

USING BANANA STEM AS SUBSTRATE FOR THE GROWTH OF LETTUCE SPROUTS**Nguyen Thi Phuong***Dong Thap University*

ARTICLE INFO	ABSTRACT
Received: 07/11/2023 Revised: 05/3/2024 Published: 11/3/2024	Using banana stems can help people utilize on-site waste and save costs. These was aligned with the trend toward sustainable agricultural development. The experiment was arranged in a completely randomized design with 8 treatments and 3 replications for each treatment. The observation period was 15 days from seed sowing. The experimental results showed that lettuce plants had the best germination ability on all substrates, except for dried banana stem. Among the substrates for lettuce germination, the fresh banana support achieved the highest germination rate (>88%). The plant height of lettuce reached its highest on the substrate of the soil mixed with fresh banana stems (9.95cm) and the lowest was on coconut fiber only (4.97cm). The fresh weight and dried weight of lettuce sprouts-ranked the highest on soil mixed with fresh banana stems (with 10.3 g fresh and 0.86 g dry weight), and those reached the lowest on the control (soil only) with values of 4.91 g and 0.04 g, respectively. Through research, it has been shown that using the fresh banana stems as a substrate has not only supplied an effectively new substrates source in production, but also handed out the pollution issue from agricultural by-products currently.
KEYWORDS	
Banana stem Fresh mass Organic substrate Plant height Salad Vegetable	

SỬ DỤNG THÂN CÂY CHUỐI LÀM GIÁ THỂ CHO SỰ SINH TRƯỞNG CỦA MẦM CẢI XÀ LÁCH**Nguyễn Thị Phương***Trường Đại học Đồng Tháp*

THÔNG TIN BÀI BÁO	TÓM TẮT
Ngày nhận bài: 07/11/2023 Ngày hoàn thiện: 05/3/2024 Ngày đăng: 11/3/2024	Việc sử dụng thân cây chuối để làm giá thể trồng rau sẽ giúp cho người dân tận dụng được nguồn phế thải tại chỗ, tiết kiệm chi phí, phù hợp với xu hướng nông nghiệp phát triển bền vững. Thí nghiệm được bố trí trong chậu hoàn toàn ngẫu nhiên với 8 nghiệm thức và 3 lần lặp lại cho mỗi nghiệm thức. Thời gian theo dõi 15 ngày từ lúc gieo hạt. Kết quả thí nghiệm cho thấy, cây cải xà lách có khả năng nảy mầm tốt nhất trên tất cả các giá thể trong nghiên cứu, ngoại trừ giá thể thân cây chuối khô ($P < 0,05$). Trong các giá thể cho sự nảy mầm của cải xà lách thì giá thể thân cây chuối tươi cho sự nảy mầm đạt cao nhất (>88%). Chiều cao của rau mầm đạt cao nhất trên giá thể đất và thân chuối tươi (9,95cm) và thấp nhất là giá thể xơ dừa (4,97cm). Khối lượng tươi và khô cải xà lách cũng đạt cao nhất trên giá thể đất và thân chuối tươi (10,3 g tươi và 0,86 g khô), đạt thấp nhất là nghiệm thức đất với giá trị lần lượt là (4,91 g và 0,04 g). Qua nghiên cứu cho thấy việc sử dụng thân cây chuối tươi làm giá thể đã mang lại nhiều hiệu quả trong việc bổ sung thêm nguồn giá thể mới trong sản xuất vừa giải quyết được vấn đề ô nhiễm từ phụ phế phẩm nông nghiệp hiện nay.
TỪ KHÓA	
Thân cây chuối Trọng lượng tươi Giá thể hữu cơ Chiều cao cây Rau xà lách	

DOI: <https://doi.org/10.34238/tnu-jst.9158>Email: ntpuong@dthu.edu.vn<http://jst.tnu.edu.vn>

210

Email: jst@tnu.edu.vn

1. Introduction

Bananas are grown in approximately 120 countries worldwide and produce around 86 tons of plant waste per hectare [1]. The entire banana plant (leaves, stem, and root) is typically left in the field by farmers after harvesting the fruit. It can take several months to naturally decompose, leading to nutrient wastage and increase environmental pollution. Additionally, waste products from banana plants contained organic compounds riched in macro and micro nutrients [2]. Banana stems primarily consist of cellulose, accounting for 54.3% of their composition and giving high total NPK (nitrogen, phosphorus, and potassium) contents with values of 2.8% N, 0.4% P₂O₅, and 4.2% K₂O, respectively [2], [3]. Therefore, the recycling of this organic waste is currently recommended for global reuse due to its ability to transform this waste into organic fertilizer sources that can substitute for chemical fertilizers and improve soil fertility.

