VERMICOMPOSTING FROM CASSAVA BAGASSE AND RICE BRAN BY USING *PERIONYX EXCAVATUS*

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ABSTRACT

Unprocessed cassava bagasse from starch factories in Vietnam created pollution issue and should therefore be utilized to minimize its effects on environmental management. In the present study, cassava bagasse was used as a substrate for *Perionyx excavatus* mediated-vermicomposting. Rice bran was added as a supplement in feeding of *P. excavatus* and the ratio of 3 cassava bagasse to 1 rice bran (w/w) was observed to give the highest biomass yield. Other optimal conditions included pH 5-7, temperature 26-29 ^oC and soil moisture 80-85%. After 60 days surveyed, vermicompost quality was similar to certain quality standards for organic fertilizer, including: total organic carbon (TOC) 22.69 %, total kjeldahl nitrogen (TKN) 1.80%, the C/N ratio of 12.63%, P_2O_5 4.67% and K_2O 1.91%. These results suggest a potential and inexpensive approach to manage environmental problems of cassava bagasse via *P. excavatus* mediated vermicompost and simultaneously provide a new fertilizer resource for agriculture.

Keywords: Vermicomposting, *Perionyx excavatus*, cassava bagasse, rice bran.

1. INTRODUCTION

Vermicomposting is increasingly gaining attention as it manages all types of biodegradable wastes including wastes from farms, kitchens, markets, live-stock etc. [1]. In vermicomposting, earthworms play an important role in improving the soil health and nutrients which are derived from wastes-converted substances. Therefore, by vermicomposting, solid organic wastes from daily life can be converted to organic fertilizers which might become an alternative solution for synthetic ones that currently cause many risks to environment [2].

According to Food and Agriculture Organization (FAO), cassava crops are important to developing countries after rice, corn and wheat. In Vietnam, cassava is the second largest crop, after rice, but only 55% of total cassava roots can be used in starch processing plants. Its bagasse is improperly used and might create local pollution issues [3-4].

Perionyx excavatus is the earthworm essential to nature, livestock as well as in farming [5]. They convert insoluble organic waste into soluble organic substances, which are believed to facilitate nutrient uptake in plants. Furthermore, the supplement of rice bran in raw materials might enhance earthworm activity during vermicomposting and upgrade fertilizer quality [6]. *P. excavatus* has been used in many applications such as cattle wastes, or industrial wastes or heavy metal remediation [7-13]. Moreover, *P. excavatus* are also used for weed, leaf, mushroom or household waste management [1, 14-16]. However, there is no evidence about *P. excavatus* application in cassava bagasse mediated-vermicompost. Therefore, in this study, we investigated the utilization of cassava bagasse in natural fertilizer generation by *P. excavatus*.

The supplement of rice bran in raw materials in attempt to increase vermicomposting yield was also examined. The study would be a very low-cost, new accessible and effective approach to cassava bagasse management in starch processing factories.

2. MATERIALS AND METHODS

2.1. Materials

The earthworm *Perionyx excavatus* was obtained from *P. excavatus* joint-stock Co., Ltd, Cu Chi District, Ho Chi Minh City (HCMC). Cassava bagasse was collected at Tan Truong Hung Co., Ltd, Tay Ninh province. Rice bran was purchased from Rico Feed, District 2, HCMC.

2.2. Methods

2.2.1. Sample preparation

P. excavatus was adapted to environmental conditions for 2 weeks prior to study. Cassava bagasse (CB) mixed with rice bran (RB) at the indicated ratios (w/w). CB only; 3CB:1RB; 1CB:1RB; 1CB:3RB and RB only were fed to *P. excavatus* within 60 days before further analysis.

2.2.2. Vermicompost preparation

A process to making vermicompost model was described in Figure 1. In brief, a layer of pebbles was put above a layer of sand, followed by a sieve (1). Next, biomass containing *P. excavatus* was put upper the sieve (2). Cassava bagasse/ rice bran were added as substrates for feeding (3). After 60 days, vermicompost was collected for further analysis (4).

