Utilization of compost derived from waste sludge of shrimp raising-ponds for crop cultivation

Do Thi Cam Van[1*], Vu Dinh Giap[1], Nguyen Quang Tung[1], Tran Viet Ha[2]

[1]*HaUI Institute of Technology, Hanoi University of Industry (HaUI)*

[2]*Vietnam National University of Forestry*

Nghiên cứu ứng dụng phân compost từ bùn thải hồ nuôi tôm phục vụ trồng cây rau màu mùa vụ

Đỗ Thị Cẩm Vân[1*], Vũ Đình Giáp[1], Nguyễn Quang Tùng[1], Trần Việt Hà[2]

[1]*Viện Công nghệ HaUI, Trường Đại học Công nghiệp Hà Nội (HaUI)*

[2]*Trường Đại học Lâm nghiệp*

**Corresponding author: docamvan85@haui.edu.vn*

https://doi.org/10.55250/jo.vnuf.8.2.2023.055-066

Article info:
Received: 18/09/2023
Revised: 20/10/2023
Accepted: 13/11/2023

Keywords:
compost, kohlrabi, mustard green, Nghe An province, organic fertilizer, plant growth, white radish.

ABSTRACT

Compost, an organic fertilizer which is rich of nutrients, safe and environmentally friendly for crop cultivation. In this study, it was aimed at evaluatiton of the effects of the compost derived from shrimp pond waste sludge on plant growth of kohlrabi, white radish, and mustard green. The application of the compost produced in five districts (Quynh Luong, Nghi Hop, Dien Trung, Quynh Di, Hung Hoa) of Nghe An province resulted in remarkably higher plant growth. In which kohlrabi, white radish, and mustard green fertilized by the compost from Quynh Luong district had crop yields of 3.6 kg/m^2, 3.4 kg/m^2, 3.7 kg/m^2 than the control without compost yielding 2.1-2.2 kg/m^2. Similarly, other plant growth parameters of number and areas of leaves and survival rate of the plants were all significantly higher than that of the control. Moreover, the mustard greens yields applied the compost produced in the four districts including Nghi Hop, Dien Trung, Quynh Di, Hung Hoa were in the range of 3.1-3.6 kg/m^2 all higher than that of the control unapplied fertilization determined as 2.2 kg/m^2, but reaching relatively equivalent to that of the commercial organic fertilizer at 3.8 kg/m^2, but slightly lower than that of the chemical fertilizer 4.4 kg/m^2. The study revealed that the compost from shrimp pond waste sludge can be fertilized for crop cultivattion which was safe and contributing to reducing a large amount of waste sludge discharged from shrimp-raising ponds in Nghe An province.

Từ khóa:
cải xanh, củ cải trắng, phân hữu cơ, phân compost, su hào, tăng trưởng cây trồng, tỉnh Nghệ An.

TÓM TẮT

Compost là loại phân hữu cơ giàu dinh dưỡng cho cây trồng, an toàn và thân thiện với môi trường. Nghiên cứu này nhằm mục đích đánh giá ảnh hưởng của phân hữu cơ từ bùn thải ao nuôi tôm đến sự phát triển của các loại cây rau màu gồm su hào, củ cải trắng và cải xanh. Việc áp dụng phân hữu cơ được sản xuất tại 5 huyện (Quỳnh Lương, Nghi Hợp, Diễn Trung, Quỳnh Di, Hưng Hòa) của tỉnh Nghệ An giúp tăng năng suất của cây trồng. Trong đó su hào, củ cải trắng và cải xanh khi được bón phân hữu cơ từ huyện Quỳnh Lương cho năng suất thu hoạch lần lượt là 3,6 kg/m^2, 3,4 kg/m^2, 3,7 kg/m^2 so với cây trồng không được bón phân đạt năng suất 2,1-2,2 kg/m^2. Tương tự, các chỉ tiêu tăng trưởng của cây trồng như số lượng, diện tích lá và tỷ lệ sống của cây đều cao hơn đáng kể so với kết quả của mẫu đối chứng. Hơn nữa, năng suất rau cải khi được bón phân hữu cơ sản xuất tại 4 huyện Nghi Hợp, Diễn Trung, Quỳnh Di, Hưng Hòa nằm trong khoảng 3,1-3,6 kg/m^2, tất cả đều cao hơn so với đối chứng không bón phân 2,2 kg/m^2 nhưng có giá trị tương đương với phân hữu cơ thương mại bán trên thị trường là 3,8 kg/m^2 nhưng thấp hơn chút so với kết quả của cây được bón bằng phân hóa học 4,4 kg/m^2. Nghiên cứu cho thấy phân hữu cơ từ bùn thải ao nuôi tôm trên địa bàn tỉnh Nghệ An nói riêng và trong nước nói chung có thể làm phân bón cho cây trồng an toàn, góp phần giảm lượng lớn bùn thải thải ra từ các ao nuôi tôm trên địa bàn Nghệ An.

1. INTRODUCTION

Composting is the process of biological decomposition and stabilization of organic matter under thermophilic conditions. As a result, compost is stable, pathogen-free and useful for plant cultivation. Compost can be produced from many different available raw materials originated from human activities and agicultural byproducts.

