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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

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Abstract. *Rusmini, Manullang RR, 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: 260-267.* Kenaf (*Hibiscus cannabinus* L) cultivation generally uses chemical fertilizers and pesticides to increase production despite the adverse effects of those chemicals toward environmental ecosystem. Meanwhile, there are a lot of unutilized wastes produced from agriculture and fishery. This study aimed to develop the best bio-activator from Golden Apple Snails and spices to decompose the shrimp shells waste. The bioactivator was utilized for the production of plant-based pesticide to control pests in kenaf plant, and shrimps-shells-based composts to improve kenaf plant growth. This study employed a Randomized Block Design with two factorials. The first factor was the shrimp shells-based composts (K) which consist of three levels, and the second factor was the plant-based pesticide (P) which also consists of three levels. Each of experiment was repeated twice. Thus, in total there were 18 treatments. The shrimp shells-based composts had a pH value of 8.79, Potassium (K) 8.13 %, organic carbon (C) 17.45%, Nitrogen (N) 3.62%, Phosphorus (P) 2.27%; Magnesium (Mg) 0.59%, and Calcium (Ca) 7.64%; and a C/N ratio of 4.82. Kenaf plant height at 6 and 9 weeks after planting (WAP) showed significant differences upon the shrimp shells-based composts treatments. At 6 weeks after planting, kenaf plant diameter showed significant differences upon the composts treatment, while at 9 weeks after planting, the plant diameter indicated significant differences upon both the compost and plant-based pesticide applications. Pest populations that were present in kenaf plants were caterpillars, bugs, and beetles.

Keywords: Golden Apple Snails, kenaf, shrimp shells

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a plant well known for producing natural fibers that are eco-friendly because of its readily degradable nature and its capacity for absorbing a significant amount of CO_2. Besides as a raw material for agricultural/estate crops product packaging, there is a vast array of diversified products of the kenaf fiber, such as: paper, wallpaper, car interior material, geotextile, soil safer, fiber drain, particle board, reinforced plastic, and raw material in biofuel industry (Lips and Dam 2013; Ryu et al. 2013; Saba et al. 2015; Ryu et al. 2016; Bourguignon et al. 2017).

Kenaf cultivation generally involves the use of chemical fertilizers to boost its production, despite the harm exerted by the chemical to the environment. The continuous application of fertilizers, pesticides, and other chemicals can harm organisms in the soil, induce pest and pathogen resistance, and change the vitamin and mineral content of crops. Indeed, if this practice is left as is, it will deleteriously affect the cycle of life survival (Xu et al. 2012; Maheswari et al. 2014; Nkbiwe et al. 2016; Thonar et al. 2017). However, agricultural farming is impossible to be undertaken without involving pesticides. Pesticide controls plant diseases and pests as well as grain insects, while at the same time pesticide causes a lot of adverse effects from its residue that affect the environment and the safety of agricultural products (Huang et al. 2014).

Another issue is the increasingly high fertilizer prices because of the chemical fertilizers distributed in Indonesian market is highly dependable on the imported raw materials whose prices rise following the US Dollar rate in the international currency market. The use of inorganic fertilizers dramatically increases because of the farmer fanaticism and the growth in the agricultural field area, whereas the use of organic fertilizers does not expand. Development of organic fertilizer was based on the adverse effects exerted by the chemical fertilizer towards soil and plants. Organic fertilizer is developed to solve the negative effects of chemical fertilizer that can drain a nutrient rich soil and turn it into a nutrient-deprived soil. Plants growing on the nutrient-deficient soil suffer malnutrition and less vigorous (Maheswari et al. 2014; Cheng et al. 2014; Nkbiwe et al. 2016; Thonar et al. 2017).

Bodies of water in Indonesia are rich with various invertebrates such as shrimps. Shrimps are commonly consumed seafood among Indonesian people. However, shrimp shells often time are wasted without being utilized. A pile of shrimp shells waste produces a putrid odor that pollutes the air and disturbs people activities (Prakash et al. 2011). One alternative to solve this issue is to utilize the shrimp shells waste as organic fertilizer by composting.

According to Jamaluddin et al. (2013; Osman (2012); Nathand Singh (2016), production of organic fertilizer in the form of liquid is less effective if the fermentation time is short and the cellulose content of the raw material is hard. These two conditions cause an incomplete fermentation of the waste material, as indicated by the low nutrient content of the analyzed material sample.

The addition of an activator in the form of microorganism can accelerate decomposition of organic waste. The activator microorganism can be from a local microorganism (MOL). MOL is a liquid fermentation product generated from easy-to-obtain local resources. One of the natural resources that can be utilized in MOL production is Golden Apple Snails (*Pomacea canaliculata* and *Pomacea maculata*). Golden Apple Snails, a disconcerting pest to farmers, is an excellent source of bacteria for compost activator. MOL of the snail includes organic matter bacteria decomposer, plant growth regulators, pest and pathogen control agents, and nutrients for plants. MOL of Golden snails contains Pseudomonas fluorescence (Rusmini et al. 2016). The bacteria were able to suppress the population of pathogens and associated with protected plant roots from soil pathogen infection via root surface colonization, secretion of chemical compounds such as antifungal and antibiotics, and competition in Fe cation absorption (Gajendran et al. 2016). Previous studies report that Pseudomonas fluorescence was able to control Anthracnose disease in banana (Peeran et al. 2014), and Fusarium wilt disease in onion and tomato (Gajendran et al. 2016; Khan et al. 2011). Furthermore, Pseudomonas fluorescens was able to solubilize phosphate from its fixed and unavailable form, thus become available and absorbable to plants (Khan et al. 2011). Furthermore, Subashri et al. (2012) reported that Pseudomonas fluorescens was also able to improve plant production.

