EFFECT OF THE RAW MATERIAL AND BACTERIAL INOCULATION ON HUMIC AND LIGNOCELLULOSIC FRACTIONS DURING COMPOSTING OF HORTICULTURAL WASTES

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ABSTRACT

The intensive agriculture practiced during the last 30 years at the Southeast of Spain has favoured the economic apogee of this zone. This practice involves negative aspects too, such as the production of huge amounts of horticultural wastes, which are mainly composed of lignocellulosic material. Though several solutions have been proposed, composting of horticultural waste seems to be one of the most interesting alternatives. The main objective of this work was to study the effect of inoculation and raw material composition on the evolution of humic and lignocellulosic fractions during the horticultural waste composting.

Vegetable residues were arranged and mixed in 1,5 m^3 piles. These piles were initially inoculated with lignocellulolytic microorganisms. Lignocellulosic fractions evaluated were neutral detergent fibre (NDF) and acid detergent fibre (ADF). On the other hand, humic fractions analysed were total humic extracts (THE), humic (HA) and fulvic (FA) acids.

Results showed that both microbial inoculation and composition of raw material contributed to the final product characteristics and quality.

Keywords: *composting process, lignocellulolytic microorganisms, humic fractions, maturation index.*

INTRODUCTION

In the past decades, the role of intensive agriculture in the economy of the South of Spain has become determinant. However, this expansion involves negative aspects, such as the production of enormous amounts of horticultural wastes (Cara and Rivera, 1998). Different solutions have been proposed in relation to this problem, being composting one of the most interesting. This alternative treatment of wastes allows the elimination of potentially dangerous residues, at the time a product of agricultural interest, compost, is obtained (Zucconi et al., 1981; Abad and Noguera, 1997). Compost is used as a source of organic matter into the soil (Stevenson, 1994) being the main effects of its addition to soils, the improvement of the soil structure and aeration, water-holding capacity, buffer capacity and cation exchange capacity.

In nature, cellulose, lignocellulose and lignin are major polymers of plant biomass (Pérez et al*.,* 2002) which could be degraded by a variety of typical microorganisms during a composting process. However, amorphic lignin surrounds the cellulose fibrils, protecting the cellulose and hemicellulose from enzymatic attack and giving strength to the plant (Brown, 1985).

In this sense, there is a great controversy with respect to the benefits of the microbial inoculation during a composting process (Finstein and Morris, 1975; Nakasaki and Akiyama, 1988). Most investigations on this subject have been based on the use of bacteria and actinomycetes (Ichida et al., 2001), though the efficacy of several fungi have been also observed (Kirk and Farell, 1987). Therefore, the major aim of this research was to study the influence of microbial inoculation and the effect of the raw material on composting of horticultural waste in order to find out the role of fungi and bacteria during degradation process and the influence of this microorganisms on the final product. The mineralization and humification of plant material was

observed in base of humic and lignocellulosic fractions.

MATERIAL AND METHODS

Pepper plant wastes were arranged in 1,5 m^3 piles and mixed with other raw materials (Table 1). Windrows were initially inoculated with selected lignocellulolytic microorganisms from our own strain collection (Table 1). No attempt was made to identify and classify these strains.

Table 1. *Raw materials and inoculating microorganisms used in the composting process*

Raw material			Inoculant Microorganism
Mixture	**Proportion**	**Code**	**Characteristics**
P: O: A	3:1.6:1.4	162	Thermophile bacterium, Gram +, spore forming
P: Pr: A	3:1:1.5	671	Thermophile bacterium, Gram +
P: R: A	3:1:1.5	252	Thermophile actinomycete, Gram +, spore forming
P: A	3: 1	Control	

P: pepper plant. O: olive-oil mill waste. Pr: pruning waste.
R: rice straw. A: almond shell