Currently, Vietnam domestic agriculture has paid a great attention to the shrimp farming industry, especially developing in the Central and Southern provinces. However, a large volume of sludge discharged from shrimp ponds into the environment is one of the causes of environmental pollution and surrounding ecology every year. On the other hand, directly using shrimp pond sludge as plant fertilizer has many potential risks including environmental treatment chemicals and preventive and curative drugs for shrimps. Therefore, it is necessary to evaluate the ability of applying wastewater sludge from aquaculture activities, including shrimp farming activities to be used as an organic fertilizer for agricultural applications.

Over the past two decades, there have been many studies on producing compost from different raw materials such as municipal solid wastes, solid organic wastes, sewage sludge,... and achieved certain successes. These materials receiving a lot of attentions and research are the reuse of wastes generated from livestock and/or sludge from treatment systems to reduce a huge volume of organic wastes. That helps to solve environmental pollution and creating quality fertilizer products by applying modern methods such as indoor/bin composting, ASP air-blown composting,...For example, the research of Rusmini *et al.* (2017) studied on composting from a mixture of shrimp shells, bran powder and chicken manure [1]. Narkhede *et al.* (2010) composted municipal solid wastes and sewage sludge in Jalgaon city, Maharashtra, India [2]. Gautam *et al.* (2010) successfully composted municipal solid wastes discharged from Jabalpur city [3]. It indicates that composting would be a suitable method for the simultaneous treatment of municipal solid waste and sewage sludge.

Recently, a lot of projects and studies on utilization of sludge from wastewater treatment system, production activities have been implemented in Vietnam. For instance, the project: “Proposal of general solutions to treat wastewater sludge from shrimp raising ponds in Can Gio district" conducted by Phu Bao Nguyen *et al.* (2011) working at Institute of Tropical Technology and Environmental Protection [4]. Van Manh Nguyen & Thi Nga Bui (2014) also conducted research on using organic fertilizers from pond bottom sludge for intensive shrimp farming and growing *brassica integrifolia* in Dam Doi district, Ca Mau province in a household scale. The other project: "Utilizing shrimp pond sludge to produce organic fertilizer" by Dac Kien Nguyen *et al.* (2016) has initially evaluated the possibility of utilizing shrimp pond sludge in Phu Long commune, Cat Hai district, Hai Phong city [5]. As a result, compost produced from green beans and weeds supplemented with the biological product Emuni resulted in higher germination rate (80%), plant height (22.20 cm) and the average fresh weight of vegetables reaches 165.50 grams/plant [6]. Many previous studies have shown that the nutrient content in shrimp pond bottom sludge is quite high, thus this sludge source to produce compost for agricultural cultivation will take advantage of the nutrient. It can reduce environmental pollution, contributing to better development of the shrimp farming industry [7-10].

In this study, the application of compost produced from composting models at households in five selective districts of Nghe An province reused waste sludge from shrimp ponds and mixed with agricultural by-products to become compost, organic fertilizer which are rich of nutrient organic ingredients for vegetable crops. It was aimed at evaluating nutritional and vegetative effects on selected crops for small-scale farming trials with the

fertilization of produced compost.

2. MATERIALS AND METHODS

2.1. Materials

This research was one part of the result belonging to the project of "Application of composting process from aquaculture shrimp farming pond sludge to transfer technology to Nghe An residents to improve crop cultivation" in the period of 2017-2019. Therefore in this study the composts derived from waste sludge of shrimp ponds produced at the five large selective shrimp-raising districts (Quynh Luong, Nghi Hop, Dien Trung, Quynh Di, Hung Hoa) in Nghe An province were applied as a fertilizer source for planting some kinds of crops.

The experimental plants including mustard green, white radish and kohlrabi were selected to evaluate the quality and effectiveness of composts which were seasonal crops planted popularly in Nghe An.

Experimental location: Institute of Agriculture and Natural Resources - Vinh University, Nghe An province.

