Vermicompost Production by Using Tomato Residue and Yard Waste

Saroj Klangkongsub
Environmental Science and Technology Program, Faculty of Liberal Arts and Sciences, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand

Prapa Sohsalam
Biology Division, Faculty of Liberal Arts and Sciences, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand
E-mail: tong_saroj@hotmail.com

Abstract—**Tomato residue and yard waste were used as substrate for vermicompost production. These two organic wastes were suitable for feeding Eudrilus eugeniae. *E.* eugeniae was cultivated under four feeding conditions; control (no organic waste added), adding tomato residue, adding grass waste and adding tomato and grass. Vermicomposts from all conditions provided major nutrients (N, P, K) higher than the standard of organic fertilizer. All vermicomposts were applied to Chinese cabbage and zinnia. The results showed that all formula of vermicomposts supported crop plants as good as chemical fertilizer. Vermicomposts may benefits both economical and environmental purposes.**

Index Terms—**waste reduction, tomato residue, yard waste, Vermicompost.**

I. Introduction

Greenhouse gas emission is a global problem which most countries have been concerned. Approximately 85% of solid waste includes food leftovers, rotting fruits, vegetables, leaves, crop residues, animal excreta and bones, which could be recycled [1]. Solid waste disposal on land is the most common method for managing municipal solid wastes in developing countries. The disposal of solid waste can either be performed in good sanitary condition like sanitary landfill or improper manner such as open dumping. In many developing countries, the latter could become predominant mode of operation due to limitation of budget, technical knowledge or awareness of their environmental impact such as leachate and gas formation [2]. In term of gaseous pollution, the decomposition of organic solid wastes at solid waste disposal site cause of landfill gas formation which mainly composed of methane and carbon dioxide. Methane was released higher in developing countries as paddle field cultivation and other decomposition of agricultural wastes. In order to minimize methane emission, methane was used in power plant in many developed countries. However, the green technology is rather limited in developing countries due to financial constraints. As an alternative option, natural methane oxidation reaction in landfill cover soil could be used to help reducing methane emission from these waste disposal activities [3]. Reduction of carbon emission from many food processing factories was also focused. Thailand can produce both fresh and processing tomatoes 1.1 tonnes per year from 54,400,000 m^2 [4]. The tomato wastes from the production and processing of tomatoes were 1,900 to 2,890 tons per year [5]. Tomato wastes were generally open dumped and used as animal feed and biogas production material [6]. Yard waste from trimming was produced in large volume every week. Most of yard waste was grass and usually was dumped in open field. This waste management was also released many greenhouse gasses emission such as CO_2, CH_4 and N_2O by decomposition during open dumping. *Eudrilus eugeniae* is an appropriate vermicomposting earthworm that could decompose various organic wastes even acidic waste from pineapple [7]. The vermicompost contains plant-available nutrients, organic matter, organic amendment and soil conditioner. In general, vermicomposts offered wide range of nutrients such as total N (0.36 - 4 %) total P (0.13 - 4.37 %) and total K (0.22 - 3.74 %) [8], [9].

Utilization of tomato wastes in vermicompost was studied for wastes reduction and value adding of tomato waste. The optimum condition in vermicompost production by using tomato waste and grass to feed *Eudrilus eugeniae* was conducted. Vermicompost was used as fertilizer in Chinese cabbage (*Brassica chinensis*) and Zinnia (*Zinnia violacea* Cav.) planting compared with chemical fertilizer. The plant physical appearances were also investigated.

II. Material and Methods

A. Preparation Earthworms Habitat

The earthworms were cultured in 4 layer plastic drawers. Each drawer was 32 cm × 38 cm × 18 cm in width, length and depth. The 6-small holes (0.5 cm for diameter) were drilled at the top of the first drawer for ventilation and bottom of the first and third for draining and humidity control. Earthworms were cultured in only

Manuscript received May 15, 2013; revised July 13, 2013.

doi: 10.12720/jomb.2.4.270-273

the first and the third drawers and the second and forth drawers were used as liquid collector. The first and third drawers were painted with surfactant at the rim of drawer to protect earthworm escape. The drawers were placed in the indoor and good ventilation. The humidity in each drawer was controlled at 60% by spraying water. Dried dairy cow dung was collected and used as bedding. It was soaked in tap water for 3 hours and air dry on plastic sieve for 3 hours before filling in each drawer for 9 cm depth as bedding [10].