Lettuce (*Lactuca sativa* L.) is a leafy vegetable highly popular for its nutritional value as well as its herbal significance. Lettuce provides a wealth of minerals, vitamins, organic acids, and various essential nutrients that are necessary for human well-being [4], [5]. However, nowadays, most of the vegetables in the market are contaminated due to human overuse of pesticides and chemical fertilizers. Although yields have increased, the quality of vegetables has significantly deteriorated [6].

On the other hand, cultivated land areas are gradually shrinking due to a part of social and urbanization development. Therefore, using banana plant stems as substrates will assist people in utilizing on-site waste resources, saving costs, and the nutrients from banana plant stems that will supplement the nutrient requirements and substitute for soil substrates.

2. Materials and methods

2.1. Soil and banana sample collections

Tango TN 518 curly lettuce seed made in Trang Nong Ltd. Company was used in this experiment.

After harvesting, banana stems were randomly selected without distinguishing among local banana varieties. Banana samples were cut to a length of 2 - 3 cm and stored in 2 kg nylon bags to analyze various input parameters. Soil samples were collected from the vegetable cultivation area at Lap Vo district, Dong Thap province. Soil samples were collected from the topsoil layer at a depth of 0 - 20 cm. Both banana stems and soil samples collected after harvesting were analyzed for parameters including pH, Electrical conductivity (EC), total NPK, and nitrate. The analysis results were presented in Table 1 below.

Table 1. Initial soil sample and fresh banana stem characteristics

Samples	pH	EC (μS/cm)	N (%)	P (%P ₂ O ₅)	K (%K ₂ O)	NO ₃ ⁻ (mg/kg)
Soil	3.98	171	0.31	0.09	2.11	3.23
Fresh Banana Stem	6.91	206	2.8	0.42	4.22	54.91

2.2. Methodology

2.2.1. Experiment design

The experiment was set up in a greenhouse condition with ambient temperatures fluctuating between 30-32°C during January 2023. The experiment is arranged completely randomly with 8 treatments and 3 replications for each treatment, making a total of 24 pots. The amount of soil, banana stems, and coconut coir used for each pot is 2 kg per pot. The experimental treatments include: Soil (control) (T1); Fresh banana plant stems (T2); Dried banana plant stems (T3); Soil + Fresh banana plant stems (T4); Soil + Dried banana plant stems (T5); Coconut coir + Fresh banana plant stems (1:1 ratio) (T6); Coconut coir + Dried banana plant stems (1:1 ratio) (T7); and Coconut coir (T8).

In T4 and T5, the amount of banana plant stems used is 5 tons per hectare (following the recommended organic matter application rate for vegetables based on the research by [7]). The total amount of soil and banana plant stems per pot remains at 1 - 2 kg per pot.

For T2 (dried banana stems), the banana stems are cut by a cutting machine to get a length of 2 - 3 cm and are directly exposed to sunlight to reach a moisture content of approximately 30% (weighing 1 kg of the fresh banana stem and exposing them until their weight decreases to 700 g).

Lettuce seeds are thoroughly washed, removed impurities, and soaked according to the instructions on the packaging. Each pot is sown 100 seeds. They are then misted to maintain around 60% moisture. During the first 3 days after sowing, the pots are misted every 2 hours. Once the seedlings emerge from the substrate surface, they are misted three times a day. The experiment was conducted for 15 days while more than 50% of the seeds were germinated in all pots (Figure 1). This study aimed to assess the influence of various substrate types that used banana stems on the lettuce germinations, leading to select suitable substrate types for cultivating lettuces.