The low productivity of kenaf plant is caused by several hindrances, one of them is biotic stress including pest, pathogen, and weed attack. Therefore, to tackle this issue, we try to develop a plant-based pesticide using a diluted bio-activator from Golden Snails to control pests that attack Kenaf plant effectively. This study aimed to produce a bio-activator from Golden Snails and the best spices and herbs as a decomposer of shrimp shells waste. The product will serve as a plant-based pesticide and generate composts from shrimp shells waste for the best interest of kenaf plant growth.

MATERIALS AND METHODS

This study was conducted in Center for Agricultural Technology Assessment (BPTP) of East Kalimantan, Indonesia for nutrient content analysis; and State Agricultural Polytechnic of Samarinda, Indonesia for bio-activator development, nutrient content analysis, and composts and plant-based pesticide application on fenaf plants.

Instruments and materials

Instruments employed in this research were a water plastic drum (capacity 200 l), scale, grinding machine, a wooden container for fermentation, and stirrer. Materials used in this study were Golden Apple Snails, cattle urine, rice-washing water, coconut water, palm sugar, kencur (*Kaempferia galanga*), turmeric, temulawak (*Curcuma zanthorrhiza*), shrimp shells, rice bran, chicken manure and Kenaf variety KR-11 seeds.

Experimental design

This study was a two factorials experiment conducted using a randomized block design. The first factor was the shrimp shells-based composts (K) which consist of three levels, namely: K_1 = 10 ton ha^{-1} compost application (1 kg/plot), K_2 = 20 ton ha^{-1} compost application (2 kg/plot), K_3= 30 ton ha^{-1} compost (3 kg/plot); the second factor was the plant-based pesticide using a diluted bio-activator from Golden Snails (P) which consists of three levels, namely: P_0 = control, P_1 = 50 ml pesticide /plant pesticide, P_2 = 100 ml pesticide/plant

Each experiment was repeated twice. Thus there were 18 units of experiment/plot. Each plot consisted of 16 kenaf plants. Hence in total, there were 288 kenaf plants. Each sampling was done on four plants in the center of the plot.

Preparation of bio-activator

All materials were prepared with specified amount as follows: 75 kg Golden Apple Snails, 45 l cattle urine, 30 l rice-washing water, 22.5 L coconut water, 37.5 kg palm sugar, 22.5 kg kencur (*Kaempferia galanga* L.), 3.75 kg turmeric, 7.5 kg temulawak (*Curcuma zanthorrhiza* Roxb.). The Golden Apple Snails were pulverized into a fine ground by using grinding machine. Palm sugar, kencur, turmeric, and temulawak were blended into fine pieces using a blender. The ground snail material and other materials were put into the plastic drum and then mixed well. The drum containing the mixture was closed with a lid that had a small hole in it. A plastic hose was attached into the drum lid hole on the one end, and into a 1500 ml plastic bottle containing 500 ml water on the other end. The mixture was stirred daily and fermented for 20-25 days. The final fermentation product or MOL would indicate certain characteristics, including no gas remaining, and smelled like tape (fermented rice or cassava). For composting, 500 ml MOL of golden snails was added into 1 kg organic matter and mixed thoroughly (a thoroughly mixed organic matter will not break upon grasping). As for the application of MOL as a plant-based pesticide, 1 l MOL was mixed with 5 l water and sprayed on kenaf plants to control the plant's pest. Furthermore, the activator from Golden Snails was analyzed for its nutrient and bacterial contents.

Composts production from shrimp shells

All the necessary materials were prepared with specified amount as follows: 50 kg fresh shrimp shells, 20 kg rice bran, 20 kg chicken manure. All Shrimp shells were cut into fine pieces by a chopping machine. Shrimp shells were mixed thoroughly with the rice bran, chicken manure and the MOL of the golden snails. The mixture was then transferred into a fermentation container. The mixture was flip once a week to maintain the ideal condition for composting. The mixture was then analyzed for its macronutrient level and C/N ratio. For application as plant fertilizers, the composts were applied 2 weeks before kenaf plantation. For the second application, the composts were used when the plants reached 1,5 month old. The plant-based pesticide was applied to the plants three times: firstly, 6 day old after planting; secondly, 30 days after the first application; and thirdly, 30 days after the second application.

Observations

Multiple observations were conducted on the MOL of the Golden Apple Snails, including color, odor, and temperature observations. Whereas, with regards to shrimp shells-based composts, in addition to observations of color, odor, temperature, the compost humidity was also monitored. Moreover, the nutrient content analysis was carried out on the mature composts. Observations on plants included plant height and diameter measurements. Both plant height and diameter were measured once every three weeks for three months. Pest observation was done through direct monitoring of the kenaf plants on a daily basis.

Data analysis

A difference in the nutrient content variable between each shrimp shells composting treatment was analyzed using a parametric statistical method of Least Significant Different (LSD) test.

RESULTS AND DISCUSSION

Bioactivator (MOL) from Golden Apple Snails

Observation on the preparation of MOL of Golden Apple Snails indicated that the MOL did not produce smell at day 28 after the onset of fermentation. This result indicated that each of the MOL raw material worked properly. In the fermentation mixture used in this study, the energy source was adequately supplied such as by the palm sugar. In addition, the carbohydrate supply in the mix also satisfied the need of the bacteria that were originated from the Golden Apple Snails. According to Rusmini et al. (2015), the nutrient content in the MOL of the Golden Apple Snails was higher than those from fruits and banana rhizome (Manullang and Rusmini, 2015). Bacteria species in the MOL of Golden Apple Snails was also different from those of fruits and banana rhizome. Bacteria in the MOL of Golden Apple Snails, fruits, and banana rhizome were *Bacillus* sp., *Enterobacter* sp., and *Pseudomonas fluorescen*ce, respectively (Rusmini et al. 2016).