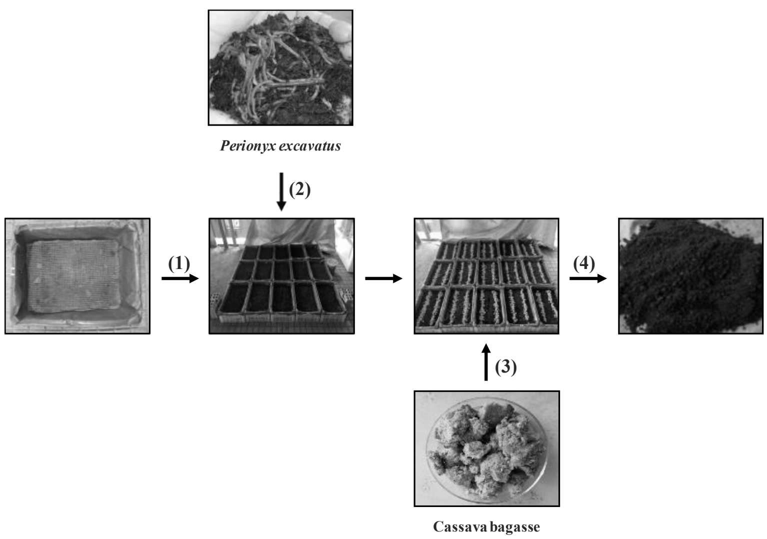

Figure 1. Process of making *Perionyx excavatus* mediated-vermicompost

2.2.3. Determination of total organic carbon in soil

The soil carbon proportion was determined by total organic carbon (TOC), followed by methods described in Walkley procedure [17].

2.2.4. Determination of N-P-K in soil

N-P-K in soil represented by total kjeldahl nitrogen (TKN), phosphorus pentoxide (P_2O_5) and potassium oxide (K_2O) which were determined according to the laboratory guide for conducting soil tests and plant analysis [18].

2.2.5. Evaluation of growth condition

During 60 days of survey, growth conditions for vermicompost-proceeding were evaluated based on the criteria for evaluation listed in Table 1.

Table 1. Criteria for vermicompost evaluation

No.	Criteria	Frequency
1	Temperature	Daily
2	pH value	Once per week
3	Soil moisture	Once per week
4	Total organic carbon (TOC)	Before & After survey
5	Total kjeldahl nitrogen (TKN)	Before & After survey
6	C/N ratio	Before & After survey
7	P_2O_5	Before & After survey
8	K_2O	Before & After survey

2.2.6. Statistical analysis

The experiments were conducted in triplicate and data were expressed as mean ± SD (Standard deviation). Experimental differences were examined using ANOVA and Student's *t*-tests, as appropriate by GraphPad Prism 6.01. The *P values* of less than 0.05 were considered to indicate statistical significance.

3. RESULTS

3.1. The ingredients of raw materials

The ingredients in raw materials (cassava bagasse and rice bran) were evaluated and the results were illustrated in Table 2.

Table 2. The ingredients of raw materials

Content	Cassava bagasse	Rice bran
TOC (%)	36.79 ± 0.16	19.72 ± 0.15
TKN (%)	0.34 ± 0.02	1.53 ± 0.07
P_2O_5 (%)	0.12 ± 0.02	0.23 ± 0.02
K_2O (%)	0.064 ± 0.003	0.059 ± 0.006

Table 2 indicated that C/N ratio in cassava bagasse is much higher than in rice bran (108.21 and 12.89, respectively). These high ratios of C/N showed the potential of materials, which can be substrates for *P. excavatus*. Many reports indicated that rice bran was capable of activating useful microorganism in soil which in turns might help for *P. excavatus* growth [19]. Therefore, in this study, various combinations between cassava bagasse (CB) and rice bran (CB) were selected for vermicomposting.

