Organic-inorganic Compound Fertilizer Treated by EM (I): Changes of Nutrient, Microbial Community and Bioactivity with Composting Time in EM Living-refuse Compost

Lida Yu, Shen Yu , Biaohu Cheng, Mei Lin and Zhengao Li

Research Institute of Citrus Science, Zhejiang Academy of Sciences, Huangyan, China, 318020

Abstract: *A series of living-refuse composts treated with EM are been carried out in an experimental period. Making of living-refuse composts, their pot experiments and field trails, and commercialization of products will be done in the following year. This paper presents some properties of EM living-refuse compost treated with different composting times, 7, 15 and 30 days, which were made in the laboratory. Results showed that EM could promote the decomposition of living-refuse, increase the concentrations of available nutrients such as N, P and K in composts, especially the available P with 1.0, 2.6 and 2.0 g* P_2O_5 kg^{-1} *accretions in EM7, EM15 and EM30 than that in the control, the natural living-refuse compost with 15 day heaping, respectively, and keep more organic carbon in compost, ranging from 35.2-75.7 g C* kg^{-1}*, than in the control. Population of bacteria and fungi rapidly increased with heaping time in EM living-refuse composts. Bacteria grew more thriftily in EM15 and EM30 than in the control at near double size. Potential of hydrogen peroxidase tended to decline with heaping time but inversely, the urease activity was increased in EM composts and the activities of EM15 and EM30 were higher than that of control.*

Introduction

Effects of EM (Effective Microorganisms) bio-technique on environment-cleaning, compost-making and odour-removal were reported, especially in some areas of Japan using EM bio-technique to treat living-refuse harmlessly. Some primary experimentations of EM application were conducted in China in the last 5 years, which included field and pot experiments of crops and vegetables, rearing of poultry and cattle as a forage additive and odour-removal, and compost making of living-refuse and much more (Li and Ni, 1996; Ni and Li, 1998).

Our aim is to develop a series of organic-inorganic compounds as fertilizers using EM bio-technique to treat living-refuse and to alleviate strains of the garbage management and to recycle some useful organic substances into soils so as to obtain more profits. This paper presents some properties of living-refuse composts treated by EM and their changes with composting time.

Materials and Methods

Organic portion of living-refuse was collected from the Factory of Living - refuse Disposal and Management, Huangyan District, Taizhou, Zhejiang Province, China. It was air-dried and grounded through 2-mm sieve.

Liquid EM was provided by the Nanjing Agency of EM Technology (Japan).

Five treatments and EM preparation were designed to compare their differences on nutrients and bio-properties and are noted below. All treatments were replicated.

CK1 EM preparation (conducted following the Guidance of EM Application provided by the Nanjing Agency of EM Technology (Japan). 100 ml molasses were dissolved into warm water and diluted with warm water 100 fold, then mixed with 100 ml liquid EM and 60 kg chaff. The mixture was packed into a black plastic bag and the air was pushed out and the bag sealed. The mixture was fermented anaerobically at room temperature (25-30 °C). When the alcohol-smell was produced, the EM preparation was done (near 2 weeks).

CK2 Natural living-refuse compost without EM preparation and composted in a black plastic bag without air for 15 days.

EM7 Living-refuse compost mixed with EM preparation at ratio 20:1 and composted in a black plastic bag anaerobically for 7 days.

EM15 Same as EM7 but for 15 days

EM30 Same as EM7 but for 30 days

Total and available N, P and K were analysed as described in Ni and Li 1998. Available N was hydrolysable N and available P was the citrate soluble P, and available K was extracted by 1.0N NH_4OAC. Soil microbe and enzymatic activity analyses were done according to the ISS 1987.

Results and Discussion

Changes of N, P and K in the Living-Refuse Composts

With the heaping time there was no significant difference of concentrations of total N, P and K in the compost treated by EM preparation among three temporal treatments, and with CK2, which was composted for 15 days in a natural way without EM preparation added, and the values of 1/20CK1 and CK2, which were reckoned from CK1 and CK2 with the same ratio of EM treatments, i.e. one part of EM preparation (CK1) mixed with 20 parts of living-refuse (CK2) (Table 1). They all ranged at averages of 6.3 g N kg^{-1}, 7.8 g P_2O_5 kg^{-1} and 5.8 g K_2O kg^{-1} respectively, which were similar to the estimated values of 1/20CK1+CK2.

