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Research Article
Effect of Agricultural Waste on Vermicompost Production and Earthworm Biomass

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Abstract
Background and Objectives: Vermicompost known as one of the natural organic fertilizers, which were commonly available to plant and environmental friendly. The objectives of this study was to produce vermicompost from agricultural waste by using *Eudrilus eugeniae* (*E. eugeniae*). The qualities of vermicompost and biomass of *E. eugeniae* were also investigated. **Materials and Methods:** About 100 g of *E. eugeniae* were cultivated in plastic containers (40×40 cm) with 2 kg of various types of agricultural waste. After 60 days of cultivation, biomass of *E. eugeniae* and nutrient contents in vermicompost were determined. **Results:** Vermicomposts produced by *E. eugeniae* had high major nutrient contents consisting of 1.108% nitrogen, 0.669% phosphorus and 1.318% potassium. Specially, all treatments showed major nutrient values of vermicomposts which were higher than those of standard organic fertilizers. Furthermore, *E. eugeniae* had the overall biomass after 60 days of cultivation, which rose to 28.33-104.67% compared to its initial weight. **Conclusion:** The data provided new evidence that agricultural waste, especially soybean meal could be used as feeds for the high quality of vermicompost production and earthworm biomass. Thus, vermicompost producing from agricultural waste was a new source of nutrients in addition to organic compost and chemical fertilizers.

Key words: Bio-fertilizer, vermicompost, *Eudrilus eugeniae*, agricultural waste, chemical fertilizer

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Agricultural and livestock waste has been difficult to manage due to the large scale of agriculture such as rice fields, livestock and increasing population. Such waste can be naturally decomposed in environment. However, the decomposition may cause pollution to environment or human diseases. Recycling waste to be organic fertilizer is one of the popular methods for waste management[1]. Transforming industrial waste into organic fertilizer without chemical pollutants is also intriquing[2]. The production of organic fertilizer from earthworms by using organic waste as raw materials was called vermicompost. It was natural organic fertilizer that was generally available to plants[3]. It contains a lot of macro and micro nutrients, such as nitrogen, potassium, phosphorus, calcium and magnesium. In addition, vermicompost is more advantageous than conventional organic compost in terms of odorless, adjustable pH and low electrical conductivity[4]. Using vermicompost in lieu of chemical fertilizer is a new and promising choice for sustainable agriculture.

Atleast 3,000 species of earthworms have been identified. However, *Eudrilus eugeniae* was popular according to its ability to play an active role in converting agricultural waste to fertilizer. This evidence was proved by many researchers[4,5]. Also, earthworms were able to increases the rate of decomposition during vermistabilization of agricultural waste[6]. Earthworm biomass could be increased while the carbon substrates were decreased to nitrogen nutrients in final feed mixtures. Organic waste is a rich source of nutrients suitable for earthworm's growth and the production of biomass. Earthworms consumed various types of agricultural waste, such as vegetable waste, cattle dung, soybean meals, agricultural residue, sewage sludge and other industrial refuse[7].

Many researchers reported that the biochemical quality of raw materials affected the amount of the earthworm biomass and vermicomposting[2,8,9]. Biological fertilizer, vermicompost could be harvested from different kinds of agricultural waste and varying species of earthworms. The vermicompost helped to boost the net yields of several crops, such as baby corn and cassava. The application of vermicompost could be used in plantation fields in order to reduce chemical fertilizer in environment[10]. Producing vermicompost could be adjusted to find suitable and optimal conditions for earthworm cultivation to a high quality of fertilizer for plantations. Generally, vermicompost at high concentration was able to stimulate the number of soil microorganisms in agricultural fields as well as providing nutrients for plant cultivation[11-13].

This study aimed at investigating the effect of diverse sources of agricultural waste on the growth of earthworms in species of *E. eugeniae* (African night crawler). Additionally, the quality of final vermicompost (nutrient status) in each treatment was also studied.

MATERIALS AND METHODS

Earthworms: Earthworm *Eudrilus eugeniae* was chosen as the vermicomposter in this research. Earthworms *E. eugeniae* was bought from a farm in Kamphaeng Saen, Nakhon Pathom province, Thailand. About 8 kg of *E. eugeniae* worms were used in this study. The experiment was done during May-December, 2017 at Faculty of Science and Technology, Phranakhon Rajabhat University.

