Biofertilizer from Waste Crab Shell Recycling for Aquaponics Systems

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Abstract

The biofertilizer, made of crab shell waste, was used as nutrients source in aquaponics system. The present study was carried out to assess the growth of watercress. The effluents from catfish culture tank were flown through aquaponic systems. The height of watercress and the length of root was increased more than two centimetres in 10 days for all experiments. The height and root length of watercress was different after 15 days. Biochemical oxygen demand (BOD₅) was increased with biofertilizer due to organic matter from the biofertilizer. The results showed the potential of biofertilizer effects on the growth of watercress and improves water quality in aquaponic systems. So, the usage of biofertilizer in aquaponics systems is the guideline for green production. However, wastewater treatment process should be added into aquaponics system to enrich water quality control.

Keywords: Watercress, Aquaponics System, Water Quality, Biofertilizer
1. Introduction

New Theory of Agriculture has gained more attention in Thailand because of its social and occupational. It is accepted that, Thailand is an agricultural country. Many studies and researches on the aspects of new agricultural theories were applied in the country. Aquaculture system has been developed in many areas of the country. This is similar to the new agricultural theory, initiated by His Majesty King Bhumibol Adulyadej, which is considered a new farming approach for farmers and all Thai people to promote sustainable development of agriculture. Aquaponics is a combination of aquaculture (fish farming) and hydroponics (plant growing without soil). It is a closed-loop recycling fresh water system between fish and plant (Kyaw and Ng, 2017). Globally, aquaculture is the fastest growing agriculture sectors that needs to be sustainable and must also meet bioeconomic demands. In principle, aquaponics, the combination of aquaculture and horticulture within a single recirculation aquaponic system (SRAPS), provides sustainable approach; however, it has lower productivity of both fish and plants in comparison to separate recirculation systems. The aim of our new concept for aquaponics is to improve sustainability and productivity concomitant with lowering environmental emissions (Kloas et al., 2015). To support the development of new agricultural theories to be more environmentally friendly, this research was aimed to develop biofertilizers from environmentally friendly materials, for example prawn and crab shells which contain chitin, protein, and inorganic compounds, such as calcium carbonate (Liang et al. 2006). The crab shell (Figure 1), as the main material for the biofertilizer production, was a waste product of sea crab meat production. Waste
shell crab will cause bad smell and disturb people in nearby communities. Since the crab shells contain chitin and chitosan (Yen, Yang and Mau, 2009), which promotes growth of the plant. Therefore, using crab shell to produce biofertilizer in aquaponics system may be feasible.

![Figure 1 Waste crab shell (by product) from Crab crabmeat production in Cottage Industry (Trang, Thailand).](image)

2. Materials and Methods

The waste crab shell recycling process was dried, grinded and mixed with crushed manure in order to produce biofertilizers in aquaponics experiment. To evaluate the potential of the biofertilizers from crab shell waste and animal manure in the aquaponics system, water cress and catfish were selected to carried out in this study. The growth of watercress was analyzed in different conditions, 1) clean water condition 2) aquaponics system and 3) aquaponics system with biofertilizer. The growth parameters of watercress including the height, root length and wet weight of the watercress were
recorded and compared among different conditions. Biochemical oxygen demand (BOD₅) was analyzed by using standard methods for the examination of water and Wastewater (APHA, AWWA and WEF 2012). The fish samples were analyzed for survival rate by using the formulae (Venkatachalam et al., 2018)

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\text{Survival} \%(%) = \frac{\text{Number of fish harvested}}{\text{Number of fishes stocked}} \times 100
\]

3. Results and Discussion

Comparison the growth from stem height

Experiments were conducted to evaluate the watercress growth in the aquaponics system. Data collection is used to measure the height of the watercress stem was recorded every 5 days during a period of 40 days experiment as shown in Figure 2. The result of all condition was not different in 1-15 days of the study. However, the stem height of the third treatment were remarkably higher than the other two condition at the final week. The results showed that the biofertilizers from waste crab shell were suitable for the growth of watercress.
Figure 2 Stem height of watercress in 40 days.