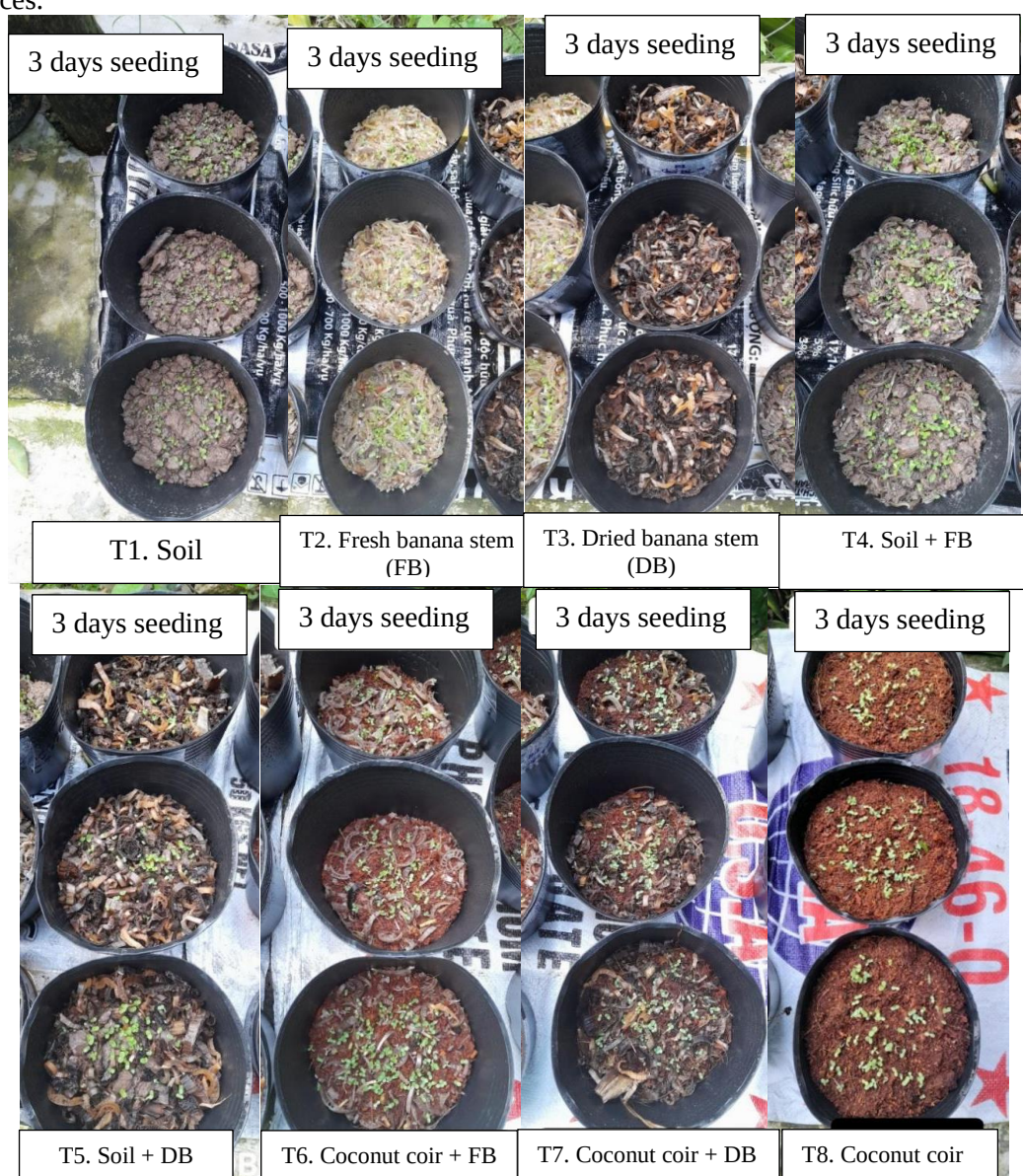


Figure 1. Germination rate of all experiment treatments

2.2.2. Data collection

The evaluation and analysis parameters include: germination percentage (%), seedling plant height, fresh weight determined by harvesting all above-ground plant parts, and dried weight of the seedlings determined by oven samples at 70°C for 14 hours.