2.2. Experiments

2.2.1. Composting process to produce compost from shrimp-raising sludge in Nghe An province

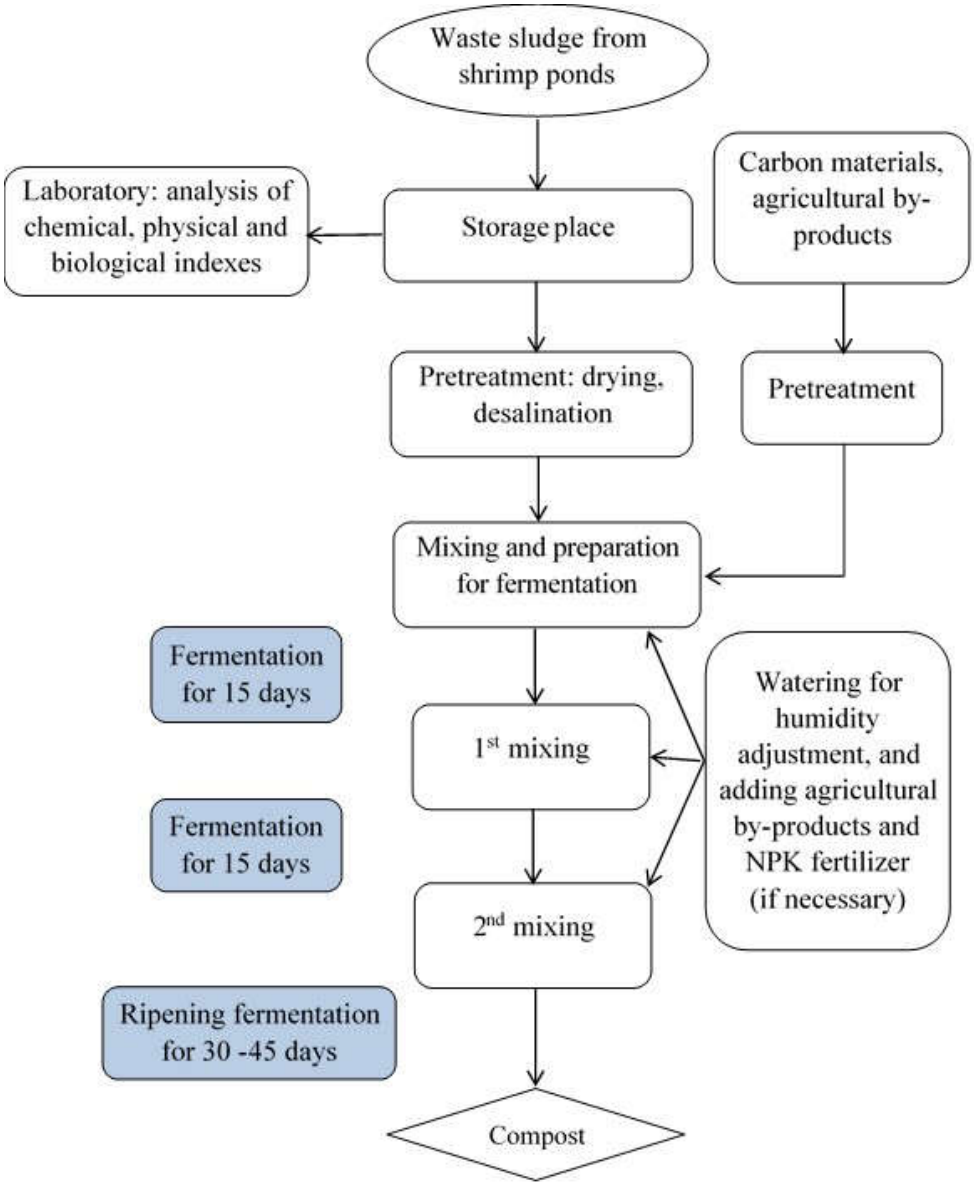

Figure 1. Production process of compost from shrimp pond's sludge [11]

Composting process explanation (Figure 1):

To produce compost from shrimp pond sludge, the following 5-steps were described below:

Step 1: Collect and pre-treat shrimp pond sludge (for 5-10 days)

Waste sludge was collected from shrimp ponds and brought to the storage place for drying and desalination. After checking the physicochemical properties (pH and salinity), the sludge was preliminarily pretreated by drying for 5 to 7 days until getting a humidity of 20-30%, then watered and mixed with lime powder to reduce salinity to improve pH and kill harmful pathogens in sewage sludge.

Step 2: Prepare agricultural by-products

It was necessary to prepare some agricultural by-products and some other biomaterials such as: straw, leaves, garden waste, vegetable stumps, fruit peels, biological products (EmuniV; AT bio) ... to increase the durability, humus, porosity and ensure nutrient content ratio for organic fertilizer production.

Agricultural by-product materials were collected, chopped, and chopped so that the material size is about 2-5 cm to ensure that the biological organic decomposition process took place quickly and achieved optimal efficiency.

Step 3: Build a compost pit

The composting pit was built on a high, dry and airy location with its size of 3m long, 2m wide, and 2m high. It had two doors to be convenient for the mixing process. A roof was setup above the pit to avoid rain and sun.

Step 4: Mix materials and additives

The compost piles are spread into layers of materials in order. Chopped organic-rich materials with its sizes of 2-5 cm including straw fruits, vegetable stumps, branches and leaves were situated at the first layer about 25 cm thick. The next layer is the shrimp pond waste sludge about 15 cm thick that has been pretreated for desalination and pH improvement. The layers of material were arranged alternately. Microbial products were watered evenly between material layers to maintain the humidity of compost pile in the range of 50-60%. Then the compost pile was covered to keep temperature stable with the tarpaulin. After 15-20 days, the layers of materials were mixed and watered with biological products and water to maintain moisture, ensuring the decomposition of microorganisms.

Step 5: Harvest and package finished products

Compost products were screened to remove non-biodegradable solid objects (such as bricks, stones, gravel, plastic, plastic...) before packaging. The compost was dried in cool conditions so that the moisture content was below 25%.