Comparison of growth from root length

Root length of the watercress during a period of 40 days is shown in Figure 3. For the first 10 days, the root length of the 2\textsuperscript{nd} and the 3\textsuperscript{rd} condition had similar values, which were higher than that of the 1\textsuperscript{st} condition. But, after 15 days, root length of watercress from the 3\textsuperscript{rd} condition had higher value than other experiments. This result shows the potential of biological fertilizers from waste crab shells is beneficial to the growth of watercress roots.
Figure 3 Root length of watercress in 40 days

Comparison of the increase in wet weight

Wet weight of watercress was compared when watercress was grown for a period of 45 days, as shown in Figure 4. The results indicated that wet weight of watercress from the 1\textsuperscript{st}, 2\textsuperscript{nd} and the 3\textsuperscript{rd} condition, at 15 day of the experiment, was 1.914±0.689, 2.445±0.822 and 2.188±0.980 grams, respectively, which were not statistically different. However, at day 30 of the study the wet weight of 1\textsuperscript{st}, 2\textsuperscript{nd} and the 3\textsuperscript{rd} condition, was 3.76±0.71, 8.84±3.42 and 10.61±2.58 grams respectively, with statistically different. On the day 45, the wet weight of the 1\textsuperscript{st}, 2\textsuperscript{nd} and the 3\textsuperscript{rd} condition was 4.53±0.42, 10.78±3.54 and 13.33±3.08 grams respectively. These results indicated that the biofertilizer from crab shells affected the growth of watercress.
Figure 4 Wet weight of watercress in 45 day

The results showed that the nutrient from biofertilizers promoted plants growth as illustrated in the first condition of aquaponic, indicating that plain water provided insufficient nutrient for the growth of watercress. The 2nd condition indicated that, fish ponds still provided in sufficiently nutrient as the watercress grew slowly. The 3rd condition indicated that the biofertilizers from waste crab shells promoted the growth of watercress. The similar results were observed in the roots, stems and weight of watercress at 3 weeks of the study.

The survival rate of catfish in all experiments was 100 percent, indicating that biofertilizers did not affect the fish's life expansion in the system. Biofertilizers from waste crab shells affected the water quality in terms of biochemical oxygen demand (BOD₅) which was increased to 20 – 80 mg/L at 3 weeks of the study. The increment of BOD may be due to addition of organic matter from the biofertilizer. Therefore, in
aquaponics systems, a wastewater treatment unit should be installed to improve water quality in the system.

4. Conclusions

The results show the potential of biofertilizers from crab shell was a potential source of nutrients to be applied in aquaponics system. Because of its ability to promotes the growth of plants. This may due to the composition of the crab shells (chitosan, calcium and other substances) and nutrients from animal manure in the biofertilizer. These are nutrients promoted plant growth and did not affect the fish's life expansion, the survival rate of catfish in all experiments was 100 percent. This research shows that the biofertilizer produced from crab shell and animal manure is capable to be applied in aquaponics system to support environmentally friendly production in agriculture industry.

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References

APHA, AWWA and WEF. (2012). Standard methods for the examination of water and wastewater. 22nd edition American Public Health Association (APHA), American Water Works Association (AWWA) and Water Environment Federation (WEF). USA

Kloas, W., Grpb R., Baganz D., Graupner J., Monsees H., Schmidt U., Staaks G., Suhl J., Tschirner M., Wittstock B., Wuertz S., Zikova A. & Rennert B., 2015. A new
concept for aquaponic systems to improve sustainability, increase productivity, and reduce environmental impacts. Aquaculture environment interactions. 7: 178 - 192

Liang, T.W., Lin J.J., Yan Y.H., Wang C.L. & Wang S.L., 2006. Purification and characterization of a protease extracellularly produced by Monascus purpureus CCRC31499 in a shrimp and crab shell powder medium. Enzyme and Microbial Technology. 38: 74 – 80

Kyaw, T.Y. & Ng A.K., 2017. Smart aquaponics system for urban farming. Energy Procedia. 143: 342 – 347

Venkatachalam, S., Kandasamy K., Krishnamoorthy I., Narayanasamy R., 2018. Survival and growth of fish (Lates calcarifer) under integrated mangrove-aquaculture and open-aquaculture systems. Aquaculture Report 9: 18 - 24

Yen, M.T., Yang J.H. & Mau J.L., 2009. Physicochemical characterization of chitin and chitosan from crab shells. Carbohydrate polymers. 75: 15 – 21