Nutrient content of shrimp shells-based composts

Nutrient content of the shrimp shells-based composts was shown in Table 1. The compost's pH was 8.79 (basic). The high pH of the composts was likely due to the alkaline mineral content in the shrimp shells. This argument was in agreement with Vandecastlee et al. (2016), and Munoz et al. (2017) that suggested that the high pH and Ca level in crab shells-based composts was due to the alkaline mineral comprising the crab shells. Crabs and shrimps are Crustacean whose shells contain protein, calcium carbonate, and chitin (Weidema et al. 2013).

Nutrient analysis revealed that the composts N content was 3.62%, which was higher than that of the previous study (0.12 %) by Rusmini et al. (2015). This N level was still below the standard stipulated by the Regulation of Minister of Agriculture Republic Indonesia (Permentan). This substandard N content was probably due to the MOL of Golden Apple Snails used in this research only contain Pseudomonas fluorescent. The addition of rice bran in the composting material did not seem to increase the N content. The low N level could also be due to the chitin and $CaCO_3$ content of the shrimp shells. Shrimp shells consisted of protein (25%-40%), chitin ($(C_8H_{13}NO_5)_n$) (15%-20%), and calcium carbonate ($CaCO_3$) (45%-50%) (Kandra et al. 2012 ; Radwan et al. 2012;Paul et al. 2015). Chitin can be further processed into chitosan ($(C_6H_{11}NO_4)n$) and glucosamine ($C_6H_{13}NO_5$). Chitosan is an antibacterial compound that can inhibit bacterial growth. The natural polycation of chitosan was able to inhibit the growth of bacteria and mold (Sarasam et al. 2008; Baherei et al. 2009; Kingkaew et al. 2014; Chudinova et al. 2016; Kulikov et al. 2016; Fardioui et al. 2017).

Shrimp shells contained chitin that inhibited decomposer microorganism development, thus hindering the composting process. Menurut Zhou and Haynes (2012). Kaya et al. (2014), Mohanasrinivasan et al. (2014), Nidheesh and Suresh (2015), chitin and its derivatives were highly potential for antimicrobial materials.The low N content in the composts could also because shrimp shells contain 15%-20% $CaCO_3$. The high calcium carbonate content made N volatilize. According to Manurung (2011), application of lime on composts was not recommended. Liming caused nitrogen to volatilize into gaseous ammonia. In comparison, the N level of the composts produced in this study was lower than that of chicken-feather-based compost (7.23 %) supplemented with manure and rice bran (Sorathiya et al. 2014), but higher than that of the compost generated by Jamaluddin et al. (2013), Azim et al. (2015), and Manullang and Rusmini (2015). Kusmiadi et al. (2014) reported a decrease in N level of the composts supplemented with crab shells because of chitin and $CaCO_3$ of the shells. Khan (2009) suggested that addition of rice bran and hull waste to the composting material as a carbohydrate and nutrition source for the activator microorganisms led to composts with high N content. Suwastika et al. (2005), Partey et al. (2013) and Sutanto et al. (2016) suggested that addition of composted rice bran was able to increase the N content of the fertilizer. This increase in the compost N content was due to the presence of organic compounds.

The phosphorus content of the shrimp shells-based composts was 3.62%, which was higher than those of composts produced by Rusmini et al. (2015) (1.42%), Azim et al. (2015), and Manullang and Rusmini (2015). The P level indicated in this study met the Indonesian National Standard (SNI) Number 19-7030-2004 on composts, which stated the minimum P content is 0.10%. The low P level in the composts was probably due to the consumption of the P contained in the activator by microorganisms during composting (Vaneeckhaute et al. 2014; Ratna et al. 2015; Vandecasteele et al. 2016).

The Potassium (K) content of the shrimp shells-based composts was 8.1%, which was higher than the minimum Permentan standard and SNI for K of 4% and 0.20%, respectively. The high K content of the composts was likely contributed by its raw material of shrimp shells. The K level of the composts produced in this study was greater than those of the composts reported by Manullang and Rusmini (2015) and Azim et al. (2015). Microorganism availability significantly affected Kalium content in composts. Ratna et al. (2015) stated that K element was obtained from organic material decomposition by the microorganism. Hence, the decline in K content was highly influenced by the microorganism nutrition factor.

Organic carbon content identified in the shrimp shells composts was 17.45%, which satisfied the standard C content for organic fertilizer according to Permentan (15%) and SNI on composts (9.8-32%). The shrimp shells-based composts resulted in this study showed a lower organic C content than that of the previous study (27.3240%) (Rusmini et al. 2015). This phenomenon was likely due to the high chitin content of the shrimp shells. Upon such high chitin environment, the decomposer microorganism required a greater amount of energy to break down the material. Microorganisms used carbon as energy sources, thus during composting the carbon content of the compost might gradually deplete. Manurung (2011) suggested that the decline in the compost organic C content was due to the utilization of carbon as an energy source by the decomposing agents to power their metabolism activities.

