Effect of different fertilizers on the growth of duckweed (*Lemna minor*) as aquatic plant resources utilization in sustaining Red Tilapia (*Oreochromis niloticus*) culture

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Abstract. Duckweed (*Lemna minor*) is one of the smallest floating aquatic plants in the world. This plant is potentially important in the aquaculture feed industry since aquaculture feed is the major operational cost in fish production. This 37-days study was done to see the effect of different fertilizers; (goat manure, chicken manure and organic fertilizer) at the same concentration of 2g/L on duckweed growth. Tap water without fertilizer was used as a control. Water parameters such as pH, temperature, nitrate, phosphate, and ammonia were observed. The result of duckweed growth rate after 37 days in goat manure fertilizer (0.76 grams/day) is the highest followed by chicken manure fertilizer (0.15 grams/day), organic fertilizer (0.02977 grams/day) and the control (-0.00 133 grams/day). The number of the duckweed at the end of experiment by using the goat manure fertilizer is higher which is 489 units, followed by chicken manure fertilizer (179 units), organic fertilizer (64 units) and control (22 unit). Treatment of goat manure fertilizer has a high concentration of nitrate 1.99 ppm, ammonia 2.69 ppm and available phosphate 7.71 ppm which suitability for duckweed growth. Since duckweed is easy to be cultured, this natural resource of aquatic plants can be produced commercially for Red Tilapia (*Oreochromis niloticus*) farm.

1 Introduction

Aquaculture is expanding rapidly as a source of food protein. Tilapia aquaculture has gained global prominence as a major source of affordable and nutritious protein beside high value and demand in the market. Tilapia contributed to about 30.7 % of the total freshwater aquaculture production in Malaysia in 2018. The red hybrid tilapia is the most important, accounting for 94 % of total tilapia production. This tilapia production meets the food security policy. However, one of the most significant challenges faced by tilapia farmers is the escalating cost of feed. Traditional feed ingredients, such as fishmeal and soybean meal, have become increasingly expensive, rendering aquaculture operations less economically sustainable. In order to increase tilapia productivity and quality, feed is a crucial component. It is good to follow feeding schedule for the fish to grow well and be marketable. Fish feed

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accounts for more than half of the costs of producing freshwater fish. It is anticipated that the development of safe and effective operations and the availability of alternate feeding for the aquaculture sector would lead to more steady fish production and increased farmer income [1, 2].

Duckweed (*lemna minor)*, a tiny aquatic plant, holds immense potential as a natural plant source for various applications due to its rapid growth, nutritional composition, and versatility. These free-floating species of aquatic freshwater plant, commonly found in still or slow-moving bodies of freshwater, in slow moving stream occurs, blackish ponds, rice fields, and still waters. Duckweed have garnered significant attention for their ability to thrive in a variety of environmental conditions. Duckweed is one of the natural resources of aquatic plants that can be utilized in the aquaculture industry as a protein source in fish feeding. They have high protein content and complete amino acids. Duckweed is one of the most protein-rich plants on earth, with protein content ranging from 20% to 40% of its dry weight. This makes it a potential source of plant-based protein for fish. Duckweed is known for its rapid growth and high reproductive rate. This small aquatic floating plant can be easily replicated. Its growth is influenced by several factors such as temperature, light, and nutrients. Duckweed grows on relatively high levels of nitrogen (N), phosphorus (P), and potassium (K) water, accumulates minerals, and produces protein. Duckweeds have reignited attention among fish nutritionists in their potential as alternate sources of fish feed because of their quick development, appealing nutritional characteristics, and relative simplicity of production. It also can be cultivated directly on the farm resulting in low production costs. Many fish have been fed on duckweed, and studies have shown that doing so improves growth performance [3, 4].

In order to solve the problem of feed cost in tilapia production, proteins based on plants can be employed as an alternative diet in line with the demand and mission towards guaranteed protein sources for the needs of local communities and food security policy. As duckweed easily can be reproduced, this study was conducted to observe the effect of different fertilizers on duckweed growth.

2 Materials and methods

This study was carried out due to the lack of pellet supply and the high cost of fish pellets causing the need to find a natural food supply that easily can be found from the surrounding. As duckweed is fast growing aquatic plant with high nutritional value for livestock, duckweed can be found on the surface of ditches in oil palm plantations and still waters or puddles in gardens, duckweed from the nearest palm oil plantation (Fig.1) was collected to be given in tilapia feeding. The duckweed collected was ingested by tilapia wisely. Hence the idea to culture the duckweed was conducted at the Polytechnic Sandakan Fish Hatchery which is located at latitude 5° 55′ N and longitude 118° 0′ E.

Fig. 1. (a)- Stagnant water in palm oil plantation area at Batu 5, Sandakan. (b) Collecting duckweed using net. (c) Duckweed kept in styrofoam container.

2.1 Duckweed and fertilizer preparation

Duckweed was collected from the nearest stagnant water in the palm oil plantation and brought to the laboratory at the fish hatchery. Duckweed was cleaned with tap water to remove any unwanted organisms such as water insects and dead leaves of other plants. The cleaned duckweed was acclimatized 24 hours in the culture tank prior to the experimental set up. Three types of commercial fertilizer (goat manure, chicken manure and organic manure) were bought from local agriculture shop. Fertilizer solution was prepared by diluting 0.005g of each type fertilizer into 2 L of tap water. Fertilizer solution was left for 24 hours prior to the experiment.