Concentrations of available N, P and K, however, were remarkably higher in EM15 than in CK2 and in other EM treatments, especially the citrate soluble P with 1.0, 2.6 and 2.0 g P_2O_5 kg^{-1} accretions in EM7, EM15 and EM30 than that in the control respectively. After multiple comparisons, the content of hydrolysable N between EM15 and CK2 with the same composting time (15 days) had an evident difference at $P<0.05$, and the citrate soluble P and available K gave significant difference at $P<0.01$ between of EM15 and CK2.

The evidences from the ratio of available and total nutrients also indicated that EM preparation could increase concentrations of the available nutrients in composts, especially in the treatment with 15-day composting.

Values of total organic substance (Table 1) showed that more organic substance was kept in EM composts, arranged from 35.2-75.7 g C kg^{-1}, than in CK2 during composting. It possibly was to indicate that EM compost could reserve more organic carbon because the abundant population of microorganisms thrived during the process of composting, especially the community of bacteria being enhanced (Table 2). Microorganisms dominantly consisting of bacteria utilized more organic matter and transformed them into cell substances. After done, CK2 was moldy and rotten with higher water concentration but EM composts had an alcohol-like smell and no liquid water. This is due likely to the change of structure of microorganisms community in composts.

Table 1. Changes of N, P, K and Total Organic Substance Concentrations with Composting Time in EM Living-refuse Composts

Treatment	Avail N	Total N	Ratio of AN/TN	Avail .P	Total P	Ratio of AP/TP	Avail .K	Total K	Ratio of AK/TK	Total Organic Substance
	g N kg^{-1}		%	(P_2O_5) g Kg^{-1}		%	(K_2O) g kg^{-1}		%	g C kg^{-1}
CK2	0.48	6.0	7.97	1.8	7.6	23.68	1.7	5.5	30.91	210.9
EM7	0.49	5.9	8.37	2.8	7.8	35.90	1.9	5.2	36.54	286.6
EM15	0.54	6.5	8.24	4.4	8.2	53.66	2.2	6.0	36.63	247.1
EM30	0.48	6.6	7.21	3.8	7.8	48.72	1.7	6.3	26.89	283.2
CK1	0.43	5.9	7.20	-	1.8	-	2.6	3.0	86.67	885.0
1/20CK1+ CK2	0.50	6.3	8.33	-	7.7	-	1.8	5.7	35.24	255.2

Status of Microorganisms Community in Living-Refuse Composts

Plate counting results of microbial biomass in living-refuse composts indicated that composts treated EM preparation had more total microbes than CK2, the natural compost (Table 2).

Table 2. Changes of Microorganisms Community with Composting Time in EM Living-Refuse Composts

Treatment	Bacteria	Fungi	Total Microbes	Percentage in Total Microbes	
	10^7 g^{-1}	10^5 g^{-1}	10^7 g^{-1}	Bacteria	Fungi
CK2	6.53	19.40	6.72	97.17	2.83
EM7	8.70	6.30	8.76	99.32	0.68
EM15	12.67	13.60	12.71	99.69	0.31
EM30	12.05	15.45	12.20	98.77	1.23

Population of bacteria increased rapidly in EM treatments compared to that of in CK2, nearly doubling in EM15 and EM30. Simultaneously, with composting time, it evidently increased between EM7 and EM15, but no remarkable difference was observed between EM15 and EM30.

Population of fungi existing in composts, was fewer in EM treatments than that of in CK2 although it increased with heaping time among EM composts and the difference statistically reached a significant level of multiple comparison at $P<0.01$. Percentages in total microorganisms of bacteria and fungi had a variance from 1.6 to 2.5 percent between CK2 and EM composts, particularly, the percentage of fungi in total microbes of the natural compost (CK2) was nearly 9.0 times of EM15 compost with the same composting time.