Laboratory analysis on the shrimp shells-based compost indicated a C/N ratio of 4.82, which failed to meet the C/N standard range of SNI 19-7030-2004 (10-20) and that of Permentan (15-25). The low C/N ratio was probably due to the complete decomposition of the shrimp shells. The compost C/N ratio achieved in this research was better than that of the previous study (Rusmini et al. 2015). In that earlier study by Rusmini et al. (2015), the interaction value between MOL (a2) and the shrimp shells (b3) was 41.52, which indicated that the compost was not completely decomposed. The low C/N ratio showed that organic material in the two composting treatments was actually decomposed. Depletion and maturation of the compost material were indicated by compost flaking, color change into soil color, no odor, and low water content in the bokashi and composts. Composting rate depends on the availability of C and N elements in the bokashi/compost material. Microorganisms require a balance amount of C and N to decompose organic materials during composting process optimally. Organic matters will be oxidized by microorganisms, thereby reducing the C/N ratio of the matters and devouring all its N element. Supplementation of the organic matter with an N-rich material such as rice bran can alleviate the N loss.

Table 1. Nutrient content of shrimp shells-based composts

Parameter	Unit	Shrimp shells-based composts	SNI range*		Per-mentan**
			Min	Max	
pH	-	8.79	6.8	7.49	4-9
N total	%	3.62	0.4	-	min.4
Water content	%	31.83	-	50	15-25
Organic C	%	17.45	9.8	32	min.15
C/N ratio	-	4.82	4.82	0.10	15-25
P	%	2.27	0.10	-	min.4
K	%	8.13	0.20	-	min.4
Ca	%	7.64	-	25.50	-
Mg	%	0.59	-	0.60	-

Note: *SNI (Indonesian National Standard) 19-7030-2004 and **Permentan (Regulation of Minister of Agriculture Republic Indonesia) Number 70/Permentan/SR. 140/10/2011

The compost exhibited a low C/N ratio probably because, during decomposition, microorganism preferred carbon as their energy source. This idea was corroborated by Zaman and Endro (2007) who suggested that during composting, microorganism decomposed organic matter aerobically and thus releasing CO_2 and H_2O and in turn diminishing carbon content in the composting material. Yuniawati et al. (2012) suggested that the decrease in C content during composting was due to the conversion of organic matters into gaseous CO_2 and CH_4, thereby lowering the C/N ratio.

Widaryanto (2013); Partey et al. (2013) and Sutanto et al. (2016) stated that the C/N ratio corresponded to the organic matters decomposition intensity. Higher C/N ratio indicates that material was recalcitrant to decomposition, whereas lower C/N ratio means that the material was readily decomposed. Also, a higher C/N ratio was indicative of cellulose and lignin-rich material, i.e. a recalcitrant material. Conversely, a lower C/N ratio was indicative of cellulose and lignin-poor material which was readily decomposed. The decrease in C content during composting was due to the conversion of organic matters into gaseous CO_2 and CH_4, thereby lowering the C/N ratio. Another factor that accelerates a decomposition is the size of the raw material. Kusmiadi et al. (2014) suggested that the low C/N ratio in compost was also likely caused by the $CaCO_3$ content in the compost material. Calcium carbonate in the composting material will increase the decomposition rate.

With regards to the Mg content of the compost in this study, its level reached 0,59% which was below the maximum Mg level dictated by SNI 19-7030-2004 for compost fertilizer (0.60 %). The Mg level of the compost in this study was slightly higher than that of the compost produced by Rusmini et al. (2015) (0.5121%). Meanwhile, the Ca content of the shrimp shells-based composts was 7.64% or in other words was below the maximum compost Ca level of 25.5% as recommended by SNI for compost fertilizer. The compost Ca level higher compared with that of the previous report by Rusmini et al. (2015) (1.10%). Probably, the significant amount of calcium carbonate constituting the shrimp shells contributed to the high Ca content of the resulted composts.

Table 2. Mean of kenaf plant height (cm) 3 weeks after planting (WAP) upon plant-based pesticideapplication (P) and shrimp shells-based compost (K)

Treatment	K_1	K_2	K_3	Mean
P_0	21.1250	20.8150	21.1900	21.0433
P_1	23.4400	20.0000	25.3150	22.9183
P_2	22.2550	25.5050	20.8150	22.8583
Mean	22.2733	22.1067	22.4400	

Note: Mean followed by the same letter indicated a non-significant difference (α = 5%)

Table 3. Mean of kenaf plant height (cm) 6weeks after planting (WAP) upon plant-based pesticide application (P) and shrimp shells-based compost (K)

Treatment	K_1	K_2	K_3	RMean
P_0	130.6250	141.1250	168.0000	146.5833
P_1	139.0000	165.5000	162.7500	155.7500
P_2	131.3750	160.8750	163.3750	151.8750
Mean	133.6667 b	155.8333 a	164.7083 a	

Note: Mean followed by the same letter indicated a non-significant difference (α = 5%) using LSD test (K) 16.00

Table 4. Mean of kenaf plant height (cm) 9weeks after planting (WAP) upon plant-basedpesticide application (P) and shrimp shells-based compost (K)

Treatment	K_1	K_2	K_3	Mean
P_0	172.5000	196.3750	220.8750	196.5833
P_1	185.3750	224.1250	217.7500	209.0833
P_2	198.2500	220.8750	230.8750	216.6667
Averange	185.3750 b	213.7917 a	223.1667 a	

Note: Mean followed by the same letter indicated a non-significant difference (α = 5%) using LSD test (K) 23,31

Table 5. Mean of kenaf plant diameter (mm) 3weeks after planting (WAP) upon plant-based pesticide application (P) and shrimp shells-based compost (K)

Treatment	K_1	K_2	K_3	Mean
P_0	2.6600	2.9450	3.6100	3.0717
P_1	2.5350	2.8350	2.7050	2.6917
P_2	2.0550	2.5200	2.5900	2.3883
Mean	2.4167	2.7667	2.9683	

Note: Mean followed by the same letter indicated a non-significant difference (α = 5%)

Table 2 showed the analysis of variance on kenaf plant height 3 weeks after planting (WAP) indicated that there were no significant differences among pesticide application treatments (P) and shrimp shells-based compost application treatments (K). This result was probably due to the suboptimum absorption of the composts and pesticides by the kenaf plants at 3 weeks after planting, thereby affecting plant height.

