GROWTH OF *GYNURA PROCUMBENS* AND *OREOCHROMIS SPP.* BY USING COCOPEAT MEDIA IN AQUAPONICS SYSTEM

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ABSTRACT

Lightweight expanded clay aggregate (LECA) and gravel are common growing media that are used to support plants in hydroponic system. However, LECA is quite expensive and gravel causes the presence of algae. Therefore, alternative media from local source are required. The study evaluates the growth rate of *Gynura procumbens* plants by using four different growing media (LECA, cocopeat, rice husk and mixture of cocopeat with rice husk) in an aquaponic system. The media were analysed based on the physical and chemical properties before being used as growing media in the aquaponics system for water quality, nutrients level and growth of *Gynura procumbens* plants and Hybrid red Nile Tilapia fish. Results attained signified the suitability of utilizing rice husk and cocopeat as alternative media compared to commercial media such as LECA because there was a significant difference ($P < 0.05$) between all analytical tests. Commercial media such as LECA did not require water treatment unit but the usage of cocopeat is not guaranteed by its effectiveness in treated water in the aquaponics system. Therefore, extra filtration system (single or combined) filter was required and the study of four different water treatment units (mechanical, biological, combination and media) by using cocopeat as media in the aquaponics system. The water treatment unit was being compared based on water quality, nutrients level and growth of plants and fish. All the aquaponics systems were operated for twelve weeks and the values of pH, temperature, and dissolved oxygen level measured to be within the range of 6.4-6.9 (± 0.07), 27.7-29.0°C, and 5.5-7.0mg/L (± 0.09), respectively. Satisfactory reduction (50-70%) was achieved for total suspended solids (TSS) and the nitrogen compounds within the systems. The results revealed that cocopeat was insufficient to act as a water treatment unit in the aquaponics system studied. The aquaponics system required at least a biological or mechanical filter for effectiveness in treating water of the system.

ABSTRAK

Agregat tanah liat ringan (LECA) dan kerikil merupakan media yang biasa digunakan untuk menyokong tumbuhan dalam sistem hidroponik. Namun begitu, penggunaan LECA agak mahal manakala kerikil menyebabkan kehadiran alga. Oleh itu, media alternatif dari sumber tempatan diperlukan. Kajian menilai kadar pertumbuhan pokok *Gynura procumbens* menggunakan empat jenis media (LECA, gambut kelapa, sekam padi dan campuran gambut kelapa dengan sekam padi) dalam sistem akuaponik. Media dianalisa berdasarkan sifat-sifat fizikal dan kimia sebelum digunakan sebagai media pertumbuhan dalam sistem akuaponik terhadap kualiti air, tahap nutrisi dan pertumbuhan pokok *Gynura procumbens* serta ikan tilapia Nile merah hibrid. Hasil yang diperolehi menunjukkan kesesuaian menggunakan sekam padi dan gambut kelapa sebagai media alternatif berbanding dengan media komersil seperti LECA kerana terdapat perbezaan yang ketara ($P<0.05$) di antara semua ujian analitikal. Media komersial seperti LECA tidak memerlukan unit rawatan air tetapi penggunaan gambut kelapa tidak menjamin keberkesanannya dalam merawat air bagi sistem akuaponik. Jadi, sistem penapisan tambahan (tunggal atau gabungan) diperlukan dan kajian terhadap empat jenis unit rawatan air (mekanikal, biologikal, gabungan dan penggunaan media) menggunakan gambut kelapa sebagai media dalam sistem akuaponik.Unit rawatan air dibanding berdasarkan kualiti air, tahap nutrisi dan pertumbuhan pokok serta ikan. Kesemua sistem dikendalikan selama 12 minggu dengan bacaan nilai pH, suhu, dan tahap oksigen terlarut diukur masing-masing dalam lingkungan julat 6.4-6.9 (± 0.07), 27.7-29.0°C, dan 5.5-7.0mg/L (± 0.09). Kadar pengurangan yang memuaskan (50-70%) dicapai untuk jumlah pepejal terampai (TSS) dan sebatian nitrogen dalam sistem tersebut. Keputusan menunjukkan bahawa gambut kelapa tidak mencukupi untuk bertindak sebagai unit rawatan air dalam sistem akuaponik yang dikaji. Sistem akuaponik memerlukan sekurang-kurangnya penapis biologikal atau mekanikal bagi meningkatkan kecekapan air terawat dalam sistem.

