# EXPLOITATION OF COMPOSTED AGRICULTURAL WASTES AS GROWING MEDIA

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## ABSTRACT

Industrial cork residue, grape marc and olive oil husk + cotton gin trash (2/3, v/v) were composted in 40 $m^3$ windrows and turned each week. Composting took a variable time depending on the materials (4.5 to 8.5 months). During composting grape marc pile and cork pile were fertilized with ammonium nitrate, superphosphate, iron sulphate and magnesium sulphate. The evolution of temperature, pH, mineral nitrogen (N $NH_4^+$ and N $NO_3$ ), total nitrogen, organic matter, C/N ratio, electrical conductivity and cation exchange capacity were measured each week. In order to estimate compost maturity, phytotoxicity test, employing index germination, and nitrogen drawdown index (NDI) were used. With curing time, organic matter and C/N ratio decreased, whereas CEC increased and pH was constant. Microbial biomass, microbial activity were measured in mature compost. Cork compost showed the highest beta glucosidase activity followed by grape marc compost. Olive oil husk + cotton gin trash compost showed the lowest activity. The composts were used as growing media for geranium and petunia during 15 weeks. The worst results were obtained when olive oil husk + cotton gin trash were used in the composted mixtures. In these cases plants showed a lower development and leaf chlorosis. This can be explained as a consequence of nutritional disorders and/or the possible presence of phytotoxic organic substances.

## INTRODUCTION

When some organic residues of agroindustrial origin are used as a soil less growing medium it is recommended to treat these previously with a composting process that stabilizes them biologically and reduces their high contents of organic phytotoxic compounds and/or the high capacity to fix N that these usually have. In this work, the long-term evolution of composting parameters are studied such as: temperature, pH, mineral nitrogen ($N\text{-}NH_4^+$ and $N\text{-}NO_3^-$), total nitrogen (Nt), total organic matter (OM), C/N ratio, ash contents, electrical conductivity (EC) and cation exchange capacity (CEC), in compost heaps of industrial cork residue (C), heaps of grape marc (Gm) and heaps with a mixture (2/3, v:v) of "alperujo" or olive oil husk + cotton gin trash (Ap).

In order to estimate the maturity of composts, phytotoxicity tests were carried out and the N fixing capacity (NDI), measuring also microbial biomass and microbial activity. To test the value of these composts as growing media, they were used in pots to grow two ornamental plant species: geraniums, which in previous experiments had been shown to be sensitive to organic phytotoxins and petunias, chosen for their sensitivity to low available N.

## MATERIAL AND METHODS

The three residues: C, Gm and Ap, were composted in open heaps of around 40 $m^3$ for a variable time depending on the materials (4.5 to 8.5 months), with weekly turnings. Each heap received a fertilizer treatment that varied in quantity and frequency depending on the nature of the residue and the rate of uptake of mineral nutrients by the microorganisms (Table 1). The Ap heap only received 0.5 kg.m$^{-3}$ of calcium sulphate and 0.625 kg.m$^{-3}$ of magnesium sulphate in week 22.

***Table 1***. *Type of fertilizer, amount (kg m$^{-3}$) and date of treatment (week) during composting.*

| | Heap of industrial cork residue (C) | | | | | Heap of grape marc (Gm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | 1 | 7 | 10 | 12 | 17 | 1 | 3 | 8 | 11 | 12 | 17 |
| F-1[a] | 2.5 | 1.875 | | 1.875 | 1.875 | 2.5 | | 1.875 | | | 0.75 |
| F-2 | 1.25 | | | | | 1.25 | | | | | |
| F-3 | 0.625 | 0.625 | | | | 0.625 | | 0.625 | | | |
| F-4 | 0.625 | 0.625 | | | | | 0.625 | 0.625 | | | |
| F-5 | | | 1.0 | | | | | | 0.5 | | |
| F-6 | | | | 0.25 | | | | | | 0.2 | |

*[a] F-1: Ammonium nitrate; F-2: Superphosphate; F-3: Magnesium sulphate; F-4: Fe(II) sulphate; F-5: Calcium sulphate; F-6: Phosphoric acid.*

In each heap, temperatures were measured weekly at depths of 20, 40, 60, 80 and 120 cm, with a temperature probe and samples were taken for analysis. The pH, EC, N-$NO_3^-$ and N-$NH_4^+$, were determined on extracts of compost/water 1:2 (v:v); measuring the N-$NO_3^-$ and N-$NH_4^+$ by reflectometry with a Rqflex de Merck colorimeter, with reflectoquant strips. The ash content was determined by calcinations and the OM by the difference between this and the dry weight. Nt was determined by the Kjeldahl method and the CEC according to the method of Harada and Inoko (1979).