Agricultural waste: Six types of agricultural waste, namely cow dung, elephant dung, coconut shell's hair, watermelon peel, soybean meal, coffee ground were used as earthworm feeds. In this study, 16 kg of dry agricultural waste were used as feeding substances for earthworms within 60 days of vermicomposting period.

Earthworm cultivation: The bedding materials consisting of coconut shell' hair, cow dung and elephant dung were pre-compost in windrows until temperature was cooled down and toxic gas disappeared before doing earthworm cultivation. The initial temperature and moisture content of bedding and feeding were 30-35 °C and 60-70%, respectively. The experimental designs were completely randomized with 8 treatments. Each treatment had 3 replications, the total of which was 24 sample units as showed in Table 1. Plastic containers by the size of 40×40 cm were used to study the vermicompost from earthworms. About 100 g of *E. eugeniae* was added to the cultivated containers. A total of 2 kg agricultural waste was fed to worms every 3 days with 100 g for each time of feeding. After cultivating for 60 days, the total weight of earthworm was determined. Vermicompost nutrients were also investigated. Each condition was repeated for 3 times.

Vermicompost analysis: After 60 days of cultivation, the vermicompost was separated from earthworms by hand and then both of them were weighted. The chemical analysis of vermicompost was done to study parameters such as pH, organic matter, electrical conductivity (EC) and macronutrients: Nitrogen, phosphorus and potassium. The pH value was tested by employing 10 g of vermicompost from each container. Then, the vermicompost was mixed with 1 L of distilled water and left at room temperature for 30 min.

The vermicompost suspension was determined by pH meter. Electrical conductivity was studied from the vermicompost suspensions as well by using a conductivity meter. Organic matter content was analyzed by chromic acid titration[14]. Nitrogen was analyzed with Kjeldahl method[15]. Olsen method[16] was utilized to study potassium. Phosphorus was investigated by Bray I and Bray II method[17].

Statistical analysis: All statistical analyses were performed by SPSS 10.0. The significance was defined by $p \leq 0.05$. Tests of differences among earthworm feed treatments were identified by using a completely randomized design (CRD) analysis of variance (ANOVA) with a posterior LSD.

RESULTS AND DISCUSSION

Earthworm growths: After 60 days of vermicompost production, weight of *E. eugeniae* was calculated. The highest weight of *E. eugeniae* was 210 g, which is from treatment 7 (T7) having coconut shell's hair, elephant dung and soybean meal as shown in Table 1. However, the weight of *E. eugeniae* from T7 was not significantly different from those of T3. The T3 had coconut shell's hair, cow dung, soybean meal with 204.67 g of the earthworms. According to Table 1, the weight of *E. eugeniae* increased by 104.67% compared to its initial earthworm weight. This might imply that soybean meal had more considerable effect on *E. eugeniae* growth than elephant and cow dung. Such effect occurred because soybean meal contained richer nutrients than animal dung. Additionally, watermelon peel and coffee ground showed the lowest influence on the growth of *E. eugeniae* (T2, T4, T6, T8). Nevertheless, the weight of *E. eugeniae* from all the treatments increased from the original weight in the range of 28.33-104.67%. This finding was supported by Zularisam *et al.*[7] and Petmuenwai *et al.*[18]. Their results also revealed that approximately 35-38% of earthworm weight was increased when sewage sludge was utilized as feed materials.

Vermicompost qualities: The macro nutrients of vermicompost were nitrogen, phosphorus and potassium. They could be found from treatment 3 (T3) (coconut shell's hair, cow dung, soybean meal) and from T7 (coconut shell's hair, elephant dung, soybean meal). These two treatments showed the highest values of macro nutrients as showed in Table 2. This result displayed that soybean meal was suitable feeding materials to increase the weight of earthworm because of its nitrogen-rich organic waste. Earthworm farms would get benefits from this result because a kilogram of earthworms was inexpensive. When earthworms ate the waste from the two treatments, they excreted vermicompost containing a high level of nitrogen, phosphorus and potassium. In contrast, T4 and T8 comprising of coffee ground

Table 1: Growth rate of *Eudrilus eugeniae* after 60 days of cultivation by using various kinds of agricultural waste