2.2.3. Statistical analysis

All analyses were carried with three replicates per sample, and mean results per sample used for statistical data treatment. Statistical calculations were carried out using software SPSS version 20.0. Significant differences between all treatments were analyzed by the Duncan when $p < 0.05$.

3. Result and Discussion

3.1. Germination rate

According to Iannotti et al. [8] to assess the direct usability of organic materials before and after exposure to sun drying containing potentially phytotoxic compounds, one of the parameters that needs to be observed is the seed germination percentage.

The experimental results showed that in the initial stage from 3 to 6 days after sowing, the germination percentage of lettuce seeds ranged from 61.67% to 95%. The highest germination rate was observed in fresh banana plant stems (T2), while the lowest was in using substrate of coconut coir (T8), with a germination rate of 61.67% (Figure 2). The germination rate of lettuces was grown on dried banana plant stems (T3) ranged from 88.4% after 3 days of sowing to a reduced rate of 70% when the plants were 6 days old. This indicates that after 3 days, the decay of dried banana stems has inhibited germination, possibly due to a lack of oxygen in the root zone [1], [9]. This clearly demonstrates that within 9 to 15 days after sowing, the germination rate of this treatment (T3) decreased surprisingly from 36% at 9 days after sowing to 0% at 12 days after sowing. The reason for this decline may be due to this period being a stage of rapid organic matter decomposition in nature. These was leading to the generation of toxic gases that affect seed germination [10]–[13].

The research results also indicated a statistically significant difference at a 5% significance level among the experimental treatments at different growth stages of the plants. Using directly fresh banana plant stems as substrate increased seed germination capability for lettuce seeds, which could be attributed to the adequate moisture content that provided by the fresh banana plant stems to support seed germination [14]–[16]. This was illustrated in Figure 2, where the germination rate of lettuce on fresh banana plant stems reached its highest level after 15 days of sowing (88.3%). Following this, treatment consists of soil + fresh banana plant stems (T4), achieved a germination rate of 87%. Treatments involving soil, soil + dried banana plant stems, and coconut coir + fresh banana plant stems had shared germination rate of 66.6%. The lowest germination rate involved dried banana plant stems, with 100% of lettuce plants failing to germinate after 15 days of seed sowing. Treatments with germination rates below 50% after 15 days of seed sowing included coconut coir (T8) and treatment with a 1:1 ratio of coconut coir and dried banana plant stems (T7).

3.2. Plant height

The results of experiment on the influence of different substrates on the height of lettuce plants at various growth stages were presented in Figure 3. The results show that the highest plant height was achieved when lettuces sown on the soil + dried banana (T4) substrate, with a harvest height of 9.95 cm. This was significantly different at the 5% level compared to the other ones. Following that, the treatment of planting on coconut coir + fresh banana stem substrate yielded a plant height of 8.02 cm at harvest, and the lowest was the dried banana stem substrate (0 cm) after 15 days of sowing. The experiment of using fresh banana substrate for enhancing plant

height after 15 days of planting resulted in a significant difference ($P < 0.05$) compared to the control (soil - T1), which achieved a plant height of 4.97 cm. The plants sown with fresh banana stem substrate got by 5.52 cm.

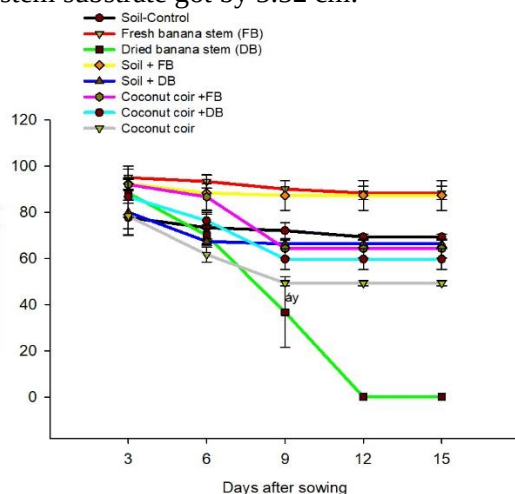


Figure 2. Germination rate (%) of lettuce over time

Note: The error bars on the graph represent the standard deviation ($n=3$)

Therefore, these results indicate that using fresh banana plant stems directly or mixing with soil or coconut fiber are more effective than other materials. This result shows that people can directly use fresh banana tree stems for farming, which is not only cost-effective but also time-saving in the processing process. This can allow people to increase their revenue and improve the efficiency of using fresh banana tree trunks to avoid environmental pollution. Therefore, reusing on-site and direct organic material resources in agricultural production will help limit the disposal and wasteful depletion of many organic resources, which can harm the environment or indirectly contribute to an increase in greenhouse gas emissions and destruct into the environment [17], [18].

