International Journal of Plant & Soil Science

33(21): 195-201, 2021; Article no.IJPSS.76014
ISSN: 2320-7035

Evaluation and Acceleration of Municipal Biowaste Compost Production and its Effect on Growth and Yield of Amaranthus

S. Dharani[1*], B. Bhakiyathu Saliha[2], S. Suresh[2] and S. Shenbagavalli[3]

[1]*Department of Soil Science and Agricultural Chemistry, Agricultural College and Research Institute, TNAU, Coimbatore-641 003, India.*
[2]*Department of Soil Science and Agricultural Chemistry, Agricultural College and Research Institute, TNAU, Killikulam–628 252, India.*
[3]*Department of Soil Science and Agricultural Chemistry, Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Trichy - 620 009, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i2130672
Editor(s):
(1) Dr. Francisco Cruz-Sosa, Metropolitan Autonomous University, México.
Reviewers:
(1) Megahed Mohamed Amer, Agricultural Research Center, Egypt.
(2) Mohammad Nazrul Islam, Bangladesh Rice Research Institute, Bangladesh.
Complete Peer review History: https://www.sdiarticle4.com/review-history/76014

Original Research Article

Received 11 August 2021
Accepted 21 October 2021
Published 23 October 2021

ABSTRACT

To limit the accumulation of municipal solid waste, quick solid waste management techniques are more vital to reuse, reduce, and recycle the Municipal Solid Wastes MSW). A study was conducted to shorten the composting time and assess the degradation efficiency of different micro consumers in Municipal Solid Waste Compost (MSWC) production and followed by a field experiment with Amaranthus as a test crop to evaluate the influence of MSWC on crop yield. Various sources *viz.*, Saw dust balls impregnated with Panchakavya solution, TNAU Biomineralizer, PUSA decomposer, Effective Microorganisms (EM) solution, RCOF Waste decomposer and Novel microbial consortia were used for rapid production of biowaste compost. The results showed that the PUSA decomposer and EM Solution significantly reduced the period of composting to 35 and 37 days respectively. The nutrient parameters of compost *viz.*, C:N ratio (13:1), total N (3.37%), total P (0.14%) and total K (0.65%) were better in the compost prepared with PUSA decomposer followed

**Corresponding author: E-mail: dharaniagp@gmail.com;*

by those with EM solution and novel microbial consortia. The bio compost obtained from this study was utilized in the field experiment to assess the biomass production of Amaranthus. Enriched MSWC @ 5t ha^{-1} + 75% NPK produced greater amount of biomass (27.84 t ha^{-1}), in comparison with control which produced 59.7% higher biomass yield. The overall results indicated that proper microbial inoculation of solid biowastes shortened the duration of composting and combined application of municipal biowaste compost with inorganic fertilizers saved 25 percent of fertilizer dosage, improved the soil quality and crop yield thus ensuring ecofriendly disposal of wastes.

Keywords: Municipal solid waste compost; degradation efficiency; PUSA decomposer; soil quality; biomass yield.

1. INTRODUCTION

Municipal Solid Wastes (MSW) generation is increasing at an alarming rate in most of the cities across the world due to the result of overpopulation, industrialization and urbanization which leads to non-selective garbage disposal. In India, annual generation of MSW has increased from 6 million tonnes to 48 million tonnes from 1947 to 1997 and 90 million tonnes in 2009, now it is expected to be 300 million tonnes in 2047 [1]. Improper management and inadequate facilities lead to the accumulation of MSW.

Today the world mandates the practice of solid waste management strategies which includes collection, transportation, processing and disposal of solid waste with high magnitude. The municipal solid waste generally includes household and commercial refuse, consisting of degradable (paper, food waste, straw and yard waste), partially degradable (wood, and sludge) and non-degradable materials (leather, plastics, metals, glass and electronics) [2,3]. Among these a major portion is occupied by organic wastes which are degradable, for which composting is a prominent management practice.