B. *Waste Preparation*

In this study, three types of earthworm feed, tomato residue, grass and tomato residue mix with grass, were compared. Tomato residue from tomato processing was daily collected from Maechuy tomato processing factory from trimming process. Tomato residue was chopped into small pieces (1 cm per piece) before feeding on the bedding. Yard waste from field cutting in Kasetsart University, Kamphaeng Saen campus was weekly collected and selected only grass for feeding earthworm. Fresh wastes were fed every 5 days for each condition. Mixed tomato and grass were one by one proportion.

C. *Earthworm Cultivation*

The 6 month old earthworms were selected. The length, thickness and body weight were measured. The pH and moisture content were daily recorded. Ninety eight earthworms were cultivated in each drawers (the first and third drawers) [10]. The experiments were varied the wastes for 4 conditions. The control condition was not fed any waste and let the earthworm live in bedding. Wastes were fed every 5 day with total mass of 490 g. per time. The tomato waste was fed for 490 g in the second condition and the grass waste was fed for 490 g in the third condition. The last condition, the mixed waste of 245 g. of tomato waste and 245 g. of grass was fed. Each condition was repeated for three times.

D. *Vermicompost Performance Test*

The vermicompost performance was investigated in Chinese cabbage and (*Brassica chinensis*) and Zinnia (*Zinnia violacea* Cav.). Both plant seeds were planted in 10 cm of diameter pot with 4 kg of Kamphaeng Saen soil per pot and was watered by 100-ml tap water every day. The experiment has 4 conditions: (1) vermicompost from tomato, (2) vermicompost from grass, (3) vermicompost from tomato+grass and (4) chemical fertilizer (15-15-15 of N-P-K formula). Vermicompost was applied by 500 g every 10 days after seed germination in condition 1, 2 and 3. In the 4^{th} condition, chemical fertilizer was applied by 20 g every 10 days after seed germination [11]. Each condition was repeated for three times. All plants were cultivated in nursery with 50% of actual light intensity. After 56 day of plant cultivation, these plants were harvested.

E. *Analytical Method*

The bedding pH was daily measured by using thermometer at 5 cm depth. After 45 days, the vermicompost was analyzed for macronutrients, nitrogen, phosphorus and potassium. Nitrogen was analyzed using Kjeldahl method [12]. Potassium was analyzed using Olsen method [13]. Phosphorus was analyzed using Bray I and Bray II method [14]. All earthworms were measured for length, thickness and body weight. All plants were weekly measured for leave number, stem diameter and plant height.

F. *Statistical Analysis*

All statistical analyses were performed using SPSS 16.0 by SPSS Inc. In all cases, significance was defined by $P \leq 0.05$. Test of difference between earthworm feed conditions and between fertilizer performance were tested using a completely randomized design (CRD) analysis of variance (ANOVA) with a posterior LSD.

III. Results and Discussion

A. *Earthworm Appearance*

After 45 days of experiments, pH of bed in each condition was not different (Fig. 1). The pH range of all conditions were 7-8 which were same range of previous reports [10], [15]. This pH was suggested as the optimum condition for *Eudrilus eugeniae* growth [10].

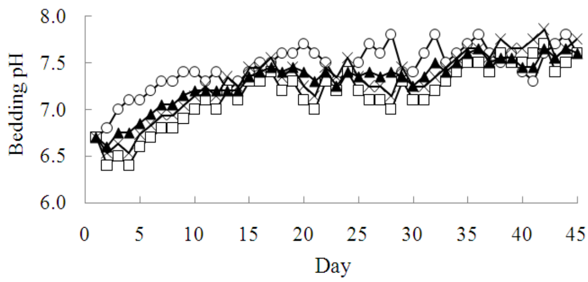

Figure 1. Bedding pH during *Eudrilus eugeniae* cultivation with ○ control, □ tomato, X grass and ▲ tomato+grass

The earthworms thickness was highest in feeding with grass significantly (Fig. 2). The thickness was depend on earthworm age. The young earthworm showed smaller thickness than old earthworm [10]. During 45 days of cultivation, presence of the young earthworm may because of they were offspring of the initial earthworms.