3.3. Fresh and dry weight

The harvested fresh weight of lettuce ranged from 4.93 g to 9.85 g per pot, with the exception of dried banana stem substrate, which did not germinate up to 15 days after sowing. The fresh weight of lettuce grew effectively on soil + fresh banana stem (T4) and the coconut coir + fresh banana stem substrates (T6) that yielded the highest fresh biomass of 9.85 grams and 9.06 grams, respectively, and there was no significant difference when compared to each other ($P > 0.05$). Both treatments differ from the other treatments ($P < 0.05$) (Figure 4). The three of T2, T5 and T7 exhibited a similar effect on lettuce growth with fresh biomass yields of 6.92 g, 7.91 g, and 7.68 g, respectively. The lowest lettuce growth was sown on T1 and T8, with fresh biomass yields of 4.93 g and 5.42 g, respectively.

The dried weight of lettuce seedlings exhibited results similar tendency to fresh weight. The dried weight of lettuce seedlings ranged from 0.00 g to 0.92 g per pot (Figure 5). The dried weight of lettuce sown in both substrates of soil + fresh banana stems (T4) and coconut coir + fresh banana stems (T6) achieved the highest values (0.86 g and 0.92 g per pot, respectively) and differed significantly compared to the control experiment (0.04 g/pot) ($P < 0.05$).

Summarily, the researched results indicated that lettuce plants sown on substrates either fresh banana stems or mixed with other organic materials, achieved the highest biomass production. This suggests that the optimal reuse of banana stems is in the form of fresh banana stems.

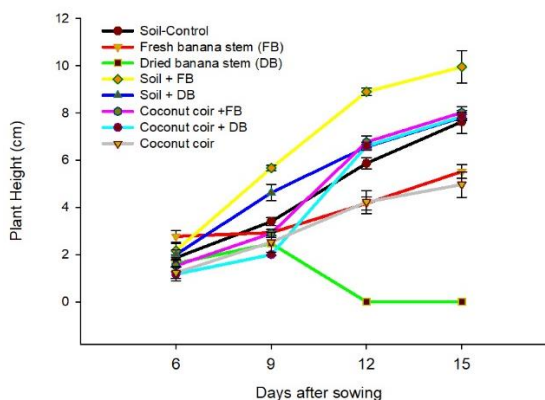


Figure 3. Plant height of lettuce over time

Note: The error bars on the graph represent the standard deviation ($n=3$)