3.2. Effects of cassava bagasse and rice bran on *P. excavatus* growth condition

The addition of cassava bagasse and rice bran was observed to have negligible effects on growth condition of *P. excavatus (*data not shown). Results revealed that temperature of the vermicompost model in range of 26-29 ºC, pH varied from 4.9 to 7.1 and the soil moisture content was about 78-90% which are well correlated to other studies [1].

3.3. Effects of combination of cassava bagasse and rice bran on *P. excavatus* biomass

The effects of rice bran supplement on *P. excavatus* biomass yield were addressed by using different ratios of cassava bagasse and rice bran. Figure 2 showed that there was no significant change in biomass between the use of only CB/1CB-3RB and only RB. In contrast, the combinations of 3CB-1RB or 1CB-1RB increased biomass significantly as compared to CB supplement only (*P value* < 0.001 and *P value* < 0.05, respectively). This data suggested that either CB or RB supplement can be the food source for *P. excavatus* and the low ratio of RB has positive effects on enhancement of CB-fed *P. excavatus* biomass yield.

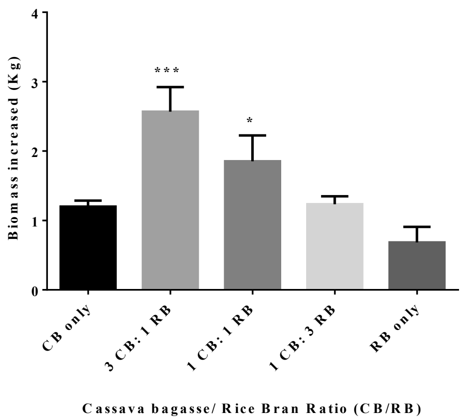

Figure 2. Effects of cassava bagasse/rice bran ratio on biomass yield

3.4. Effects of cassava bagasse and rice bran combination on C/N ratio

Due to increases of *P. excavatus* biomass by combination of cassava bagasse and rice bran (Figure 2), it is supposed that there was a shift in C/N ratio, which can be figured out by measurement of TOC and TKN. Data showed that the proportion of organic carbon was reduced in all cases, especially when using only CB or 3CB-1RB and the lowest change was obtained in case of only RB. In contrast, the level of nitrogen was upregulated as CB proportion in supplement increase (Figure 3A). Furthermore, the C/N ratio was also reduced after 60 days of inoculation in all combinations and this trend was clearly observed with the use of only CB and 3CB-1RB group (Figure 3B). These data suggested that the change of C/N ratio is differently varied, depending on CB proportion and the use of only CB or 3CB-1RB seems to be optimal C/N ratio during vermicomposting.