Table 3 showed the analysis of variance of Kenaf plants height treated with plant-based pesticide treatments (P) and shrimp shells-based compost treatments (K) at 6 weeks after kenaf planting. Applications of shrimp shells-based composts gave significant effects on kenaf plant height. K3 treatment resulted in the highest plant height of 165.7083 cm. The plant height upon K3 treatment (164.7083 cm) was significantly different from that of K1 treatment (133.6667 cm) but was not from that of K2 treatment (155.8333 cm). This result indicated that at 6 weeks after planting, the shrimp shells-based composts were maximally absorbed by the kenaf plants. In agreement with this result, Daryono (2016) reported that at 75 days after planting, plant growth increase showed significant differences in response to fertilizer treatments applied in the experiment, whereas at 15, 30, 45, and 60 days after planting, such significant differences in plant growth increase were absent.

Table 4 indicated the plant height upon pesticide (P) and composts (K) treatments on kenaf plant 9 weeks after planting. The shrimp shells-based compost treatments significantly affected kenaf plant height. K_3 treatment which represented the highest amount of compost applied to the plants resulted in the highest plant height of 223.1667 cm. This plant height upon K_3 treatment was significantly different from that of the lowest concentration of compost applied, the K_1 treatment (185.3750 cm) but was not from that of K_2 treatment (213.7917 cm). Again, this result was in agreement with Daryono (2016) who reported that at 75 days after planting, plant growth increase showed significant differences in response to fertilizer treatments applied in the experiment, whereas at 15, 30, 45, and 60 days after planting, the growth increases were not significantly different. Rusmini and Nurlaila (2016) pointed out that application of liquid fertilizer from three types of agricultural wastes did not give significant effect on the kenaf plant height. Meanwhile, Khodijah et al. (2015) reported that application of solid and liquid formulations of bioinsecticide supplemented with an active ingredient of entomopathogenic *B. bassiana* fungi together with a liquid formulation of bioinsecticide with a shrimp shells-based carrier material as well as with a solid formulation of compost enriched with *Trichoderma* sp. fungi on rice plants was able to positively affect rice plant vigor such as stem height, productive tiller number, grain weight per clump, grain number per panicle. Furthermore, a study by Yenanni (2013) on the effect of shrimp shells-based compost media on the growth of ornamental plant, *Aglaonema costatum*, identified that 4% shrimp shells waste powder treatment resulted in the optimum growth of the *Aglaonema costatum*, with a mean of total leaf number of 6.25 and an average of plant height of 21.5 cm.

Table 5 presented the analysis of variance of kenaf plant diameter at 3 weeks after planting. There were no significant differences in the plant diameter in response to the plant-based pesticide (P) and the shrimp shells-based composts (K) treatments. It was likely that at 3 weeks after planting, both the pesticide and the compost were not optimally absorbed by the plant, resulting in no significant effect on the plant diameter. In line with this present result, Rusmini and Nurlaila (2016) have also shown that application of liquid fertilizers produced from three different agricultural wastes did not significantly affect the content of kenaf fiber.

Tabel 6. Mean of kenaf plant diameter (mm) 6weeks after planting (WAP) upon plant-based pesticide application (P) and shrimp shells-based compost (K)

Treatment	K_1	K_2	K_3	Mean
P_0	11.3000	13.5000	16.4650	13.7550
P_1	10.9950	15.7150	16.8100	14.5067
P_2	13.2850	15.7500	16.9650	15.3333
Mean	11.8600 c	14.9883 b	16.7467 a	

Note: Mean followed by the same letter indicated a non-significant difference (α = 5 %) with LSD test (K) 1.23

Tabel 7. Mean of kenaf plant diameter (mm) 9weeks after planting (WAP) upon plant-based pesticide application (P) and shrimp shells-based compost (K)

Treatment	K_1	K_2	K_3	Mean
P_0	13.0650	17.3550	22.4400	17.6200 b
P_1	15.2200	21.7450	21.3150	19.4267 ab
P_2	18.4900	20.9900	23.4600	20.9800 a
Mean	15.5917 b	20.0300 a	22.4050 a	

Note: Mean followed by the same letter indicated a non-significant difference (α = 5 %) LSD test (K) 1.23 ; LSD test (P) 2.40

Table 8. Pest population of kenaf plants during 9 weeks of observation

Pest type	Amount
Caterpillar	15
Bugs	5
Beetle	4

Table 6 showed the plant diameter upon pesticide (P) and composts (K) treatments on kenaf plant at 6 weeks after planting. The shrimp shells-based compost treatments significantly affected kenaf plant height. K3 treatment which represented the highest amount of compost applied to the plants resulted in the largest kenaf plant diameter of 16.7467 mm. This plant diameter upon K_3 treatment was significantly different from that of K_2 treatment (213.7917 cm), and that of the lowest compost concentration applied, the K_1 treatment (185.3750 cm). The significant difference in the plant diameter in response to the compost treatments might indicate that at 6 weeks after planting, the shrimp shells-based compost was already maximally absorbed by the plant. This result, again, was in line with the study conducted by Daryono (2016) who reported that at 75 days after planting, plant height increase showed significant differences in response to fertilizer treatments applied in the experiment, whereas at 15, 30, 45, and 60 days after planting, the height increases were not significantly different.