In this study, the composts produced at five typical districts of shrimp-farming locations in Nghe An province were chosen as organic fertilizers for some tested crop cultivation [11]. The quality of composts in Nghe An was reported in the published paper by Do *et al.* (2020) [11] that the analyzed nutritional indexes such as pH (7.32-7.55), salty (0.79-1.28‰), moisture (22.6-25.7%), contents of humic acid (2.29-2.60%), nitrogen (1.59-3.95%), carbon (19.91-23.75%), phosphorus (0.33-0.68%), heavy metals of Pb (29.12-45.58 mg/kg), As (0.78-2.05 mg/kg), Hg (0.067-0.41 mg/kg), Cd (0.059-0.190 mg/kg) and *Samolnella* undetected in 25 mL (CFU) all met the requirements of the Circular No.36/2010/TT-BNNPTNT. Therefore, the composts applied in this study were safe and potential for crop cultivation.

2.2.2. Evaluation of plant growth

Mustard green, white radish and kohlrabi known as popular vegetable plants in Nghe An province were selected as the growing subjects applied the compost derived from shrimp pond sludge. The time of plant growth from sowing seeds or seedlings to harvest was about 60 days.

Experimental setup: plant treatments arranged randomly on soil beds with an area of 4 m^2 (4x1 m). Each experimental treatment was repeated 3 times. The treatments and fertilization methods were described, presented in detail in the Table 1.

Table 1. Establishment of plant treatments

Treatment	Composition	Fertilization method
Treatment 1 (NT 1)	30 g/m^2 NPK fertilizer (16-16-8) + manure: 60 g/m^2	9 g/m^2 NPK fertilizer (16-16-8) + 60 g manure/m^2 Fertilized before sowing seeds 12 g/m^2 NPK fertilizer (16-16-8) fertilized when planting seeds within 7 days 9g/m^2 NPK fertilizer (16-16-8) for 7 days before harvesting
Treatment 2 (NT 2)	60 g/m^2 Huong River Microbial organic fertilizer	Fertilized before sowing seeds
Treatment 3 (NT 3)	60 g/m^2 compost produced in Quynh Luong	Fertilized before sowing seeds
Treatment 4 or control (NT 4)	No fertilizer	
Treatment 5 (NT 5)	60 g/m^2 compost produced in Nghi Hop	Fertilized before sowing seeds
Treatment 6 (NT 6)	60 g/m^2 compost produced in Quynh Di	Fertilized before sowing seeds
Treatment 7 (NT 7)	60 g/m^2 compost produced in Dien Trung	Fertilized before sowing seeds
Treatment 8 (NT 8)	60 g/m^2 compost produced in Hung Hoa	Fertilized before sowing seeds

Figure 2. Experimental planting site

The diagram of plant growing experiments was shown in the Figure 2.

The soil was cleared of grass, plowed to a depth of about 30 cm, dried in the sun for 3 days, loosened and then raised into furrows with an area of 4 m^2 (length x width = 4x1 m). The distance between the furrows was about 0.3 m. Applying lime powder evenly at 50 g/m^2 and then watering slowly several times to dissolve the lime in the soil. Radish and mustard greens were sown by seeds, kohlrabi was grown by seedlings. The distance between plants was 25x25 cm. Watering twice a day in the morning about 8-9 am and in the late afternoon at 4-5 pm. After 2 months, harvesting the plants, cleaning the soil, weighing and recording the weight of fresh plants.

2.2.3. Evaluation of crop productivity

During the process of experimental plant growth, parameters (height, leaf area, number of leaves, number of tubers, plant density, post-harvest plant weight), and some other special signs were monitored and observed. Continuously measure, take pictures and record to evaluate the growth and development of experimental plants. Through the results of crop yield assessment, it was possible to accurately assess the effectiveness of the compost used to fertilize plants, bringing productivity and sustainable and safe development for the plants. Monitoring indicators and evaluation methods are presented in the Table 2.

Table 2. Parameters of plant observation

Parameters of plant growth	Sampling method	Evaluation method	Applied subjects
Plant height (cm)	Select, sample and evaluate plants diagonally (TCVN 9016:2011)	Use a ruler to measure the height of the plant growth after 10, 20, 40 and 60 days.	Radish, kohlrabi, mustard green
Leaf area (cm^2)		Use a ruler to measure leaf length and width after 10, 20, 40 and 60 days S = 0.66. L.R L: Maximum leaf blade length R: Maximum leaf blade width	Radish, kohlrabi, mustard green
Number of leaves		Count the number of leaves on the plant after 10, 20, 40 and 60 days	Radish, kohlrabi, mustard green
Root height (cm)		Use a ruler to measure the entire tuber portion when harvesting	Kohlrabi
Diameter (cm)		Use a ruler to measure the largest diameter of the tuber when harvesting	Radish, Kohlrabi
Plant density (plant/m^2)	All experiment plants	Count all plants to harvest and calculate density	Radish, Kohlrabi, mustard green
Survival rate (%)		Count all plants at harvest and calculate density: $TLSS = (MĐ_{th}/MĐ_{bd}).100\%$ $MĐ_{bd}$: Initial density (plant/m^2) $MĐ_{th}$: Harvest density (plant/m^2) TLSS: Survival rate (%)	Radish, Kohlrabi, mustard green
Harvest yield (kg/m^2)		Weigh the entire vegetable biomass of each treatment at harvest.	Radish, Kohlrabi, mustard green.