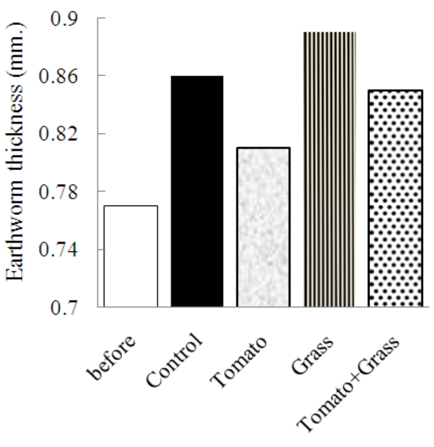

Figure 2. The thickness of *Eudrilus eugeniae* after 45 days of cultivation. Symbol; □ before, ■ control, tomato, grass and tomato+grass

The longest earthworm was found in feeding with tomato, grass and tomato+grass (Fig. 3). This may results of additional nutrient from tomato and grass that promote the length of earthworm significantly. Earthworm weight with organic waste mixed was higher than control and the weight was highest in feeding with grass significantly (Fig. 4).

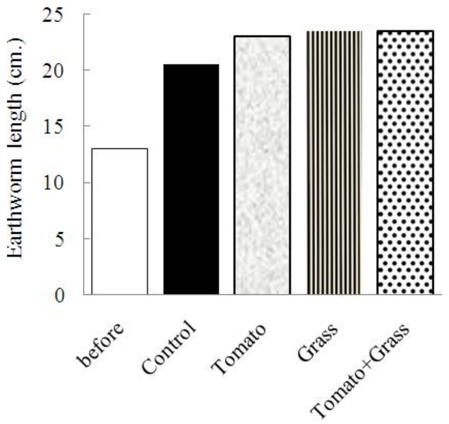

Figure 3. The length of *Eudrilus eugeniae* after 45 days of cultivation. Symbol; ☐ before, ■ control, tomato, grass and tomato+grass

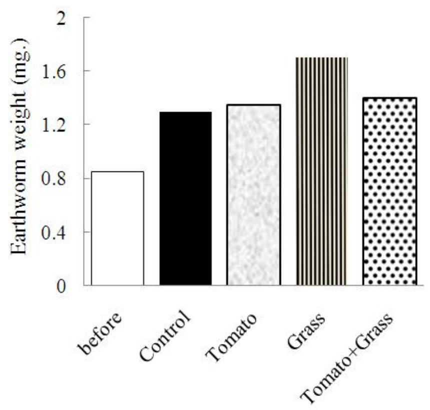

Figure 4. The weight of *Eudrilus eugeniae* after 45 days of cultivation. Symbol; ☐ before, ■ control, tomato, grass and tomato+grass

B. Vermicompost Quality

Nitrogen, phosphorus and potassium in all vermicompost in this study showed the higher value than standard of organic fertilizer (Table I) [11]. Nitrogen and phosphorus content in vermicompost from waste feeding was significantly higher than control condition. The highest N and P content were found in vermicompost from tomato+grass feeding. While potassium was low in vermicompost from grass and tomato+grass.

Vermicompost production using *Eudrilus eugeniae* under 30 ^{o}C condition provided higher macronutrient than under 20 ^{o}C condition. Comparing with vermicompost production from various wastes, agricultural waste such as tomato residue and yard waste gave higher nitrogen content than biodigest slurry, pressmud, cowdung combined with weed. While phosphorus and potassium content were similar. The nutrient content in vermicompost varied due to different kind of input materials used [16].

TABLE I. THE AMOUNT OF NUTRIENTS FORM VERMICOMPOST.