A total of 3 isolates from horticultural wastes were assayed in relation to their influence on the properties of the final product, during a composting assay. Each windrow was inoculated with a bacterial suspension to reach a concentration between 10^7-10^8 cfu/g of waste, being the last windrow used as uninoculated control (Table 1). Samples were extracted at different stages of the composting process (0, 14, 28, 45 and 180 days) and tested in relation to strain persistence. In addition, the modified procedure of Waldern (1971) was used as the standard for neutral detergent fibre (NDF) and acid detergent fibre (ADF) analysis. On the other hand, the modified method of Kononova (1964) was used for total humic extracts (THE), humic (HA) and fulvic (FA) acids analysis. In this sense several humification indexes were beside calculated (Iglesias and Pérez, 1989, 1992).

RESULTS AND DISCUSSION

Results showed the influence of microbial inoculation on NDF and ADF values, while raw material only exerted some influence on NDF. In both cases, lower fibre account was achieved at the end of the composting process and the strain showing the lower fibre values was the thermophile bacterium named 671 (Tables 2 and 3).

Table 2.- *Multiple Range Test for FND by Inoculum, Raw material and Time. Means shown with different letters differ significantly (P < 0.05) according to Fisher's protected LSD test.*

FACTOR	MEAN	FACTOR	MEAN	FACTOR	MEAN
Inoculum		**Raw Material**		**Time**	
671	21.0573 a	A	21.2249 a	180	16.0543 a
162	22.4552 b	Pr	22.1581 b	45	21.8438 b
252	22.7416 b	O	22.8817 b	28	23.0021 c
Control	23.9784 c	R	23.968 c	14	25.1742 d
				0	26.7164 e

On the other hand, microbial inoculation did not influence on the different humic fractions while the type of raw material was found as a factor that significantly influenced on the amount and proportion of humic compounds (data not shown). Higher humification degree was obser-

ved at the end of composting (Table 4).

***Table 3**.- Multiple Range Test for FAD by Inoculum and Time. Means shown with different letters differ significantly (P < 0.05) according to Fisher's protected LSD test.*

FACTOR Inoculum	MEAN	FACTOR Time	MEAN
671	16.0628 a	180	9.0334 a
Control	17.267 b	45	15.6081 b
162	17.9964 b	28	17.9208 c
252	18.1348 b	14	20.5714 d
		0	23.6925 e

***Table 4**.- Multiple Range Test for Humification Ratio and Humification Index by Time. Means shown with different letters differ significantly (P < 0.05) according to Fisher's protected LSD test.*

FACTOR Time	MEAN Humification Ratio	FACTOR Time	MEAN Humification Index
14	15.7677 a	0	4.2379 a
0	16.8176 ab	14	4.5530 ab
28	17.3359 b	45	4.8993 bc
45	18.1298 b	28	5.2071 c
180	20.6444 c	180	6.0229 d

The biodegradation of lignin during the composting process has recently been reviewed (Tuomela et al., 2000). According to Waksman et al., (1939a, b), thermophilic fungi are the most important lignin degrading microorganisms in composting conditions, and their synergistic effects with other microorganisms can significantly enhance degradation. In this sense, fungi no were selected in this work but the character thermophilic was the main judgment to select the bacterial strain indicated. On the other hand, white-rot fungi are the most efficient lignin degrading microorganisms in nature (Hatakka, 1994) but they do not survive in thermophilic conditions. Actinomycetes have also been reported to degrade lignin by means of solubilization rather than depolymerization and mineralization (Buswell and Odier, 1987; Eriksson et al., 1990).

From the results obtained in this work it can be concluded that both inoculation and composition of raw material contributed to the final product characteristics and quality.

CONCLUSIONS

Therefore, results obtained at the present work suggest that the inoculation with thermophile bacteria and actinomycetes provides several benefits on the degradation of lignin fractions during horticultural waste composting. The use of olive mill and pruning wastes into the raw materials increases the different humic fractions and the higher humification degrees were finally observed at the end of composting although highest humic acid values were earlier accounted (28 days from the beginning of the process)

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