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LIST OF ABBREVIATIONS

NFT	-	Nutrient Film Technique
DWC	-	Deep Water Culture
RAS	-	Recirculating Aquaculture System
LECA	-	Lightweight Expanded Clay Aggregate
TAN	-	Total ammonia nitrogen
SGR	-	Specific growth rate
FCR	-	Food conversion ratio
BOD	-	Biological oxygen demand
TSS	-	Total suspended solid
DO	-	Dissolved oxygen
mg/L	-	milligram per litre
ppm	-	part per million
mL	-	millilitre
cm	-	centimetre
kg/m^3	-	kilogram per cubic meter
L	-	litre
s	-	second
h	-	hour

LIST OF SYMBOLS

°C	-	degree Celsius
°F	-	degree Fahrenheit
π	-	Pi
Z	-	Height
NH_3	-	Ammonia
NO_2^-	-	Nitrite
NO_3^-	-	Nitrate
PO_4^{3-}	-	Phosphate
%	-	Percentage

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Aquaponics systems are known as an eco-friendly and capable way to deal with food production. In the latest couple of years, it has been demonstrated as a driven development of aquaponics because of the expanding interest for regular sustenance and a change in urban life style in accessibility of organic foods. Aquaponics systems give significant advantages in minimum exertion as far as shortest planning time and reduced maintenance. Rakocy (2007) expressed that an aquaponics system is the combination of two systems between the RAS and hydroponics sub-system.

Growing plants utilize organic constituents from the waste of the fish while clean water flows back to the fish by the plants which act as a natural filter (Alshrouf, 2017). Effective microbes (nitrifying bacteria) are required during the nitrification process where the ammonia (NH_3) is converted to nitrites (NO_2^-) first and lastly to nitrates (NO_3^-). These nitrites and nitrates are used as nutrients for the plant growth (Graber & Junge, 2009). There are many advantages that can be counted from aquaponics system such as reduction in utilization of land area and consumption of water. Other than that, aquaponics system is ready to increase the growth rates of plants and high production of crops in controlled environments (Somerville *et al.*, 2014).

Growth bed media, nutrient film technique (NFT) and floating raft (otherwise called deep water culture, DWC) are normally used as hydroponics sub-system methods in the aquaponics system. NFT requires little effort for maintaining the system, lower initial start-up costs and water usage compared to the other two systems. However, the reduction in the amount of water usage brings down the crops production of plants and the system can be less stable (Goddek *et al.*, 2015). Warrensford (2015) stated that NFT and DWC need extra water treatment system such as mechanical filter and aerated biofilter. Moreover, DWC is primarily constrained to small plants for example lettuce and herbs wherein bigger plants are too heavy to float in rafts. Moreover, root of plants that grow bigger might clog both systems (Lennard & Leonard, 2006).

In the meantime, growth bed media can be utilized as a part of small-scale system that is particularly for novice and also can be installed using recycle materials. Growth bed media is known as the simplest system because it does not require additional water filtration system due to the advantage of the media which acts as a filter itself. Media such as gravels or lightweight expanded clay aggregate (LECA) in the growth bed can be used as filter for the nitrification process (Graber & Junge, 2009; Hindelang *et al.*, 2014). Growth bed media indicates higher yield in the aquaponics system on growth rate of fish and vegetables (Lennard & Leonard, 2006; Shete *et al.*, 2017). An extensive variety of plants can be produced in this system such as green plants and herbs which are popular crops nowadays.