On the final composts were determined: germination indices (GI) using lettuce seeds, and vermiculite as a control substrate (Ortega *et al*., 2000), the nitrogen fixation capacity (NDI) (Handreck, 1992), the microbial biomass by the fumigation-extraction method (Rice *et al.,* 1996) and microbial activity were determined by measuring the β-glucosidase activity (μg *p*-hydrolysed nitrophenol ml$^{-1}$) (Bandick and Dick, 1999).

The composts were used to grow geraniums (*Pelargonium x Hortorum* Bailey) and petunias (*Petunia híbrida* Hort.) in pots. To improve aeration conditions, the composts of C and Ap were mixed with rice husk in proportions (v:v) of 2:1 and 1:1 respectively. The three materials were fertilized with slow release fertilizer at a dose of 4 g.l$^{-1}$, before transplantation. Blond peat was used as control substrate. A total of 6 repeats (pots) were used per treatment and the experimental design was completely randomized. For the statistical analysis, analysis of variance was used, separating the means with Tukey's test ($p<0.5\%$).

## RESULTS AND DISCUSSION

The highest temperatures were recorded between depths of 40 and 80 cm (Fig. 1). Although the three materials reached the thermophyllic phase, there were differences in: the temperatures reached, heating rates, thermal maintenance and cooling. The different nature of the materials in relation to the proportion of easily oxidisable carbon/total carbon and the presence of substances which, owing to their phytotoxic nature could slow down the microbial activity, could, together with the unequal granulometry of the three materials, explain the different thermal dynamics observed. Gm is a mixture of grape stalk and skin, which are easily decomposed, and pips of a much more stable lignocellulotic nature. This would explain the rapid heating/cooling cycle of the heap when the former have been oxidized. The slower evolution in C and Ap, revealed by the lower observed temperatures can be explained by lower availability of easily oxidisable carbon and high polyphenol contents, as well as polyalcohols in Ap. Also, the small particle size decreased oxygen diffusion in the pile, contributing to explain the slower evolution process.

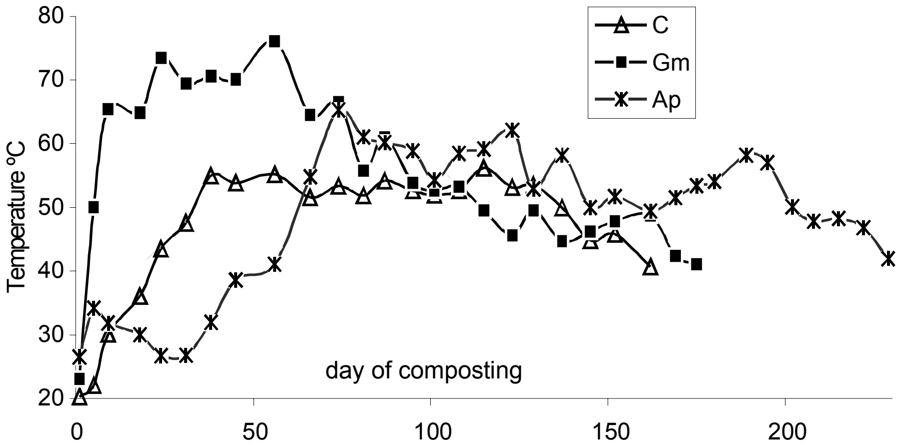


***Figure 1**. Change in temperatures (at 60 cm depth) during composting*

When changes in the chemical properties during composting were studied (Table 2) some parameters followed similar trends in the three materials. This indeed was the case with the overall rise in ash and OM, respectively, explained by the pronounced oxidation of organic compounds during the process. This should be reflected in a clear drop in the C/N ratio, which only occurs in the case of C. The pH and Nt show a clear tendency to maintain levels in all three materials. In the case of the pH this could indicate a predominance of aerobic conditions during the whole process, and in the case of Nt, the losses in this element by volatilization or denitrification can not be important. Although one would expect the CEC to increase, in parallel with humification of the residues, this only clearly occurs in C and Gm.