Composting is the prominent technique for municipal solid waste management and is an effective biological process in which biowastes are degraded into high-value organic material which acts as a soil stabilizer for crop production. Composting possesses a number of advantages which include being economically feasible, improves soil properties, reduces the use of chemical fertilizers thus minimizing environmental pollution [4]. However, the drawback of the conventional composting technique is the period of composting which takes more than 60 days to degrade the wastes into organic material. Reducing the composting period is more important for the current situation to minimize the accumulation of municipal wastes and also to maximize the frequent utilization of municipal bio-compost for crop production.

Nowadays, rapid degradation of organic wastes requires the action of microorganisms with enhanced enzymatic activity to break down complex polymers into simpler degradable molecules [5,6]. In this connection, modern approaches in composting deploy microbial products such as microbial consortium and waste decomposers that facilitate faster production of compost and also enhances the quality of compost. Therefore, inoculation of waste with microorganisms which produce extracellular enzymes such as cellulase, amylase, protease, pectinase and lipase at higher levels may enhance waste degradation, thus aids in keeping up the waste degradation rate to that of waste dumping. Improved methods are developed based on quick recovery and nutrient enrichment in the end product.

Application of MSW compost in agricultural land helps in ameliorating physio-chemical properties of the soil, soil fertility and MSW management. Apart from this, it also assists in improving the biological response of cultivated land. Integrated application of MSWC and inorganic fertilizers facilitates nutrient use efficiency, better growth and yield which reduces further use of inorganic fertilizers [7]. Hence the study hypothesized an eco-friendly rapid production of municipal solid waste compost (MSWC) and its agricultural utilization.

2. MATERIALS AND METHODS

The experiment was conducted in two phases *viz*., (i). Standardization of composting process and (ii). Field experiment with Amaranthus as test crop.

2.1 Standardization of Composting Process

Microbial cultures and decomposition agents *viz*., saw dust impregnated with Panchakavya, TNAU Biomineralizer, PUSA decomposer, Effective Microorganism's (EM) solution, RCOF waste decomposer, Novel Microbial consortia were used for composting. The microbial inoculants prepared for decomposing one tonne of municipal solid waste are as follows. (i). 6 kg of sawdust ball @ 1 kg sawdust per 2 lit of panchakavya (ii). 2 kg of TNAU Biomineralizer in 20 litres of water (iii). 4 capsules of PUSA decomposer in 10 litres of jaggery solution made with 300 g of jaggery (iv). 10 ml EM solution in 100 litres of jaggery solution containing 50 g jaggery (v). 30 g RCOF waste decomposer in 200 litres of water containing 2 kg of jaggery (as mother culture) (vi). 4 litres of TNAU Microbial consortia in 10 litres of jaggery solution made with 300 g of jaggery.

The prepared inoculant solutions were added to the respective individual compost pits (4 m × 1.5 m × 1 m) containing 1 tonne of municipal solid biowastes each in a randomized block design with three replications. The moisture content (60%) and aeration (turning once in 2 days) were maintained throughout the composting duration. Temperatures were kept between 32 and 60 degrees Celsius during the composting process to keep microbes active. Periodical observations of colour, odour, texture, pH and EC were done, based on which the maturity of compost was evaluated for each of the treated compost pit. The municipal solid biowaste composts prepared with less duration were selected for the field experiment. The composts selected for field experiment were evaluated for physical, physio-chemical and chemical parameters adopting the standard procedures prescribed for total NPK [8] and total carbon content (dry combustion method) using elemental TOC analyzer [9].

2.2 Field Experiment

The field experiment was taken up during Kharif 2021 at Agricultural College and Research Institute, Killikulam located at 8.70559˚N latitude and 77.85818˚E longitude at an altitude of 29.93±99 m above Mean Sea Level (MSL). The characterization of initial soil samples of the experimental site was found to be mildly alkaline, sandy clay loam and the NPK status was low (190 kg ha^{-1}), low (10.5 kg ha^{-1}), high (300 kg ha^{-1}) for available nitrogen [10], phosphorous [11] and potassium [12] respectively.