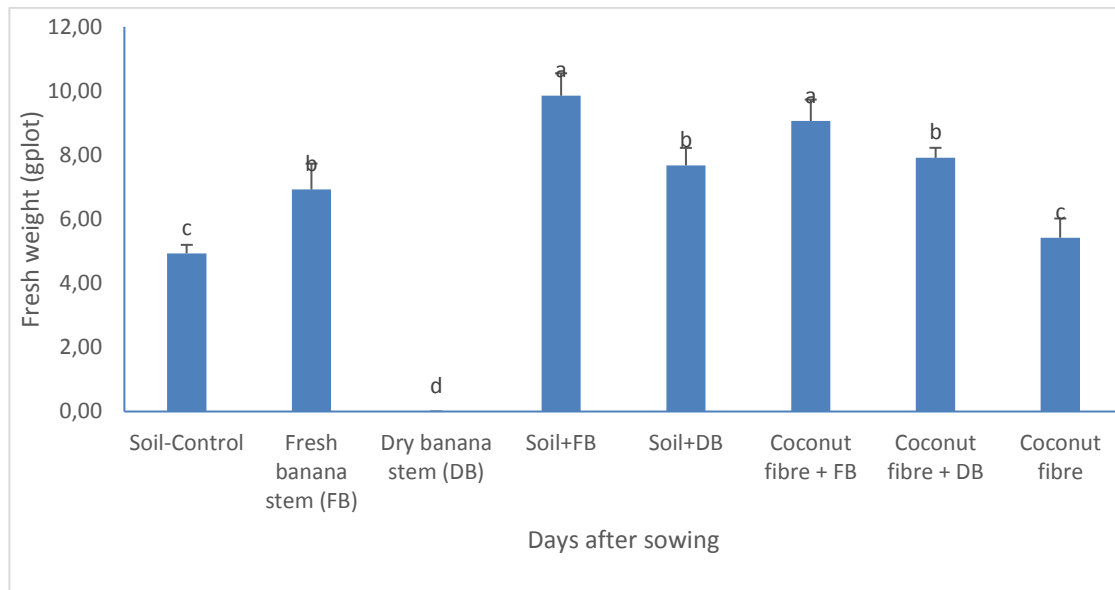


Figure 4. Effects of different substrates on fresh weight

Note: The vertical bars represent the standard error (n=3)

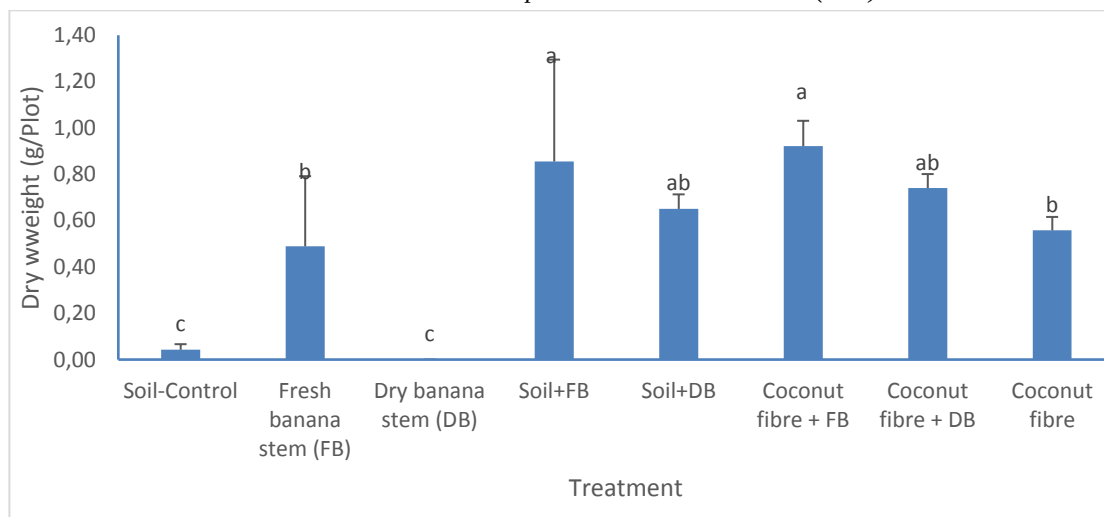


Figure 5. Effects of different substrates on dry weight

Note: The vertical bars represent the standard error (n=3).

4. Conclusions

Lettuce sown on both of soil amended fresh banana stem and coconut fiber mixed fresh or dried banana stem substrates granted the highest indicators in yield. From there, it can provide additional substrate sources in agriculture, avoiding waste of raw materials and reducing environmental pollution. Further research is needed to study the impact of banana plant stems on improving lettuce in multiple growing seasons and to assess additional quality parameters of lettuce after harvesting.

Acknowledgement

This research is supported by project **SPD2022.01.01**.