Treatment	Total N(%)	Total P (%)	Total K(%)
control	1.02^{a}	0.05^{a}	0.79^{a}
Grass	1.46^{b}	0.77^{b}	0.77^{a}
Tomato	1.37^{c}	0.68^{c}	0.68^{b}
tomato+grass	1.57^{d}	0.89^{d}	0.68^{b}
STD*	>1.00	>0.05	>0.05

Remark: Mean followed by the same letter in the same column are not significantly different at P = 0.05
* Standard Organic Fertilizer [11]

C. Vermicompost Performance

Chinese cabbage and zinnia was planted for 56 days. In Chinese cabbage, chemical fertilizer gave the higher quality in number of leave and stem diameter than vermicompost significantly (Table II). Plant height was not significantly different in all fertilizer types. All formula of vermicompost showed the similar result of Chinese cabbage growth. The color of Chinese cabbage was not significantly different in all type of fertilizers. The interference from insects, worms and diseases were not found.

TABLE II. EFFECT OF TYPE OF VERMICOMPOST ON CHINESE CABBAGE AT 56 DAYS OF CULTIVATION

	Control	Tomato	Grass	Tomato +grass	Chemical fertilizer
Number of leave	6.67^{a}	6.33^{a}	6.33^{a}	6.67^{a}	7.33^{b}
Plant height (cm)	6.83^{a}	6.73^{a}	7.00^{a}	6.97^{a}	7.13^{a}
Stem diameter (cm)	6.88^{a}	6.99^{a}	6.97^{a}	6.84^{a}	8.46^{b}

Remark: Mean followed by the same letter in the same row are not significantly different at P = 0.05

In zinnia, chemical fertilizer also gave the higher quality in number of leave than vermicompost significantly while plant stem diameter was not difference (Table III). Plant height was significantly different in all fertilizer types. Plant with chemical fertilizer application had shown the highest plant height, followed by vermicompost from tomato, grass, control and tomato+grass, respectively. All fertilizer had shown non-significant difference performance on stem diameter. In day 3-7, zinnia was interfered by ants but there was not any interference after 10 days of cultivation.

TABLE III. EFFECT OF TYPE OF VERMICOMPOST ON ZINNIA AT 56 DAYS OF CULTIVATION

	Control	Tomato	Grass	Tomato +grass	Chemical fertilizer
Number of leave	10.33^{a}	10.33^{a}	10.00^{a}	10.33^{a}	10.67^{b}
Plant height (cm)	23.93^{a}	24.43^{b}	24.10^{b}	22.97^{c}	26.00^{d}
Stem diameter (cm)	1.84^{a}	1.87^{a}	1.77^{a}	1.78^{a}	1.79^{a}

Remark: Mean followed by the same letter in the same row are not significantly different at P = 0.05

IV. Conclusion

Waste from tomato processing and yard waste especially grass could be used for vermicompost production and provide the high quality vermicompost than the organic fertilizer standard. The physical condition such as pH could promote earthworms growth until they could lay egg and produced new generation. Edible plant, Chinese cabbage showed the satisfaction appearance after vermicompost was applied. The results in flower plants zinnia were also at satisfied level. Application of vermicompost was studied in various plants such as rice, legume, marigold, upland cress, radish, tomato and strawberry [16]-[20]. The result showed that plant yield was not different when compared with conventional fertilizer and sustained soil heath. Furthermore, utilization of organic waste for vermicompost production may able to reduce organic waste, GHG emission and increase the income for farmers.

Acknowledgement

The authors express our sincere gratitude to The Graduate School Kasetsart University for the financial and equipment support for this study. We also express the deeply thank for Thailand Research Fund for research fund in the TRF-MAG program.

References

[1] R. Asomani-Boateng and M. Haight, "Reusing organic waste in urban farming in African cities: A challenge for urban planners," in *Urban Agriculture in West Africa Contributing to Food Security and Urban Sanitation. International Development Research Centre/Technical Centre for Agricultural and Rural Cooperation ACP-EU*, O. B. Smith, Ed., Ottawa, Canada/Wageningen, Netherlands, 1999, pp. 138–154.

[2] AIT, Municipal Solid Waste Management in Asia, *Asian Regional Research Program on Environmental Technology, Asian Institute of Technology*, 2004, pp. 108.

[3] M. Huber-Humer, J. Gebert, and H. Hilger, "Biotic systems to mitigate landfill methane emissions," *Waste Management & Research*, vol. 26, pp. 33–46, 2008.

[4] A. Jounsakoon, "Agricultural statistics of Thailand 2012," Office of Agricultural Economics Bangkok Thailand, 2012.