Aquaponics fits for circumstances with limited land and water since it makes greater production of vegetables around three to six times and extensively less water usage compared to normal agriculture (Stout, 2013; Somerville *et al.*, 2014). Growth bed media has been selected because of its similarity with the necessity of low cost installation and small-scale system. The main reason behind this research was to determine the effect of the different growth bed media and water treatment system on aquaponics system in terms of quality of water; growth rate of fish and plants; and nutrients level of filtration water. In an aquaponics system, the control and monitoring of water quality are essential to evaluate accomplishment of the crop and aquaculture productions (Turcios & Papenbrock, 2014).

Longevity spinach plant, *Gynura procumbens* and Hybrid Red Nile Tilapia fish, *Oreochromis spp.* were used as growing plants and rearing fish in this research. *Gynura procumbens* plants were utilized as hydroponics plant due to no study was conducted regarding this plants by using this aquaponics system. Moreover, *Gynura procumbens* plants done research on its advantages as traditional medicine to cure diseases such as high blood pressure, hypertension and headaches (Sandoval & Bolante, 2016). Usage of Tilapia fish as aquatic lives because high demand especially in local market. Due to the information, the price of Tilapia fish can be up to RM6 - 7 per kg of fish. Tilapia fish have the potential to be the primary fish species for the export market due to its strong global demand (Somerville *et al.*, 2014).

1.2 Problem Statement

Growth bed media of aquaponics system required growing media to support the growth of plants. Generally, gravel (Mader, 2012) and lightweight expanded clay aggregate, LECA (Petrea *et al.*, 2014) frequently used as a part of commercial media because of its demand and compatibility with common plants. LECA shows its character by showing neutral pH and not releasing any minerals into the water stream while gravel is usually utilized because of its worldwide accessibility and reasonable price (Petrea *et al.*, 2014; Somerville *et al.*, 2014). In Malaysia, 25 L of LECA media cost about RM 70 (~17 USD) and can only be purchased from oversea supplier (Stout, 2013; Somerville *et al.*, 2014). Meanwhile usage of gravel seems to be substantial because of its high density thus providing a solid structure to support the container of growth bed media and it has high potential for the presence of algae on gravel surfaces (Stout, 2013). Clearly, low cost growing media as alternative to LECA are needed if farmers in Malaysia were to adopt such aquaponics system for growing plants and cultivate fish.

Potential growing media include carbonized rice husk and cocopeat. Report indicated that over 0.5 (kg/m^2)/year of coconut waste are being produced where else it was estimated nearly 400 000 metric tonnes of carbonized rice husk are produced in Malaysia (Muhammad & Rabu, 2015; Ilahi & Ahmad, 2017). If these agro wastes are not managed properly, if will cause a severe environmental issues. Finding alternative use for these wastes is one of the motivation of this work. Most importantly, both carbonized rice husk and cocopeat as growing media are easily accessible by local farmers at very low cost. For every 25 L volume, carbonized rice husk and cocopeat cost only about RM15 (3.6USD) and RM5 (1.2USD), respectively. Therefore, as an alternative, other mediums were utilised in this research for the hydroponics sub-system in an aquaponics system that include cocopeat, carbonized rice husk and mixture of cocopeat with carbonized rice husk. Selection of both cocopeat and carbonized rice husk is due to the reasonable cost that is appropriate for novice farmer. Furthermore these media can effortlessly be obtained because they are of local sourced materials (Somerville *et al.*, 2014). Also, both media are widely utilized as growth media in fertigation system to grow short term herbs and vegetables in Malaysia (Sharkawi *et al.*, 2014; Taweesak *et al.*, 2014). Chemical fertilizers are not required in an aquaponics system because the waste from aquatic lives will become nutrients that are supplied to the plants in the hydroponics grower.