Potentials of Hydrogen Peroxidase and Urease in Living-Refuse Composts

Potential of urease in EM composts showed an increased trend with composting time (Fig. 1). It got a significant correlation of multinomial regression with time, and its multinomial equation was as follows: $Y= 0.0005X2-0.0017X+0.1511$ ($R^2= 1.000$). The accretion was quite large and nearly double between two contiguous treatments. Urease activity of CK2 was relatively equal to that of EM15. Potential of urease possibly suggested the capacity of available N provided by the compost. In contrast,

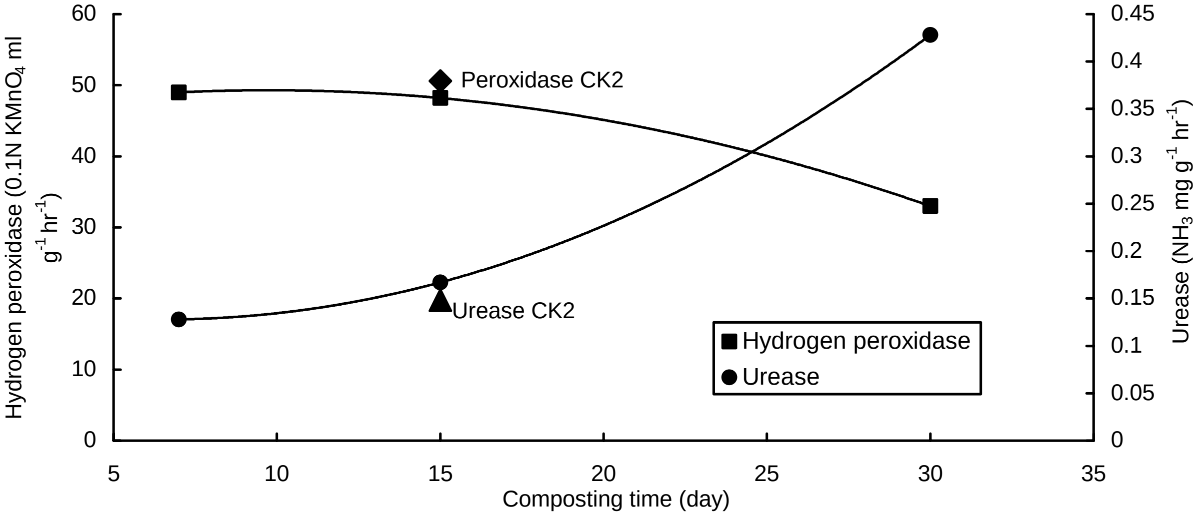

Fig. 1. Potentials of Hydrogen Peroxidase and Urease in Composts

activity of hydrogen peroxidase declined with composting time among EM composts and its sizes were lower than that in CK2. A remarkable correlation of multinomial regression varied with time was also detected in potential of hydrogen peroxidase of EM living-refuse composts ($Y=-0.0397X^2+0.7736X+45.53$, $R^2=1.000$). Natural compost with higher potential of hydrogen peroxidase was because more peroxide was produced during organic matter of living-refuse decomposed continuously.

Conclusion

Decomposition level of compost usually could be accounted for intensity of some enzymes and size of microorganisms and concentration of available nutrients. Results presented in Tables 1 and 2 and Fig. 1 could deduce that composts treated by EM preparation, especially with the same composting time was at a more intensive level of decomposition than the natural compost due to EM living-refuse composts having a higher level of available N, P and K, and larger population of microorganisms and more active urease plus lower hydrogen peroxidase than the natural compost (CK2).

In general, from the discussion above, it follows that the investigation of nutrition, microbe community and enzymatic activity in EM living-refuse composts indicated EM preparation could promote the decomposition of living-refuses during composting. EM enabled living-refuse composts to provide more rapidly crop-available nutrition than its natural compost. Simultaneously, EM composts contained larger population of effective microorganisms, which could enhance the mineralization of soil organic matter to release much more efficient nutrition and to increase soil bioactivity when it was added into soil.

This series of EM living-refuse composts are ongoing research on pot and field experiments to prove their actual effects on yield and quality of crops, vegetables and fruits.

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