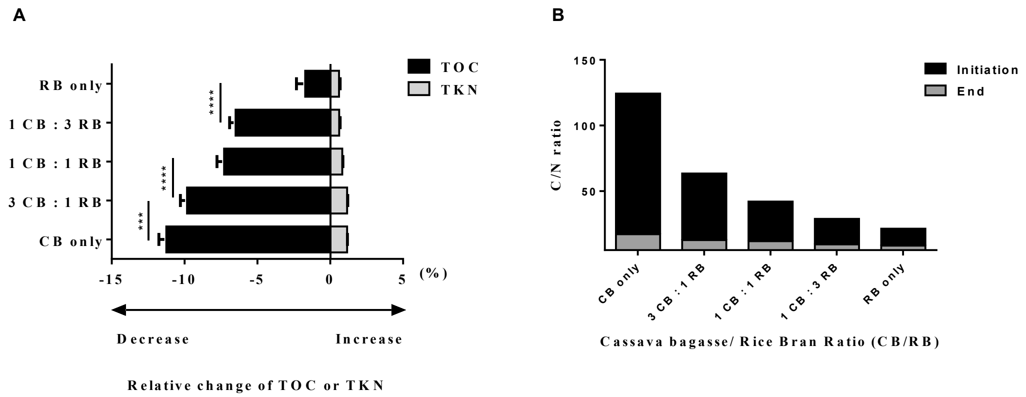

Figure 3. Effects of cassava bagasse and rice bran combination on C/N ratio

3.5. Effects of rice bran supplement in raw materials on percentage of P_2O_5 in vermicompost

Nitrogen, phosphorus and potassium (N-P-K) are the main nutrients that qualify vermicompost since their effects on plant growth and health [20]. Nitrogen helps plant growing strong leaf, whereas phosphorous is essential to root or early plant growth and seed formation and potassium helps plant against disease or stress. Therefore, N-P-K content in soil are of great concern in fertilizer evaluation. In this study, the effects of supplement of rice bran in raw materials on percentage of vermicomposting P_2O_5 were investigated with different combinations of cassava bagasse and rice bran. Results showed that the levels of P_2O_5 were significantly increased when rice bran (RB) was supplemented as compared to the use of only cassava bagasse (CB) and RB ratio was inversely proportional to P_2O_5 enhancement (Figure 4). However, there was no significant change of K_2O in all cases. This data suggested that the supplement of RB (3CB-1RB or 1CB-1RB) in raw materials helps increase P_2O_5 in vermicompost.

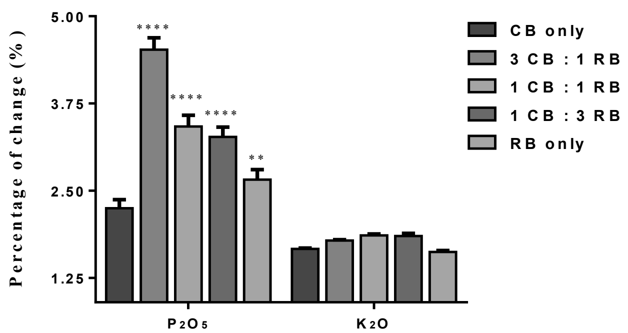

Figure 4. Effects of rice bran supplement in raw materials on percentage of vermicomposting P_2O_5

3.6. Summary of *P. excavatus* mediated vermicompost quality

From the data above, the ratio of 3 cassava bagasse:1 rice bran (3CB-1RB) resulted in vermicompost with the highest biomass yield, high C/N ratio and proper amount of P_2O_5 for vermicompost. As shown in Table 3, the vermicompost quality from 3CB-1RB is comparable to reference indexes.

Table 3. Quality of vermicompost after survey

No.	Criteria	Quality of vermicompost from 3CB:1RB after 60 days	Reference Index (Adhikary, 2012)	Conclusion
1	Temperature (ºC)	26-29	10-32	Suitable
2	pH value	6.6	7	Acceptable
3	Soil moisture (%)	78.06-90.07	32-66	Higher
4	TOC (%)	22.69	9.8-13.4	Higher
5	TKN (%)	1.8	0.51-1.61	Higher
6	C/N ratio	12.61	20.09	Lower
7	P_2O_5 (%)	4.67	0.19-1.02	Higher
8	K_2O (%)	1.85	0.15-0.73	Higher

4. DISCUSSION

Vermicompost is a promising and inexpensive approach to managing solid organic waste. In this study, the utilization of cassava bagasse and rice bran combination was evaluated for vermicomposting. The results indicated that 3CB-1RB-derived vermicompost meets requirements in some certain standards (i.e, temperature and pH value). The higher moisture in soil might be explained that the activities of *P. excavatus* facilitate soil moisture increasing or probably due to types of raw materials (cassava bagasse and rice bran). Therefore, before harvesting vermicompost, it is necessary to dry biomass under sunshine to retain *P. excavatus* and to reduce soil moisture.

As shown in the report of Edward and Arancon, our vermicompost quality meets some of standards such as temperature for *P. excavatus* approximately 25 ºC, 80-85% soil moisture [21]. Moreover, Nagavallemma *et al.* reported that via the earthworm *P. excavatus* activities, vermicompost qualities are almost similar to our study [22]. However, our vermicompost shows high TOC, C/N ratio as compared to normal vermicomposts (Table 2 and Table 3). This might be dependent to the type of raw materials. Nevertheless, the levels of higher TKN, P_2O_5 and K_2O indicated the highly effective activities of *P. excavatus* to make raw materials become absorbable. In term of preventing the local pollution, our study also indicated that only CB in raw materials showed the highest yield in conversion of cassava bagasse (Figure 3). As a result, in attempt to eliminate cassava bagasse, the supplement of rice bran during vermicomposting might not be considered.