Table 7 showed that both the plant-based pesticide (P) and the shrimp shells-based composts (K) applications gave significant effects on the plant diameter at 9 weeks after planting. In response to K_3, the highest amount of composts applied, the kenaf plants showed the largest plant diameter of 22.4050 mm. The plant diameter upon K_3 treatment differed significantly from that of the lowest concentration of compost applied, the K_1 treatment (15.5917 mm) but did not so from that of the K_2 treatment (20.0300 mm). This result indicated that at 6 weeks after planting, the applied composts were optimally absorbed. With regards to the effect of the plant-based pesticide, the application of P_2 dose (100 ml pesticide/plant) showed a significant effect on plant diameter compared with that of control treatment (P_0). Meanwhile, there were not significant differences in the resulting plant diameter between the $P_{\neg 1}$ with those of the control and the P_2 treatments. As stated earlier, this finding was in agreement with Daryono (2016). Previously, Daryono (2016) reported that plant height increase exhibited significant differences in response to fertilizer treatments applied in the experiment at 75 days after planting, whereas such significant differences were not observed at 15, 30, 45, and 60 days after planting.

Table 8 showed demonstrated that there were three pest populations infesting the kenaf plants. The total individuals constituted each pest population of each pest was still below the economic threshold. This observation indicated that the plant-based pesticide supplemented with diluted MOL of the Golden Apple Snails was able to control the pests as well as to provide nutrients required for the plant diameter growth and increase. Furthermore, it appeared that the application of shrimp shells-based composts was able to control the pests that attacked the plants. This present finding was in agreement with Syahril et al. (2014) that reported that an extract of shrimp shells compost effectively suppressed the severity of leaf rust disease in long beans (*Vigna unguiculata*) with a suppression rate of 59.4%, and rotten leaf disease in angled luffa (*Luffa acutangula*) and cucumber with a suppression rate of 10.31% and 14.85%, respectively. In addition, the application of the extract of shrimp shells compost was also able to increase oyong and yardlong bean plants production up to 17.40% and 246.67%, respectively. Moreover, Khodijah (2012) stated that utilization of shrimp shells-based compost extract as a carrier material for liquid formulation bioinsecticide with an active ingredient of *Beauveria bassiana* had been proved to be effective in controlling the rice stem borer pest in the swamp and non-tidal marsh areas. In addition to containing chitin which was required by *B. bassiana* fungi in order to maintain the fungi virulence during storage, the extract of the shrimp shells-based compost also included other elements for improving rice plant production.

To conclude, this present study concluded that the shrimp shells-based composts exhibited a pH value of 8.79; nutrient content: Potassium (K) 8.13 %, organic carbon (C) 17.45%, Nitrogen (N) 3.62%, Phosphorus (P) 2.27%; Magnesium (Mg) 0.59%, and Calcium (Ca) 7.64%; and a C/N ratio of 4.82. Kenaf plant height at 6 and 9 weeks after planting (WAP) showed significant differences upon the shrimp shells-based composts treatments. At 6 weeks after planting, kenaf plant diameter showed significant differences upon the composts treatment, while at 9 weeks after planting, the plant diameter indicated significant differences upon both the compost and plant-based pesticide application. Pest populations that present in kenaf plants were caterpillars, bugs, and beetles.

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REFERENCES

Azim K, Komenane S, Soudi B. 2017. Agro-environmental assessment of composting plantsin Southwestern of Morocco (Souss-Massa Region). Intl J Recycl Org Waste Agric 6 (2): 107-115.

Beherei HH, Mohamed KR, Mahmoud AI. 2009. Preparation, Bioactivity and Antibacterial Effect of Bioactive Glass/Chitosan Biocomposites. In: Lim CT, Goh JCH (eds) 13th International Conference on Biomedical Engineering. IFMBE Proceedings, vol 23. Springer, Berlin, Heidelberg

Bourguignon M, Moore KJ, Brown RC et al. 2017. Variety trial and pyrolysis potential of kenaf grown in midwest united states. Bioenerg Res 10: 36. DOI: 10.1007/s12155-016-9773-8.

Cheng Z, McCoy E.L, Grewal PS. 2014. Water, sediment, and nutrient runoff from urban lawns established on disturbed subsoil or topsoil and managed with inorganic or organic fertilizers. Urban Ecosyst 17: 277. DOI: 10.1007/s11252-013-0300-9.

Chudinova YV, Shagdarova BT, Il'ina AV et al. 2016. Antibacterial effect of peptide conjugates with a quaternized chitosan derivative and its estimation by the method of atomic force microscopy Appl Biochem Microbiol 52: 496. DOI: 10.1134/S0003683816050069.

Daryono. 2016. The Response of Kenaf Varieties (Hibiscus cannabinus L.) the Nitrogen and Chicken Manure Fertilizer. Loupe 1: 33-38.

Fardioui M, Guedira T, Qaiss AEK et al. 2017. A comparative study of doum fiber and shrimp chitin based reinforced low density polyethylene biocomposites. J Polym Environ. DOI: 10.1007/s10924-017-0955-z.

Gajendran G, Dinakaran D, Mohankumar S. et al. 2016. Integrated Pest Management for Onion in India. In: Muniappan R, Heinrichs EA (eds.). Integrated Pest Management of Tropical Vegetable Crops. Springer, Dordrecht.

Huang SW, Wang L, Liu LM, Fu Q, Zhu DF. 2014. Nonchemical pest control in China rice: a review. Agron Sustain Dev 2: 275-291.

Jamaluddin, Nurlaila, Roby, Rusmini. 2013. Development of liquid organic fertilizer from agricultural waste with bioactivator cow rumen. Poltanesa 1: 7-11.

Kandra P, Challa MM, Jyothi HKP. 2012. Efficient use of shrimp waste: present and future trends. Appl Microbiol Biotechnol 93: 17. DOI: 10.1007/s00253-011-3651-2.

