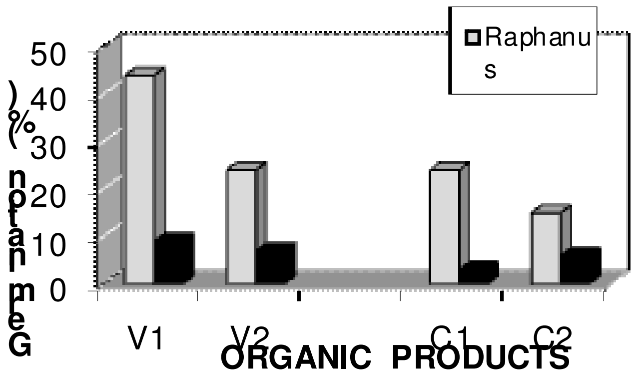

FIGURE 4 **Germination percentage of raphanus and lettuce seeds added with vermicompost (V) or compost (C) aqueous extract.**

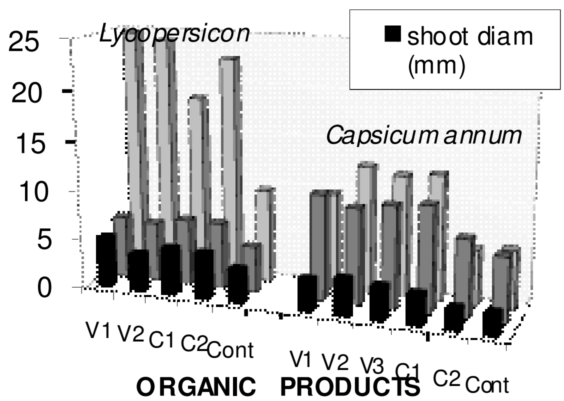

FIGURE 5 **Vegetative growth of two plant species affected by the addition of vermicompost (V) or compost (C) in a pot assay**

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