Moreover, the vermicompost quality is also related to types of earthworms used during vermicomposting. Earthworms are mainly divided into burrowing and non-burrowing earthworms [1]. Burrowing earthworms live deeply in the soil while non-burrowing earthworms live whole time on the soil surface and therefore, these earthworms convert waste faster than burrowing type. In this study, we have used burrowing type (*P. excavatus*) to convert cassava bagasse and thus composting efficiency might be lesser than that belongs to non-burrowing vermicompost [22]. Therefore, it is necessary to have further studies on non-burrowing earthworm activities (i.e, *Eisenia foetida*) to cassava bagasse conversion. This might be an efficient way to yield cassava bagasse-derived vermicompost.

Rice bran is also an option to improve vermicompost quality. Pourzamani *et al.* claimed that rice bran can be supplemented in raw materials to enhance vermicompost processing and food waste: rice bran (1:1) ratio converts most efficiently [6]. This is quite different from our study which has shown such ratio of 3:1. The reason for this difference might be source of raw material. Cassava bagasse contains low protein, high crude fibre and cyanide contents which might have influences on the conversion ability of *P. excavatus* [23]. As a consequence, *P. excavatus* in this study prefer to use rice bran for their growth rather than cassava bagasse, resulting in low efficiencies of 1:1 and 1:3 CB/RB ratios (as shown in Figures 3 and 4). Therefore, the ratio of cassava bagasse to rice bran (ratio 3:1) might be a reference ratio for further study in non-burrowing earthworm vermicomposting.

5. CONCLUSIONS

The earthworm *P. excavatus* is able to use cassava bagasse as the main food source, a waste from starch processing factories which created local pollution issues. Cassava bagasse should be mixed with rice bran at ratio 3:1 to match the nutrient requirements of *P. excavatus* and also enhance their conversion activities during vermicomposting. The results of this study are a premise for further cassava bagasse utilization mediated by vermicompost.

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TÓM TẮT

SẢN XUẤT PHÂN HỮU CƠ TỪ HỖN HỢP BÃ SẮN VÀ CÁM GẠO BẰNG TRÙN QUẾ

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Bã sắn từ các nhà máy chế biến tinh bột tại Việt Nam đang gây ô nhiễm và cần có biện pháp tái sử dụng để giảm thiểu tác động đến quản lý môi trường. Trong nghiên cứu này, bã sắn được sử dụng làm nguồn nguyên liệu trong sản xuất phân vermicompost thông qua hoạt động của trùn quế (*Perionyx excavatus*). Cám gạo được phối trộn bổ sung vào thành phần nguyên liệu. Kết quả cho thấy, tỷ lệ phối trộn 3 bã sắn:1 cám gạo (w/w) cho hiệu quả tối ưu. Bên cạnh đó, các điều kiện môi trường sống cũng được xác định là pH 5-7, nhiệt độ 26-29 ºC, độ ẩm 80-85%. Sau 60 ngày khảo sát, chất lượng của phân vermicompost tương tự với phân hữu cơ, cụ thể: tổng carbon hữu cơ (TOC) 22,69%, hàm lượng đạm tổng (TKN) 1,8%, tỷ lệ C/N 12,63%, P_2O_5 4,67 % và K_2O 1,91%. Kết quả này giúp xây dựng cách tiếp cận tiềm năng và chi phí thấp trong quản lý những vấn đề môi trường phát sinh từ bã sắn, đồng thời cung cấp nguồn phân bón hữu cơ mới cho nông nghiệp.

Từ khóa: Phân hữu cơ, *Perionyx excavatus*, trùn quế, bã sắn, cám gạo.