2.3. Data analysis

Experiments were carried out in triplicate (n=3) and results were expressed as average ± standard deviation (SD). Data was treated using Microsoft Excel software 2016.

3. RESULTS AND DISCUSSION

3.1. Evaluation of compost influence on kohlrabi growth

The results of evaluating and monitoring the growth and development of kohlrabi plants in different treatments over time are presented in the Table 3.

Table 3. Evaluation result of compost influence on kohlrabi growth

	Parameters of plant growth		Treatment			
			NT1	NT2	NT3	NT4
Kohlrabi	Plant height (cm)	10 days	14.5±0.21	13.3±0.24	13.8±0.23	10.3±0.16
		20 days	23±0.27	20.2±0.46	21.4±0.15	15.±0.15
		40 days	36.7±0.33	31.6±0.15	32.7±0.25	23.1±0.24
		60 days	46.3±0.25	39.2±0.35	41.6±0.16	30.1±0.27
	Leaf area (cm^2)	10 days	15.2±0.58	14.8±0.78	14.9±0.33	12.1±0.78
		20 days	77.8±0.74	74.1±0.61	73.6±0.54	60.2±0.14
		40 days	192.2±0.45	189.0±0.22	188.2±0.11	165.8±0.21
		60 days	305.1±0,18	301.5±0.34	300.4±0.22	250.1±0.32
	Number of leaves	10 days	6.5±0.57	6.1±0.70	6.2±0.67	5.5±0.71
		20 days	9.3±0.68	8.7±0.73	9.1±0.70	7.8±0.69
		40 days	12.2±0.71	11.5±0.62	11.9±0.70	10.4±0.90
		60 days	14.3±0.65	13.3±0.72	13.5±0.75	12.0±0.90
	Tube diameter (cm)	10 days	0.7±0.12	0.6±0.13	0.6±0.25	0.4±0.31
		20 days	2.3±0.41	1.9±0.21	1.8±0.17	1.1±0.28
		40 days	9.8±0.33	8.2±0.24	7.9±0.13	5.2±0.17
		60 days	12.5±0.11	11.7±0.18	11.5±0.22	7.6±0.11
	Tube height (cm)	10 days	1.3±0.12	1.2±0.21	1.3±0.15	0.8±0.12
		20 days	3.3±0.14	3.1±0.18	3.2±0.29	2.4±0.03
		40 days	4.9±0.05	4.7±0.22	4.8±0.31	3.5±0.21
		60 days	6.4±0.31	6.0±0.14	6.2±0.21	4.5±0.15
	Plant density (plant/m^2)	Beginning	9	9	9	9
		60 days	7.75±0.5	7.00±0.82	7.25±0.96	7.00±0.82
	Survival rate (%)	60 days	86.11	77.77	80.56	77.77
	Productivity (kg/m^2)	60 days	4.03±0.26	3.29±0.38	3.55±0.47	2.10±0.24

As presented in the Table 3, it can be seen that all monitoring and evaluation indexes of the treatments gradually increased over time, especially the treatments with the addition of organic fertilizers. Namely, the treatments (NT1, NT2, NT3) all gave significantly higher kohlrabi yields than the control treatment using only soil without fertilization (NT4). Notably, the results of the treatment NT1 using a combination of chemical fertilizer (NPK) and manure showed the highest growth rate and crop yield of 4.03 kg/m^2, followed by the treatment NT2 applied with Huong River microbial organic fertilizer. The treatment NT3 with compost addition had slightly lower crop yields in the range of 3.3 - 3.5 kg/m^2. The kohlrabi yields obtained from the treatments NT1, NT2, NT3 were significantly higher than that of the treatment NT4 unfertilized soil achieving a yield of 2.1 kg/m^2. After 2 months of experimental planting, the density of kohlrabi decreased significantly. That means it needed to be provided enough nutrients for kohlrabi to maintain, grow, survive and develop well. This result was in agreement with Ozores–Hampton and Bryan's study (1993) that the addition of compost from biodegradable municipal wastes helped eggplant and bell pepper gaining 90 and 134 mg/ha to grow and develop stably greater than that without compost addition [12]. In fact,

the application of chemical fertilizercan can significantly increase crop productivity. However, long-term use of chemical fertilizers has the potential to cause land pollution and depletion, soil ecological imbalance, so it is not the optimal solution for sustainable agricultural production. While the organic fertilizer was determined to be good for both plant yield enhancement, soil improvement and soil ecology balance. The application of Song Huong organic fertilizer sold in the market led to the crop yield as good as the shrimp-pond waste composts from five districts in Nghe An province.

Consequently, the results of evaluation of kohlrabi growth rate certified that the compost produced from shrimp pond waste sludge had positive effects on the plant growth.