The field experiment was laid out in split plot design with three replications using *Amaranthus tricolor L. (syn. A.gangeticus)* Variety - CO 2 as a test crop. Selected compost was applied before sowing of crop and recommended NPK [13] was applied as basal. The experimental soil was found to be low in available phosphorus and hence the composts selected (PUSA decomposer and Effective Microorganism's Solution) were enriched with Rock Phosphate and incubated for 25 days before field application.

These municipal solid biowaste composts were applied in main plots at 5 levels *viz.*, M_1 - Control, M_2 - Organic bio compost @5 t ha, M_3 - Organic bio compost @10 t ha^{-1}, M_4 - Enriched bio compost @2.5 t ha^{-1}, M_5 - Enriched bio compost @ 5 t ha^{-1} with the plot size of 3.5 m × 4.5 m. The NPK using inorganic fertilizers were applied in subplots at 3 levels *viz.*, S_1 - Control, S_2 - NPK @ 75%, S_3 - NPK @ 100% and the plot size was 3.5 m × 1.5 m. Biomass yield of Amaranthus in each plot was recorded using 0.25 m^2 quadrant. Within the quadrant, plants were harvested, weighed and the yield was expressed in tonnes per hectare. It helped to find the efficiency of municipal solid biowaste compost in crop production.

2.3 Statistical Analysis

The data collected from both the phases of experiment were subjected to analysis of variance (ANOVA) at a 5% probability level with one-way (Standardization of composting process) and two-way analysis (Field experiment-Amaranthus) using AGRES software. This was statistically scrutinized as per the procedure by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

3.1 Effect of Microbial Inoculants on Maturation Period of Compost

Significant difference was observed among the microbial inoculants on maturation period of compost. The results showed that T_4 (PUSA decomposer) inoculated municipal solid wastes (MSW) matured earlier (35 days) followed by T_5 (Effective Microorganism's solution) and T_6 (RCOF waste decomposer) which recorded 37 days for maturation. The compost prepared with sawdust balls (T_2) recorded longer duration of composting (49 days) which may be due to the higher carbon content. Comparatively, quicker decomposition by PUSA decomposer is due to the higher activity of microorganisms which enhanced the organic matter degradation. Similarly, chander *et al.,* 2018 reported that high microbial activity through the addition of effective cultures reduced the duration of composting and enhanced faster degradation [14]. The details of the influence of microbial inoculants on the maturation period of compost are furnished in Table 1.

3.2 Effect of Microbial Inoculants on Bulk Density of Compost

The bulk density of compost is a simple measure of organic matter decomposition which indicates the volume reduction of finished compost. The bulk density of municipal solid waste increased from 0.29 Mg m^{-3} to 0.60 Mg m^{-3} which indicated the size and volume reduction of municipal solid biowastes. Gabhane *et al.,* 2012 found a significant difference in bulk density among the treatments due to not only the increased degradation rate but also bulking effect of additives added for composting [15] and Shilpa P and Girija D, 2021 recorded a volume reduction of 63 to 70 percent after 80 days of inoculation due to self-heating during the maturation process [6]. However, a high bulk density was recorded in T_4 (PUSA decomposer) inoculated municipal solid biowaste followed by T_5 (Effective Microorganism's solution) and T_6 (RCOF waste decomposer). Significant variations were recorded among the microbial inoculants on bulk density of finished compost and are furnished in Table 2.