Kaya M, Cakmak Y.S, Baran T et al. 2014. New chitin, chitosan, and O-carboxymethyl chitosan sources from resting eggs of *Daphnia longispina* (Crustacea); with physicochemical characterization, and antimicrobial and antioxidant activities. Biotechnol Bioproc E 19: 58. DOI: 10.1007/s12257-013-0488-9.

Khan MAI, Ueno K, Horimoto S. et al. 2009. Physicochemical, including spectroscopic, and biological analyses during composting of green tea waste and rice bran. Biol Fertil Soils 45: 305. DOI: 10.1007/s00374-008-0335-x.

Khan MR, Anwer MA, Shahid S. 2011. Management of gray mold of Chicpea *Botrytis cinera* with bacterial and fungal biopesticides using different modes of inoculation and application. Biol Contr 57: 13-23.

Khodijah. 2012. Development and application of bioinsecticide based on entomopathogenic fungi to control rice stem borer, as well as its effect on the entomofaga insect community in the ecosystem of swamps of lebak and tidal.Universitas Sriwijaya, Indaralaya.

Khodijah, Meidalima D, Nunilahwati H et al. 2015. The Performance of Paddy That Applied by Bioinsektisida Plus in Lowland Swamp; Proceedings of National Seminar of Suboptimal Land, Palembang, 8-9 Oktober 2015.

Kingkaew J, Kirdponpattara S, Sanchavanakit N. et al. 2014. Effect of molecular weight of chitosan on antimicrobial properties and tissue compatibility of chitosan-impregnated bacterial cellulose films. Biotechnol Bioproc E 19: 534. DOI: 10.1007/s12257-014-0081-x.

Kulikov SN, Bayazitova LT, Tyupkina OF et al. 2016. Evaluation of a method for the determination of antibacterial activity of chitosan. Appl Biochem Microbiol 52: 502. DOI: 10.1134/S0003683816050100.

Kusmiadi R, Khodijah N, Akbar A. 2014. The Utilization Chicken Feather and Crab Shells for improving the Physical and Chemical Quality Compost. Enviagro 7: 33-42.

Lips SJJ, Dam JEGV. 2013. Kenaf fibre crop for bioeconomic industrial development. In: Monti A, Alexopoulou E (eds.). Kenaf: A Multi-Purpose Crop for Several Industrial Applications. Springer, London

Maheshwari DK, Dheeman S, Agarwal M. 2014. Decomposition of organic materials into high value compost for sustainable crop productivity. In: Maheshwari DK. (eds). Composting for Sustainable Agriculture. Springer International Publishing, Switzerland

Manullang, RR, Rusmini. 2015. Empty recemus of oil palm as source of organic fertilizer with bio-activator on soybean plants. Glob J Agric 3 (2): 1-12.

Manurung H. 2011. Application of bioactivators (effective microorganisms4 and orgadec) to accelerate the formation of Kepok banana bone waste compost (*Musa paradisiaca* L). Bioprospek 2 : 7-16.

Mohanasrinivasan V, Mishra M, Paliwal J.S et al. 2014. Studies on heavy metal removal efficiency and antibacterial activity of chitosan prepared from shrimp shell waste. 3Biotech 4: 167-175.

Muñoz I, Rodríguez C, Gillet D et al. 2017. Life cycle assessment of chitosan production in India and Europe. Int J Life Cycle Assess DOI 10.1007/s11367-017-1290-2.

Nath S, Singh K. 2016. Analysis of different nutrient status of liquid bio-fertilizer of different combinations of buffalo dung with gram bran and water hyacinth through vermicomposting by *Eisenia fetida*. Environ Dev Sustain (2016) 18: 645. DOI: 10.1007/s10668-015-9666-6

Nidheesh T, Suresh PV. 2015. Optimization of conditions for isolation of high quality chitin from shrimp processing raw byproducts using response surface methodology and its characterization. J Food Sci Technol 52: 3812. DOI: 10.1007/s13197-014-1446-z.

Nkebiwe PM, Weinmann M, Müller T. 2016. Improving fertilizer‑depot exploitation and maize growth by inoculation with plant growth‑promoting bacteria: from lab to field. Chem. Biol. Technol. Agric. 3: 15.DOI: 10.1186/s40538-016-0065-5.

Osman KT. 2012. Plant Nutrients and Soil Fertility Management. In: Soils: Principles, Properties and Management, Springer, Dodrech.

Partey ST, Preziosi RF, Robson GD. 2013. Maize Residue Interaction with High Quality Organic Materials: Effects on Decomposition and Nutrient Release Dynamics. Agric Res 2 (1): 58-67.

Paul T, Halder SK, Das A et al. 2015. Production of chitin and bioactive materials from Black tiger shrimp (Penaeus monodon) shell waste by the treatment of bacterial protease cocktail. 3 Biotech 5: 483-493.

Peeran MF, Krishnan N, Thangamani PR et al. 2014. Development and evaluation of water-in-oil formulation of *Pseudomonas fluorescens* (FP7) against*Colletotrichum musae* incitant of anthracnose disease in banana. Eur J Plant Pathol 138: 167.

Prakash D, Nawani NN, Kapadris BP. 2011. Microbial mining of value added products from seafood waste and their applications. In: Satyanarayana T, Johri BN, Prakash A (eds.). Microorganisms in Environmental Management. Springer, Berlin.

Radwan MA, Farrag SAA, Abu-Elamayem MM et al. 2012. Extraction, characterization, and nematicidal activity of chitin and chitosan derived from shrimp shell wastes. Biol Fertil Soils 48: 463.