[5] J. S. na Ayuttaya, "Use of tomato wastes for feed," in *Proc. Animal Nutrition Division of Department of Livestock Development*, N. D. Bangkok, Thailand, 2005, pp. 396-402.

[6] V. Nuchpamoon, "Fermentation of tomato air pulp two steps," Ph.D. Thesis Biochemical, Srinakharinwirot University, Prasarnmit, Thailand, 1991.

[7] N. O. K. Mainoo, J. K. Whalen, and S. Barrington, "Earthworm abundance related to soil physicochemical and microbial properties in Accra, Ghana," *African Journal of Agricultural Research*, vol.3, pp.186-194, 2008.

[8] E. Aranda, I. Barios, P. Arellano, S. Irisson, T. Salazar, J. Rodriguez, and J. C. Patron, "Vermicompost in the tropic," in *Earthworm Management in Tropical Agro-Ecosystems*, P. Lavelle, L. Brussard, P. Hendrix, Eds., CABI Publishing, Wallingford, UK, 1999, pp. 253-288.

[9] B. Kaviraj and S. Sharma, "Munucipal solid waste management through vermicomposting employing exotic and local species of earthworm," *Bioresource Technology*, vol. 90, pp.169-173, 2003.

[10] A. Tuncho, "Manual for vermicompost production from organic waste," Trio Advertising and Media Co.,Ltd., 2010, pp. 114.

[11] J. Prasitket, N. Chuvorrivate, M. Ruengnab, T. Padung, P. Choulvanapong, and S. Reanjareang, "Organic fertilizer: Production, utilization and quality," *Department of Agriculture*, 2005, pp. 87.

[12] J. M. Bremner and C. S. Mulvaney, "Method of soil analysis," in *American Society of Agronomy*, J. M. Bremner, C. S. Mulvaney, Eds, Soil Science Society of America Publisher, Wisconsin. Nitrogen-Total, 1982, pp. 598-624.

[13] Land Development Department, "Analysis of soil chemical processes," Land Development Department Bangkok Thailand, pp. 4-6, 2010.

[14] J. M. Bray and L. T. Kurtz, "Determination of total organic and available forms of phosphorus in soil," *Soil Sci*, vol. 59, 1945, pp. 39-45.

[15] O. K. Nana Mainoo, B. Suzelle, K. Joann, and S. Luis, "Pilot-scale vermicomposting of pineapple wastes with earthworms native to Accra, Ghana," *Bioresource Technology*, vol. 100, pp. 5872-5875, 2009.

[16] A. Jayabal and G. Kuppauswamy, "Recycling of organic waste for the production of vermicompost and its response in rice-legume cropping system and soil fertility," *European Journal of Agronomy*, vol. 15, pp. 153-170, 2001.

[17] P. R. Warman and M. J. AngLopez, "Vermicompost derived from different feedstock as a plant growth medium," *Bioresource Technology*, vol.101, pp. 4479-4483, 2010.

[18] A. Federico, Guitierrez-Miceli, J. Santiago-Borraz, J. A. M. Molina, *et al.*, "Vermicompost as a soil supplement to improve growth, yield and fruit quality of tomato (Lycopericum esculentum)," *Bioresource Technology*, vol. 98, pp. 2781-2786, 2007.

[19] S. Rajbir, R. R. Sharma, K. Satyendra, R. K. Gupta, and R. T. Patil, "Vermicompost substitution influence growth, physiological disorders, fruit yield and quality of strawberry (Fragaria x ananassa Duch.)," *Bioresource Technology*, vol. 99, pp. 8507-8511, 2008.

[20] G. Z. Johann, "Vermicompost as a substitute for peat in potting media: Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties," *Scientia Horticulturae*, vol. 112, pp. 191-199, 2007.

Mr. Saroj Klangkongsup (B.Sc., Agriculture) was born on August 22, 1984, he is now 27 years old. He finished the Bachelor degree in 2006 from Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand from Department of Agricultural in major of extension and communication. Now he is studying in Master degree of Environmental Science and Technology Program, Faculty of Liberal Arts and Sciences, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand.

He worked for division of science at Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus during 2009-2010. He has worked as assistant monitor in recycle factory in Thailand for Recycle factory examination project of Department of Industrial Work during July to September, 2012