Growth bed media with existence of LECA as growing media not required extra water treatment unit in the aquaponics system. However, when using the alternative media to replace LECA such as cocopeat and carbonized rice husk might not efficient as filtration system due to different characteristic of media. Another interest to study the aquaponics system is due to the water treatment which is a pivotal component for nitrification process in water treatment system (Somerville *et al.*, 2014). The aquatic lives will then obtain clean water from the media and plants through the water treatment system in the recirculating aquaculture system (RAS). Comparison between the absence and presence of extra water treatment unit in the aquaponics system to determine whether the alternative LECA which is cocopeat and carbonized rice husk effective on treated water. Mechanical, biological and combination of mechanical with biological filter were used as extra filtration system to compare with the aquaponics system without extra filtration unit (usage of media only).

1.3 Objectives of the Study

The objectives of this study are:

i. To evaluate the suitability of cocopeat and carbonized rice husk substrates as alternative media bed in aquaponics system for cultivation of Hybrid Red Nile tilapia fish (*Oreochromis spp*) and longevity spinach (*Gynura procumbens*) plants.

ii. To assess the performance of various types of water treatment technique on the best alternative media filled grow bed aquaponics system.

1.4 Scope of the Study

This research was carried out based on the objectives of the study:

i. LECA was reviewed as reference media; meanwhile cocopeat, carbonized rice husk and mixture of cocopeat with carbonized rice husk have been used as media in growth bed of aquaponics system. The media used were quantified based on their physical and chemical properties. The, the media were used as growing media in growth bed media of aquaponics system. Analytical tests were done based on water quality and nutrient level of water samples. The growth performance of *Gynura procumbens* plants and Tilapia fish for 12 weeks were recorded and tabulated.

ii. The best alternative media (e.g. cocopeat) utilized in the aquaponics system was evaluated based on the different type of water treatment unit. Utilization of aquaponics system with and without extra water treatment unit to know the effectiveness of media with presence and absence of filtration unit. Media, mechanical, biological and combination of mechanical with biological water treatment unit were used in aquaponics system. Water samples collected at specific sampling points for analytical tests on water quality and nutrient level. The growth performance of *Gynura procumbens* plants and Tilapia fish for 12 weeks were also recorded and tabulated

1.5 Significant of Study

This research provides useful information related to replacement for LECA as the growth bed media in aquaponics system. Growth bed media that should be widely used in Malaysia should be cheaper, simplest and suitable for small-scale aquaponics system for urban farmers especially those who live in limited space of planting. The small system is easy to install for them without much care needed by giving out small amount of costs to start with. Wide variety of fishes and plants can be used in an aquaponics system and urban farmers can either install the system as a food source or as a hobby. Furthermore, the usage of growth bed type in hydroponics sub-system is much more compatible compared to floating raft and NFT due to its simplicity and low cost in production, thus only small space is needed.

Besides that, aquaponics system can help to cut off the usage of chemical products such as fertilizers, antibiotics and anti-chlorine because the waste from the fishes will be accumulated as nutrients for the plants by filtration process. On top of that, this aquaponics system was run in a natural way without providing any additional supplement to the fishes and plants. In addition, this research is able to reduce the usage of water because the aquaponics system was run as a recirculating aquaculture system (RAS). The water from the fish tank was pump to the grower bed (plant) by passing through the filtration tank before it goes back to the fish tank. This process was continuous where the water was recirculated throughout the aquaponics system.

Although installation of aquaponics system in Malaysia is still in the early stages, a strategic effort from government as the key players and various parties, especially promoter, farmers and community is able to make its progress. Aquaponics system can be fully materialized if there is a holistic infrastructure, technologies, and communities, which are important. The government efforts to encourage urban community to participate in the greening program is well accepted.

Aquaponics system is seen as an innovative approach to improve access to healthy food, and simultaneously, boost the economy and society. There is also a need to conduct relevant studies that can help develop policies to encourage more Malaysians to be involved in urban farming. After all, the aquaponics system gives much more benefits to the people especially those who want to cut cost in the living expenses due to economic problem. This can significantly bring people to have a better lifestyle.

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