3.3 Effect of Microbial Inoculants on Compost pH

The changes in pH of the municipal solid biowaste compost during the composting period exhibited significant variation for different microbial inoculants. The pH of the municipal solid waste increased from 5.97 to 8.01 during the first two weeks of composting. Later on, a significant decrease was observed in pH which might be due to the production of organic acids during composting process. The pH of the raw material decreased at early stage of composting in all the treatments due to the production of organic acids by microbes during fermentation [16]. This lesser pH of the compost coincided with the thermophilic stage (during 2nd week) of composting process where there was a continuous degradation of organic matter. However, the compost prepared with sawdust balls (T_2) recorded a very slow increase in pH indicating a slower rate of organic matter decomposition. The effect of microbial inoculants on compost pH is shown in Fig. 1.

Table 1. Effect of microbial inoculants on maturation period of compost

Treatment		Duration (days)
T_1	Control	42
T_2	Saw dust balls	49
T_3	TNAU Biomineralizer	41
T_4	PUSA decomposer	35
T_5	EM Solution	37
T_6	RCOF Waste decomposer	37
T_7	Microbial Consortia	40
	SEd	0.694
	CD (*P=0.05*)	1.512

Table 2. Effect of microbial inoculants on bulk density of compost

Treatment		Bulk density (Mg/m^3)
T_1	Control	0.375
T_2	Saw dust balls	0.455
T_3	TNAU Biomineralizer	0.469
T_4	PUSA decomposer	0.600
T_5	EM Solution	0.556
T_6	RCOF Waste decomposer	0.556
T_7	Microbial Consortia	0.500
	SEd	0.012
	CD (*P=0.05*)	0.026

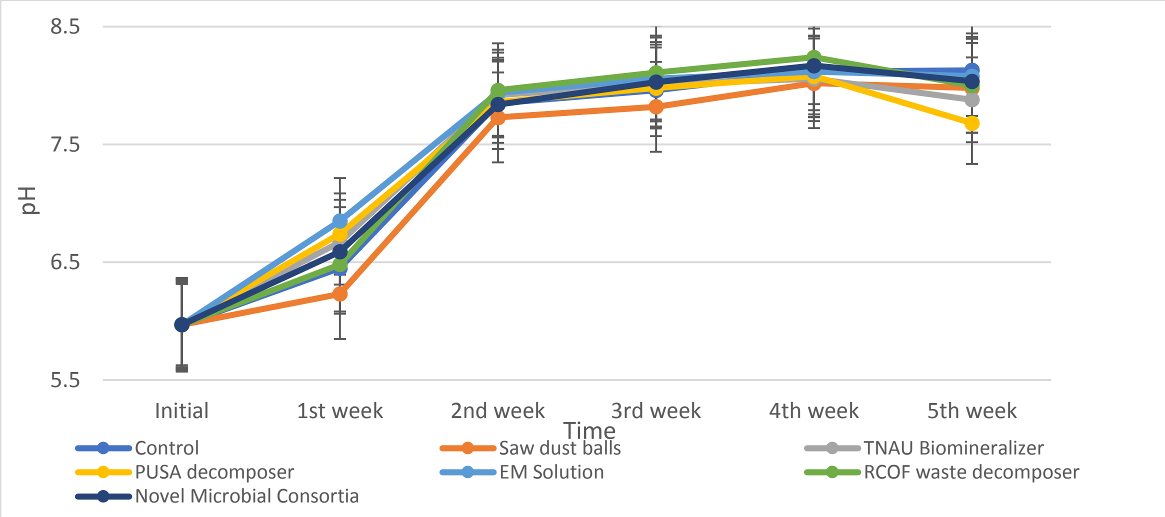

Fig. 1. Effect of microbial inoculants on compost pH

Table 3. Influence of microbial inoculants on nutrient contents of matured compost

Treatments		Total Nitrogen (%)	Total Phosphorus (%)	Total Potassium (%)
T_1	Control	2.94	0.11	0.37
T_2	Saw dust balls	3.38	0.21	0.40
T_3	TNAU Biomineralizer	3.31	0.19	0.43
T_4	PUSA decomposer	3.37	0.14	0.65
T_5	EM Solution	3.36	0.28	0.52
T_6	RCOF Waste decomposer	3.05	0.34	0.38
T_7	Novel microbial Consortia	3.74	0.42	0.48
	SEd	0.061	0.008	0.01
	CD *(P=0.05)*	0.133	0.018	0.02