3.2. Evaluation of compost influence on white radish growth

Similarly, the results of evaluation of the white radish growth in different treatments over time are reported in the Table 4.

Table 4. Evaluation result of compost influence on white radish growth

	Parameters of plant growth		Treatment			
			NT1	NT2	NT3	NT4
Radish	Plant height (cm)	10 days	11.2±0.15	10.1±0.14	10.2±0.34	7.3±0.15
		20 days	23.4±0.14	20.8±0.33	20.9±0.45	16.2±0.21
		40 days	34.8±0.27	31.0±0.22	31.2±0.18	23.1±0.75
		60 days	45.6±0.54	41.3±0.26	41.7±0.34	30.8±0.67
	Leaf area (cm^2)	10 days	3.1±0.51	2.9±0.12	3.1±0.15	2.1±0.22
		20 days	14.8±0.35	13.9±0.15	14.0±0.05	9.8±0.12
		40 days	51.9±0.25	48.2±0.02	48.8±0.55	35.6±0.15
		60 days	89.1±0.15	74.7±0.50	75.4±0.25	59.8±0.15
	Number of leaves	10 days	3.20±0.57	2.70±0.45	2.75±0.55	2.60±0.51
		20 days	7.20±0.56	6.70±0.57	7.04±0.51	6.13±0.67
		40 days	12.30±0.56	11.40±0.51	12.10±0.57	11.10±0.57
		60 days	17.90±0.63	16.80±0.63	17.20±0.63	16.10±0.57
	Tube diameter (cm)	60 days	4.3±0.3	4.0±0.2	4.1±0.3	2.5±0.2
	Tube height (cm)	60 days	20.1±0.35	19.6±0.12	19.2±0.23	17.5±0.08
	Plant density ($plant/m^2$)	Begining	16	16	16	16
		60 days	11.7±0.41	11.5±0.11	11.3±0.08	10,1±0.13
	Survival rate (%)	60 days	73.12	71.87	70.62	63.12
	Productivity (kg/m^2)	60 days	4.20±0.56	3.36±0.12	3.42±0.75	2.10±0.43

The result revealed that the growth parameters of the plants in the treatments gradually increased over time. Especially the treatments with the addition of the organic fertilizers (NT1, NT2, NT3) yielded significantly higher than that of the control

using only the soil without fertilization (NT4). Notably, plant density and survival rate did not change remarkably among 4 treatments after 60 days of harvesting, determined in the range of 10-11 plants/m^2. However, the raddish yields showed a clear difference when the treatment combining NPK fertilizer and manure (NT1) gained the highest yield of 4.2 kg/m^2; the second were the two treatments using Huong River microbial organic fertilizer (NT2) and compost from shrimp waste sludge (NT3) with the yield range of 3.36-3.42 kg/m^2. And the lowest yield of 2.1 kg/m^2 was the treatment NT4 (no fertilizer application). That means applying chemical fertilizers, manure, Huong River commercial bio-organic fertilizer and compost helped the experimental plants to grow, survive and adapt well because they were provided enough nutrients better than the control. This result was in consistent with the results of Stoffella and Graetz (1997) [13]. In Stoffella and Graetz's study, when tomato plants were fertilized with the compost derived from sugarcane wastes at any rate, the shoot height, diameter, volume and yield were higher than those in the treatment without fertilization.

3.3. Evaluation of the compost influence on mustard green growth

The results of mustard green growth and development in the treatments NT1-NT4 over time are presented in the Table 5.

Table 5. Evaluation result of compost influence on mustard green growth

	Parameters of plant growth		Treatment			
			NT1	NT2	NT3	NT4
Mustard green	Plant height (cm)	10 days	9.5±0.37	8.2±0.08	8.7±0.11	5.7±0.31
		20 days	22.7±0.75	22.1±0.36	20.3±0.08	12.6±0.15
		40 days	34.6±0.36	30.9±0.17	30.0±0.22	18.9±0.28
		60 days	43.5±0.08	38.1±0.13	37.3±0.35	24.0±0.18
	Leaf area (cm^2)	10 days	5.3±0.12	4.2±0.14	4.2±0.17	3.4±0.14
		20 days	61.8±0.23	52.6±0.21	51.3±0.16	26.9±0.51
		40 days	431.8±0.17	392.5±0.41	390.0±0.41	102.4±0.18
		60 days	682.7±0.22	625.1±0.28	613.8±0.32	135.7±0.36
	Number of leaves	10 days	5.50±0.61	5.40±0.57	5.30±0.65	3.50±0.50
		20 days	7.40±0.68	7.30±0.68	7.00±0.74	4.50±0.57
		40 days	11.60±0.70	10.80±0.75	10.40±0.89	6.30±0.59
		60 days	14.10±0.90	13.0±0.81	12.8±0.86	7.6±0.66
	Plant density (plant/m^2)	Beginning	16	16	16	16
		60 days	11.75±0.50	11.00±0.81	11.25±0.50	9.25±0.50
	Survival rate (%)	60 days	73.43	68.75	70.31	57.81
	Productivity (kg/m^2)	60 days	4.4±0.02	3.8±0.03	3.7±0.02	2.2±0.01