Ratna ND, Sarwono AE, Hariyono B. 2015. The Effect of Organic and Inorganic Fertilizer on Production, Sesame Seed Oil Content, and Feasibility in Sandy Coastal Land. In: Hongladarom S. (eds) Food Security and Food Safety for the Twenty-first Century. Springer, Singapore

Rusmini, Nurlaila. 2014. Development of organic wastes with bioactivators as fertilizer to the kenaf plant fiber content. Poltanesa 2: 47-54.

Rusmini, Nurlaila. 2016. Effect of Liquid Organic Fertilizer on Growth and Yield of Kenaf Plant . Loupe 2 : 9-17. [Indonesian]

Rusmini, Manullang RR, Daryono. 2015. Development Compost Bio-Activator Gold Snail Skin With Shrimp and Pesticides Vegetable on The Growth And Population In Plant Pest Kenaf Politeknik Pertanian Negeri Samarinda, Samarinda. [Indonesian]

Rusmini, Manullang RR, Daryono. 2016. Physical and chemical properties of local microorganism of gold snail with different amount of materials. Seminar Nasional Masyarakat Biodiversitas Indonesia (MBI), Samarinda, 26 November 2016.

Ryu J, Ha BK, Kim D.S. et al. 2013. Assessment of growth and seed oil composition of kenaf (*Hibiscus cannabinus* L.) germplasm. J Crop Sci Biotechnol 16: 297. DOI: 10.1007/s12892-013-0074-x.

Ryu J, Kwon SJ, Sung SY et al. 2016. Molecular cloning, characterization, and expression analysis of lignin biosynthesis genes from kenaf (*Hibiscus cannabinus* L.). Genes Genom (2016) 38: 59. DOI: 10.1007/s13258-015-0341-y

Saba N, Paridah MT, Jawaid M, et al. 2015. Potential utilization of kenaf biomass in different applications. In: Hakeem KR, Jawaid M, Alothman OY (eds.). Agricultural Biomass Based Potential Materials. Springer, Berlin.

Sarasam AR, Brown P, Khajotia SS et al. 2008. Antibacterial activity of chitosan-based matrices on oral pathogens. J Mater Sci Mater Med 19 (3): 1083-1090.

Sorathiya LM, Fulsoundar AB, Tyagi KK et al. 2014. Eco-friendly and modern methods of livestock waste recycling for enhancing farm profitability. Int J Recycl Org Waste Agricult 3: 50. DOI: 10.1007/s40093-014-0050-6.

Subashri R, Raman G, Sakthivel R. 2012. Biological Control of Pathogens and Plant Growth Promotion Potential of Fluorescent Pseudomonads. In: Maheshwari DK (eds.). Bacteria in Agrobiology: Disease Management. Springer, Berlin.

Sutanto S, Go AW, Chen KH et al. 2016. Maximized utilization of raw rice bran in microbial oils production and recovery of active compounds: A proof of concept. Waste Biomass Valor 8 (4): 1067-1080.

Syahri, Hartono, Suwandi. 2014. Utilization of shrimp leaf compost extract in disease control and increase vegetable production. Proceedings of national seminar on organic farming. Bogor, 18-19 Juni 2014.

Thonar C, Lekfeldt JDS, Cozzolino V et al. 2017. Potential of three microbial bio-effectors to promote maize growth and nutrient acquisition from alternative phosphorous fertilizers in contrasting soils. Chem Biol Technol Agric 4: 7. DOI: 10.1186/s40538-017-0088-6.

Vandecasteele B, Willekens K, Steel H et al. 2016. Feedstock Mixture Composition as Key Factor for C/P Ratio and Phosphorus Availability in Composts: Role of Biodegradation Potential, Biochar Amendment and Calcium Content. Waste Biomass Valor. DOI: 10.1007/s12649-016-9762-3.

Vaneeckhaute C, Janda J, Meers E, Tack FMG. 2014. Efficiency of soil and fertilizer phosphorus use in time: a comparison between recovered struvite, $fepo_4$-sludge, digestate, animal manure, and synthetic fertilizer. In: Rakshit A, Singh HB, Sen A (eds.). Nutrient Use Efficiency: from Basics to Advances. Springer, Berlin.

Xu D, Liu D, Tang Z et al. 2012. Structure of chemical components in different compost extracts characterized by chromatogram and spectroscopy analysis and its influence on plant growth promotion. J Mater Cycles Waste Manag 14: 325. DOI: 10.1007/s10163-012-0071-z.

Yenanni. 2013. Influence of Combination Media Combination Combination With Shrimp Flour Waste Aglaonema (*Aglaonema costatum*. Growth [Hon Thesis]. Universitas Pakuan, Bogor.

Yuniwati MF, Iskarima A, Padulemba. 2012. Optimization of composting process from organic waste by fermentation using EM4 Teknologi 2: 172-181.

Weidema BP, Bauer C, Hischier R, Mutel C, Nemecek T, Reinhard J, Vadenbo CO, Wernet G (2013) Overview and methodology. Data quality guideline for the ecoinvent database version 3. Ecoinvent Report.

Widaryanto A. 2013. C / N Ratio, Phospor Content (P), Acidity (pH), and Compost Texture The Result of Composting of Market Organic Rubbish with Starter EM4 (Effective Microorganism 4) in Various doses. [Hon Thesis]. IKIP PGRI, Semarang.

Zaman B, Endro S. 2007. Study the effect of domestic waste mixing, rice husk, and bagasse with mac donald method to compost maturity.Presipitasi 1: 1-7.

Zhou YF, Haynes RJ. 2012. A comparison of organic wastes as bioadsorbents of heavy metal cations in aqueous solution and their capacity for desorption and regeneration Environ Earth Sci 66: 1137. DOI: 10.1007/s12665-011-1321-4