REFERENCES

- [1] C. Khatua, S. Sengupta, V. K. Balla, B. Kundu, A. Chakraborti, and S. Tripathi, "Dynamics of organic matter decomposition during vermicomposting of banana stem waste using *Eisenia fetida*," *Waste Manag.*, vol. 79, pp. 287-295, 2018.
- [2] M. E. ElNour, A. G. Elfadil, F. A. Manal, and B. A. Saeed, "Effects of banana compost on growth, development and productivity of sorghum bicolor cultivar (Tabat)," *J. Adv. Biol.*, vol. 8, no. 2, pp. 1555-1561, 2015.
- [3] N. D. Yilmaz, M. Sulak, K. Yilmaz, and G. M. Khan, "Effect of chemical treatments on physico-chemical properties of fibres from banana fruit and bunch stems," *Indian J. Fibre Text. Res. IJFTR*, vol. 42, no. 1, pp. 111-117, 2017.
- [4] N. H. Nguyen, T. N. Nguyen, and T. N. Nguyen, "Potential use of some media for growing white radish sprouts with safety and high quality in household scale," *VNU Journal of Science: Earth and Environmental Sciences*, vol. 32, no. 1S, pp. 413-418, 2016.
- [5] N. T. Minh, "Treatment of mushroom culture wastes for use as organic substrate for safe vegetable cultivation," *Vietnam Journal of Agricultural Sciences*, vol. 14, no. 11, pp. 1781-1788, 2016.
- [6] N. X. Giao, *Growing vegetables techniques at household*. Publisher of Natural Science and Technology, 2009.
- [7] T. P. Nguyen, "Using sludge from wastewater treatment systems of beer and seafood processing plants in microbial organic composting," Can Tho University, PhD Thesis, 2019.
- [8] D. A. Iannotti, T. Pang, H. M. Keener, and H. A. J. Hoitink, "A quantitative respirometric method for monitoring compost stability," *Compost Sci. Util.*, vol. 1, no. 3, pp. 52-65, 1993.
- [9] D. A. Iannotti, M. E. Grebus, B. L. Toth, L. V. Madden, and H. A. J. Hoitink, "Oxygen respirometry to assess stability and maturity of composted municipal solid waste," *J. Environ. Qual.*, vol. 23, no. 6, pp. 1177-1183, 1994.
- [10] S. Siddiqui *et al.*, "Recent Advances in Assessing the Maturity and Stability of Compost," in *Biology of Composts*, vol. 58, M. K. Meghvansi and A. Varma, Eds., in Soil Biology, vol. 58., Cham: Springer International Publishing, 2020, pp. 181–202, doi: 10.1007/978-3-030-39173-7_9.
- [11] D. Corradini, M. Mezzetti, S. Grego, M. Spiteller, and E. Mincione, "Fingerprinting of the development of aerobic composting processes of agricultural wastes by on-line combination of liquid chromatography and mass spectrometry," *J. Liq. Chromatogr. Relat. Technol.*, vol. 24, no. 9, pp. 1229-1244, 2001.
- [12] H. M. Luu and N. H. Nguyen, "Effect of decomposed rice straw at different times on rice yield," *Omonrice*, vol. 14, pp. 58-63, 2006.
- [13] K. Svetkova, M. Henselová, and M. Morvová, "Effects of a carbonization product as additive on the germination, growth and yield parameters of agricultural crops," *Acta Agron. Hung.*, vol. 53, no. 3, pp. 241-250, 2005.
- [14] N. F. Gariglio, M. A. Buyatti, R. A. Pilatti, D. G. Russia, and M. R. Acosta, "Use of a germination bioassay to test compost maturity of willow (*Salix* sp.) sawdust," *N. Z. J. Crop Hortic. Sci.*, vol. 30, no. 2, pp. 135-139, 2002.
- [15] N. Jirukkakul, "Physical properties of banana stem and leaf papers laminated with banana film," *Walailak J. Sci. Technol. WJST*, vol. 16, no. 10, pp. 753-763, 2019.
- [16] P. R. Warman, "Evaluation of Seed Germination and Growth Tests for Assessing Compost Maturity," *Compost Sci. Util.*, vol. 7, no. 3, pp. 33-37, Jun. 1999, doi: 10.1080/1065657X.1999.10701972.
- [17] H. Takahiko *et al.*, *2013 supplement to the 2006 IPCC guidelines for national greenhouse gas inventories: wetlands: methodological guidance on lands with wet and drained soils, and constructed wetlands for wastewater treatment*. Geneva, Switzerland: Ipcc, Intergovernmental Panel on Climate Change, 2014.
- [18] M. A. Chowdhury, A. de Neergaard, and L. S. Jensen, "Potential of aeration flow rate and bio-char addition to reduce greenhouse gas and ammonia emissions during manure composting," *Chemosphere*, vol. 97, pp. 16-25, 2014.