From the results of the growth rate of mustard greens in the treatments shown in Table 5, it was observed that all the plant growth parameters of the treatments (NT1, NT2, NT3, NT4) gradually increased over time. In particular, the treatments (NT1, NT2, NT3) added chemical and organic fertilizers yielded significantly higher than that of the control treatment without fertilization (NT4). In which the growth rate and crop yield of the treatment

NT1 with the combination of NPK fertilizer and manure were the highest of 4.4 kg/m^2. It was followed by the treatment NT2 with the addition of Huong River organic fertilizer and the treatment NT3 with the application of compost from shrimp pond waste sludge had slightly lower crop yields in the range of 3.7 - 3.8 kg/m^2. The yields obtained from the treatments NT1, NT2, NT3 were significantly higher than that of the treatment NT4, the unfertilized soil achieved a yield of 2.2 kg/m^2. After 2 months of experiment, all the treatment's plant densities decreased significantly and almost little difference among treatments.

The result in this study was similar to that of Le Thi Minh Nguyet *et al.* (2017) [6]. In particular, green mustard plants using NPK fertilizer gave the best results in terms of volume, plant growth, and no pests or diseases. The treatment using compost helped plants to grow better than the control treatment.

In addition, the study was also conducted further evaluation for the mustard green applied 60 g/m^2 of the compost produced in Nghi Hop, Quynh Di, Dien Trung, and Hung Hoa districts of Nghe An province which are presented as the treatments NT5, NT6, NT7, NT8 in the Table 6.

Table 6. Evaluation result of compost influence on mustard green growth

Parameters of plant growth		Treatment				
		NT4	**NT5**	**NT6**	**NT7**	**NT8**
Plant height (cm)	**10 days**	5.3±0.31	7.9±0.25	7.4±0.14	7.1±0.27	6.4±0.17
	20 days	12.2±0.15	18.8±0.35	17.6±0.25	16.8±0.12	16.1±0.31
	40 days	18.5±0.28	27.4±0.08	25.4±0.19	24.2±0.21	23.5±0.26
	60 days	23.6±0.18	34.1±0.43	31.8±0.32	30.1±0.22	29.3±0.13
Leaf area (cm^2)	**10 days**	3.4±0.14	4.1±0.24	3.9±0.31	4.0±0.43	4.0±0.19
	20 days	26.9±0.51	46.8±0.32	41.5±0.39	40.9±0.25	40.3±0.41
	40 days	102.4±0.18	359.8±0.22	347.3±0.56	332.6±0.41	329.2±0.57
	60 days	135.7±0.36	539.8±0.67	521.2±0.51	499.8±0.69	492.7±0.56
Number of leaves	**10 days**	3.50±0.50	5.20±0.50	5.00±0.50	4.40±0.50	4.30±0.50
	20 days	4.46±0.57	6.90±0.70	6.70±0.66	6.50±0.50	6.40±0.50
	40 days	6.30±0.59	9.40±0.66	9.10±0.70	8.90±0.64	8.70±0.62
	60 days	7.60±0.66	11.60±0.75	11.30±0.66	11.10±0.73	10.80±0.67
Plant density (plant/m^2)	**Beginning**	16	16	16	16	16
	60 days	9.25±0.5	11.25±0.5	10.75±0.5	11.0±0.81	10.5±0.57
Survival rate (%)	**60 days**	57.81	70.31	67.18	68.75	65.62
Productivity (kg/m^2)	**60 days**	2.2±0.01	3.6±0.02	3.4±0.02	3.3±0.02	3.1±0.01

The results of the Chinese mustard green growth in all the treatments NT4, NT5, NT6, NT7 and NT8 gradually increased over time. It was easy to find the clear difference of the mustard green yields in the treatments using the compost and the control treatment without compost application and among the treatments applied the compost from different locations. The Chinese mustard green using the Quynh Luong compost had the highest yield reaching 3.7 kg/m^2 while and the lowest of 3.1 kg/m^2 for the plant using the Hung Hoa compost. The productivity of the other three locations of Nghi Hop, Dien Trung, Quynh Di ranged from 3.3 - 3.6 kg/m^2. This means that the compost produced at Quynh Luong helped the plants to

grow and achieve the highest efficiency and productivity compared to that of the compost produced from the other disticts in Nghe An province.

In consequence, the evaluation results of the experimental plants after 60 days for the control (NT4), the treatments applied NPK fertilizer and manure (NT1), Song Huong bio-organic fertilizer (NT2), the other treatments applied compost derived from shrimp pond waste sludge (NT3, NT5, NT6, NT7, NT8) from 5 distict in Nghe An province. The productivity of the other three locations of Quynh Luong, Nghi Hop, Dien Trung, Quynh Di, Hung Hoa in Nghe An province were shown the importance of organic fertilizers for plant growth. Notably, when the plants were fertilized with the compost produced from shrimp pond sewage slugde, their yields archieved equivalent to those of fertilized with organic fertilizers sold on the market, but little difference with that of chemical fertilizer application. The largest significance of the compost application derived from shrimp pond waste sludge was safe, having positive effects on yields, fewer pests and longer survive for crop plantting than that of using chemical fertilizers. The results in this study are scientific demonstrations of the effectiveness and suitability of compost produced from shrimp pond sludge which can be applied in agriculture, as a source of safe, clean organic fertilizer meeting the nutritional needs of plants.