***Table 2**. Changes in the chemical parameters during composting of C, Gm and Ap.*

| Week | pH | EC mS/cm | Ash % | OM % | Nt % | C/N | CEC Me/100g | $N\text{-}NO_3^-$ ppm | $N\text{-}NH_4^+$ ppm |
|---|---|---|---|---|---|---|---|---|---|
| | | | Compost of industrial cork residue | | | | | | |
| 1 | 7.2 | 1.70 | 16.03 | 84.0 | 1.01 | 22.7 | 52.3 | 26.4 | 19.1 |
| 7 | 7.5 | 1.88 | 31.2 | 68.8 | 0.87 | 25.8 | 70.0 | 2.0 | 0 |
| 14 | 7.4 | 1.44 | 39.8 | 60.2 | 1.04 | 20.2 | 72.1 | 96.9 | 33.4 |
| 22 | 7.3 | 1.20 | 40.5 | 59.5 | 1.20 | 16.6 | 87.3 | 49.5 | 1.3 |
| | | | Compost of grape marc | | | | | | |
| 1 | 7.3 | 1.35 | 7.1 | 92.9 | 2.18 | 11.7 | 99.1 | 71.2 | 57.6 |
| 8 | 7.2 | 1.74 | 12.1 | 88.0 | 1.90 | 11.4 | 118.3 | 6.7 | 26.4 |
| 13 | 7.5 | 2.34 | 11.9 | 88.1 | 2.33 | 10.5 | 118.3 | 140 | 95.7 |
| 24 | 7.2 | 1.17 | 20.1 | 79.9 | 2.04 | 10.6 | 125.2 | 21.7 | 0.1 |
| | | | Compost of olive oil husk + cotton gin trash | | | | | | |
| 8 | 8.3 | 3.42 | 36.2 | 63.8 | 1.85 | 11.2 | 95.9 | 4.63 | 52.1 |
| 17 | 8.4 | 5.07 | 41.0 | 59.0 | 1.89 | 10.3 | 88.6 | 9.26 | 151.7 |
| 27 | 8.2 | 4.32 | 49.6 | 50.4 | 1.80 | 8.7 | 81.7 | 68.65 | 48.2 |
| 34 | 7.9 | 2.66 | 48.7 | 51.3 | 1.90 | 8.2 | 94.1 | 12.65 | 11.6 |

Other parameters seem to follow a strongly oscillating trend (EC, N-$NO_3^-$ and N-$NH_4^+$) that could be explained by the different chemical fertilization received by each material. In C and Gm, the rises in N-$NO_3^-$ and N-$NH_4^+$, coincide with the addition of ammonium nitrate and/or followed by nitrification of ammonium. The declines are due to the intense uptake of mineral N by the microorganisms. In Ap, where mineral N fertilizer was not applied, the changes would be explained by recycling of N during decomposition, resulting in the mineralization of organic N, nitrification of the ammonium formed and new reorganization as mineral N is consumed by the microflora. In any case, the small changes in mineral N would not significantly affect the Nt contents.

Bioassays to detect phytotoxins revealed significant rises in the GI in the three composted materials compared to the corresponding fresh residues suggesting decomposition of these substances during the process. In the C and Gm composts, the GI values were not significantly different to those obtained on vermiculite. In the Ap compost, however, GI only reached 50% of the control value, increasing up to 85% after being rinsed with water. This suggests the presence of some soluble factor in the Ap compost, possibly high salinity that would impede germination and root development.

NDI only reaches values that could suggest possible N fixation in the C compost (NDI=0.68). This could be because the composting process of this residue has not been completed and the cellulotic fraction is still in the active decomposition phase.

The microbial biomasses of the three composts were equivalent (data not shown). In contrast, the highest microbial activity was shown by Ap followed by C and the lowest was shown by Gm.

In relation to the composts' behavior as growing medium (data not shown), only the geraniums grown on Ap+rice husk had a significantly less development and dry weight than those grown on blond peat The petunia plants did not show any differences compared to those grown in peat in any of the three materials. In relation to the mineral composition of the plants, the most significant were the high K contents, that both species showed when grown on composts of Ap+rice husk and Gm, and the high Mn contents in those grown on composts of C+rice husk. Also evident were the low Fe contents in plants grown on compost of Ap+rice husk and C+rice husk, which were probably responsible for the foliar chlorosis observed in the geraniums.

Although more experiments are required to overcome the nutritional imbalances observed, the results obtained here after composting these residues demonstrate that they could be a good alternative to partially or completely replace peat as a growing medium in pots.

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