Treatments	Weight of earthworm (g)
T1: Coconut shell's hair, cow dung	158.00^{ab}
T2: Coconut shell's hair, cow dung, watermelon peel	151.33^{ab}
T3: Coconut shell's hair, cow dung, soybean meal	204.67^{c}
T4: Coconut shell's hair, cow dung, coffee ground	165.00^{ab}
T5: Coconut shell's hair, elephant dung	128.33^{a}
T6: Coconut shell's hair, elephant dung, watermelon peel	137.67^{ab}
T7: Coconut shell's hair, elephant dung, soybean meal	210.00^{c}
T8: Coconut shell's hair, elephant dung, coffee ground	167.00^{b}
F-test	**
CV (%)	19.55

Mean followed by the same letter in the same column are not significantly different at p = 0.05, **Highly significant

Table 2: Chemical characteristics of vermicompost after 60 days of *Eudrilus eugeniae* cultivation with diverse sorts of agricultural waste

Treatments	pH	EC (mS cm^{-1})	Organic matter (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T1	7.20	3.653^{bc}	57.91	1.058^{b}	0.606^{de}	0.977^{b}
T2	7.04	5.040^{cd}	54.25	0.995^{ab}	0.544^{cd}	0.944^{ab}
T3	6.46	5.053^{cd}	54.40	1.093^{b}	0.742^{f}	1.487^{c}
T4	7.19	1.945^{ab}	56.50	1.006^{ab}	0.409^{b}	0.723^{ab}
T5	7.22	1.556^{a}	56.24	0.847^{a}	0.453^{bc}	0.935^{ab}
T6	6.97	4.373^{cd}	54.56	0.884^{ab}	0.546^{cd}	0.902^{ab}
T7	6.24	6.183^{d}	58.11	1.108^{ab}	0.669^{ef}	1.318^{c}
T8	6.80	1.264^{a}	57.61	0.886^{ab}	0.291^{a}	0.678^{a}
F-test	ns	**	ns	**	**	**
CV (%)	10.34	53.72	7.17	11.49	28.30	29.00

Mean followed by the same letter in the same column are not significantly different at p = 0.05, **Highly significant, ns: Not significant, EC: Electrical conductivity demonstrated a low level of nitrogen, phosphorus and potassium in vermicompost. The quality of vermicompost was classified based on its macro nutrient content, such as nitrogen (N), phosphorous (P) and potassium (K). In this study, the nitrogen content was found highest in the treatment with soybean meal feeding. Such feeding from T7 and T3 yielded 1.108 and 1.098% nitrogen, respectively.

Particularly, all of the vermicompost obtained from this study also produced higher values of nitrogen than the standard organic fertilizer with the values of 1.00, 0.05 and 0.05%, respectively[19,20].

Electrical conductivity (EC) refers to the salinity of soil organic matters and bio-fertilizers. EC values of all vermicompost in this research were 1.264-6.183 mS cm^{-1}. In T3 and T7 in which a high level of major nutrients was spotted exhibited high values of EC. Their values were 5.053 and 6.183 mS cm^{-1}, respectively. The high values might result from the release of mineral salts such as potassium, ammonium and phosphates from vermicompost. The EC value of vermicompost was a good indicator for agriculture, supporting by many researchers. Some researchers reported that during the vermicomposting process EC values decreased[21,22], while others found an increase in EC values[23,24]. Usually, EC values of vermicompost should not be more than 4 mS cm^{-1} to safely apply to agricultural fields[25].

Organic matters and pH of vermicompost after 60 days cultivation of *E. eugeniae* in each treatment were not different. Almost pH was slightly acidic to slightly alkaline (5.04-7.22). The vermicompost contained high percentages of organic matters, which were in the range of 54.25-58.11%, whereas, pH were 6-7 which were similar to previous reports[7,26]. This study will help the researcher to uncover the critical areas of biofertilizer production for plant production with environmental friendly. Thus a new information on development of vermicompost quality may be arrived at.

CONCLUSION

All agricultural waste, especially soybean meal could be used as feeds for *E. eugeniae* for high quality of vermicompost production compared to organic fertilizer standard of Thailand. Vermicompost which was obtained from soybean meal showed the highest level of major nutrients, namely nitrogen, phosphorus and potassium. Soybean meal also increased the biomass of *E. eugeniae* from the initial process, resulting in high commercial values. Thus, farmers can use vermicompost produced from agricultural wastes in place of chemical fertilizers to reduce cost in agriculture. Moreover, earthworm biomass can be sold for more income.

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