4. CONCLUSION

The composts produced from shrimp pond waste sludge in the five selective districts of Quynh Luong, Nghi Hop, Dien Trung, Quynh Di, Hung Hoa of Nghe An province were evaluated to have positive effects on plant growth. All the tested vegetables including kohlrabi, white radish, and mustard green when applied the compost produced in the five districts of Quynh Luong, Nghi Hop, Dien Trung, Quynh Di, Hung Hoa yielded in the range of 3.1-3.7 kg/m^2 all higher than that of the control unapplied fertilizers determined as 2.2 kg/m^2. Besides, the other parameters of plant growth such as number and areas of leaves and survival rate of the plants were all increased in comparison with the control without the compost. In addition, it showed that the plants fertilized with the composts obtained crop yields equivalent to that of the commercial Song Huong organic fertilizer valued 3.8 kg/m^2, while slightly lower than that of the chemical fertilizer of 4.4 kg/m^2. The study revealed the application of the composts from shrimp pond waste sludge in Nghe An province provided a potential organic fertilizer for crops as well as contributing to reduce a huge solid wastes from shrimp-farming activities in Nghe An province by reusing and recoverying the waste sludge for compost production.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Institute of Natural Resources and Environment (INRES) and the Institute of Agriculture and Natural Resources - Vinh University, Nghe An province. This research was one part of the project of "Application of composting process from aquaculture shrimp farming pond sludge to transfer technology to Nghe An people to improve the efficiency of crops" in the period of 2017-2019.

CONFLICT OF INTEREST STATEMENT

Nothing declared.

REFERENCES

[1]. Rusmini, Manullang R.R. & Daryono (2017). Development of shrimp shells-based compost and plant-based pesticide using bio-activators from Golden Apple Snails and their effects on the kenaf plant growth and pest population. Nusantara Bioscience. 9(3): 260 - 267. https://doi.org/10.13057/nusbiosci/n090304

[2]. Narkhede S.D., Attarde S.B. & Ingle S.T. (2010). Combined Aerobic Composting of Municipal Solid Waste and Sewage Sludge. Global Journal of Environmental Research. 4(2): 109-112.

[3]. Gautam S.P., Bundela P.S., Pandey A.K, Awasthi M. & Sarsaiya S. (2010). Composting of

municipal solid waste of Jabalpur City. Global Journal of Environmental Research. 4(1): 43-46.

[4]. Nguyen Phu Bao (2011). Proposing general solutions to treat sludge from shrimp ponds in Can Gio district.

[5]. Nguyen Van Manh & Bui Thi Nga (2014). Using organic fertilizers from sediments of intensive shrimp farming for *Brassica integrifolia* cultivation at the household-scale in the Dam Doi district, Ca Mau province. Agriculture & Rural Development. 91-98.

[6]. Le Thi Minh Nguyet & Pham Thi My Tram (2017). Research of efficiency of compost from blue plants and flowers in minh tan commune, Dau Tieng district, Binh Duong province. Thu Dau Mot University Journal of Science. 4(35): 63-72.

[7]. Briggs M.R.P. & Funge-Smith S.J. (1994). A nutrient budget of some intensive marine shrimp ponds in Thailand. Aquaculture and Fisheries Management. 25(8): 789-811. https://doi.org/10.1111/j.1365-2109.1994.tb00744.x

[8]. Hopkins J.S., Sandifer P.A. & Browdy C.L. (1994). Sludge management in intensive pond culture of shrimp: Effect of management regime on water quality, sludge characteristics, nitrogen extinction, and shrimp production. Aquacultural Engineering 13(1): 11-30. https://doi.org/10.1016/0144-8609(94)90022-1

[9]. Funge-Smith S.J. (1996). Coastal aquaculturestrategies for sustainability. Final report to the ODA, Project R6011. Institute of Aquaculture, University of Stirling, Scotland.

[10]. Do Thi Cam Van & Vu Dac Duy (2019). Study on composition, characteristics of waste sludge from nghe an shrimp raising-pond and evaluation of sludge quality for compost production. Journal of Science & Technology, Hanoi University of Industry. 53: 90-95.

[11]. Do Thi Cam Van, Vu Dac Duy, Nguyen Thi Sen & Tran Nam Anh (2020). Study on compost production from waste sludge of nghe an shrimp raising-pond. Journal of Science & Technology, Hanoi University of Industry. 56(5): 111-116.

[12]. Orozes-Hampton M. & Bryan H.H. (1993). Effect of amending soil with municipal solid waste (MSW) compost on yield of bell pepper and eggplant. HortScience 28(103).

[13]. Stoffella P.J. & Graetz D.A. (1997). Sugarcane filtercake compost influence on tomato emergence, seedling growth, and yields. The Science of Composting. 1351-1356.