Table 4. Effect of municipal solid biowaste compost on biomass yield of Amaranthus (t ha^{-1})

Treatments		S_1 Control	S_2 NPK@75%	S_3 NPK@100%	
M_1	Control	11.21	13.52	13.90	
M_2	Organic compost @ 5 t ha^{-1}	11.70	24.20	14.63	
M_3	Organic compost @ 10 t ha^{-1}	13.76	14.50	14.67	
M_4	Enriched compost @ 2.5 t ha^{-1}	12.42	18.51	17.01	
M_5	Enriched compost @ 5 t ha^{-1}	14.75	27.84	18.90	
		M	S	M × S	S × M
SEd		0.255	0.171	0.403	0.382
CD *(P=0.05)*		0.588	0.356	0.876	0.797

3.4 Influence of Microbial Inoculants on Nutrient Contents of Matured Compost

Significantly high amount of total nitrogen (3.74 %) was recorded in T_7 (Novel microbial consortia) incubated compost and low amount of total nitrogen was recorded (2.94 %) in T_1 (control). Microbial degradation and release of nutrients during mineralization may be attributed to the high availability of nutrients in finished compost. Similarly, Patil *et al.*, found that finished compost of various substrates had higher nutritional content than control due to the rapid activity of microbes, which resulted in volume reduction of the material [17]. The total P content was significantly high (0.42%) in novel microbial consortia treated biowastes and the total potassium content (0.65 %) in PUSA decomposer treated biowastes. Phosphorous and potassium content of compost were enhanced during the process, according to Pourmazaheri *et al* (2015) and stated that the loss of volatile carbon and nitrogen during the process could be the cause for the increased levels of P and K [18].The details are furnished in Table 3.

3.5 Effect of Municipal Solid Biowaste Compost on Biomass Yield of Amaranthus

Biomass yield of Amaranthus was significantly influenced by the application of municipal solid waste compost along with recommended inorganic fertilizers. The high biomass yield of 27.84 t ha^{-1} was obtained in the treatment of P enriched compost (5 t ha^{-1}) along with 75% NPK (24.20 t ha^{-1}) followed by the application of organic compost alone (5 t ha^{-1}) along with 75 % NPK. Treatment without the application of compost and inorganic fertilizers recorded a low biomass production (11.20 t ha^{-1}). Application of 5 t ha^{-1} of enriched compost along with 75% NPK produced 59.7 % higher biomass yield than control which might be due to the effect of microorganisms present in compost which increased the utilization of nutrient sources of the crop. Rahman *et al.,* 2012 recorded that combined treatment with biocompost and NPK increased the crop yield [19]. Application of 75% inorganic fertilizer and 25% of nutrient enriched compost recorded high dry matter production and better growth in all stages of crop which was due to the nutrient uptake by the crop [20]. The details of biomass yield of Amaranthus are furnished in Table 4.

4. CONCLUSION

The overall findings of the study indicated that the inoculation of PUSA decomposer @ 4 capsules per tonne of municipal solid biowaste proved to be an effective microbial source for rapid degradation. Thus, reducing the duration of composting from 60 days to 35 days. Further the compost produced by the inoculation of PUSA decomposer recorded significantly high quality and nutrient contents which can be effectively recommended for crop production. Integrated application of municipal solid biowaste compost (5t ha^{-1}) along with inorganic fertilizers (75:25:25 NPK @ 75%) recorded better performance and produced significantly high biomass yield. Thus, the application of municipal solid biowaste compost in crop production might reduce the use of inorganic fertilizers besides proving to be an ecofriendly alternative for sustainable crop production.

ACKNOWLEDGEMENTS

The study was financially supported by the Thoothukudi City Municipal Corporation, Tuticorin, Tamil Nadu, India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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