2.2 Biomass cultivation

Seven unit's plants of duckweed with complete of three fronds were stock in container (16x14 x5.5 cm) with fertilizer solution. Each treatment was done in triplicate as treatment A (goat manure), treatment B (chicken manure), treatment C (organic fertilizer) and treatment D is control (tap water). The experiment was done in 37-days. All the containers were connected to the aeration system.

2.3 Data collection and analysis

All the duckweed from each treatment was sampled once per week to measure their growth performance in term of weight (g) and the growth rate using formula of [(final weight-initial weight)/day of culture]. Nutrient content in the media culture such as Nitrite (NO_2), Ammonia Nitrogen (NH_3) and Phosphate (PO_4) was done weekly for the culturing period. Water temperature was measured by dissolve oxygen meter and water pH was measured using pH meter weekly.

3 Result and discussion

Duckweed plants showed growth development for every week except for the control treatment (Fig. 2). Duckweed growth in goat manure treatment possess the highest growth rate where the final growth rate for each treatment is 0.76, 0.15, 0.02977 and -0.00133 gram/day for each treatment A, B, C and D respectively. The use of goat manure fertilizer

showed the highest growth compared to other fertilizers. This is because the goat manure contained good nutrients for duckweed growth, such as phosphate, nitrate, and ammonia. Treatment of goat manure fertilizer has also proven that at the end week of the study, the growth of duckweed is higher and has a wider leaf surface compared to other treatment. It shows the most significant changes in the second week of the study until the end of the study.

The use of chicken manure shows a positive effect on growth, but the growth rate of duckweed is relatively slow compared to treatment that uses goat manure. In addition, the good growth effect of duckweed is shown in the observation where this chicken manure promotes the reproduction of new duckweed plants in large quantities but small in fronds size hence cause the growth rate in term of weight is relatively slow. The use of organic fertilizer in the first week show almost the same growth rate with treatment using of goat manure fertilizer. While in the second, third and fourth weeks, the growth of duckweed slows down due to the presence of algae that grow enclosing the roots of duckweed. This is due to the excessive certain nutrient content that accelerate the growth of this unwanted algae. The use of tap water as a control without using fertilizer in the growth of duckweed shows the lowest results of growth. In the second week, the growth of duckweed begins to show a decline until the end of the study due to lack of nutrients for duckweed growth.

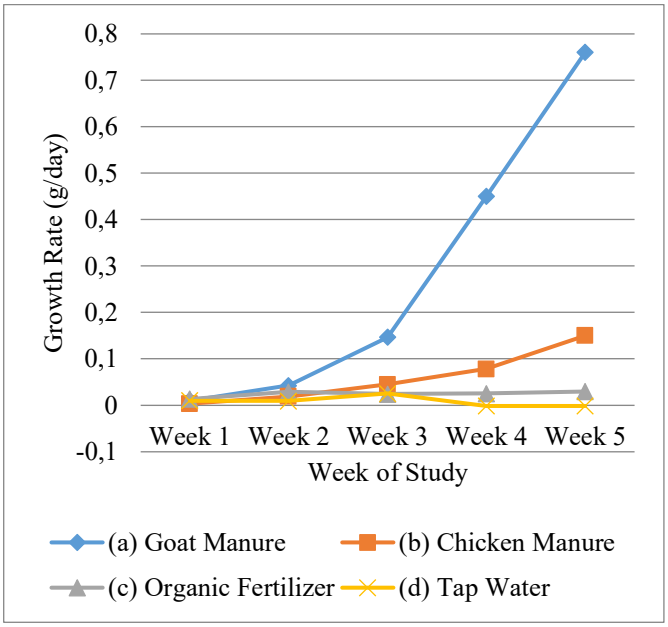

Fig. 2. Graph of duckweed growth rate.

The use of goat manure showed the most significant highest number of duckweed growth which is 489 unit complete duckweed tiny aquatic plants recorded in week 5 (Fig. 3). This was followed by the treatment of chicken manure, organic fertilizer and tap water showed the number of 179, 64 and 22 unit plants respectively.

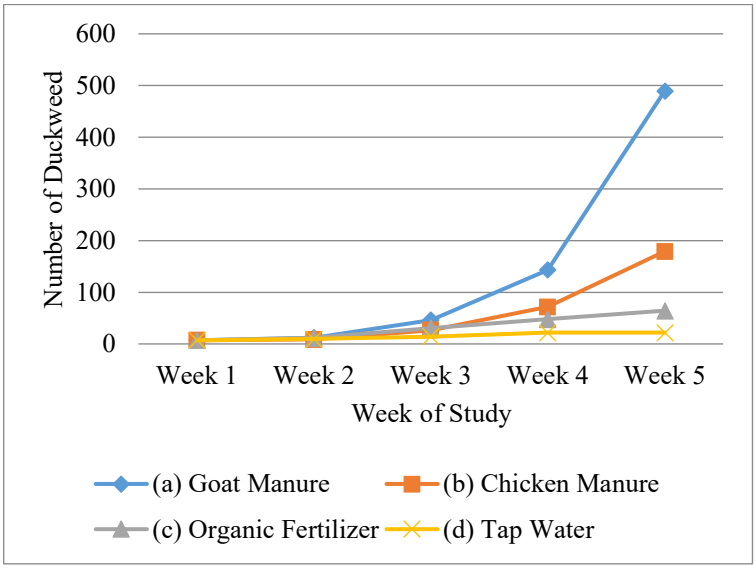

Fig. 3. Graph show the average number of duckweed plants per week.

Table 1 shows the reading of water quality parameters such as temperature, pH, ammonia, nitrate, and phosphate which contribute in duckweed growth. These factors of water parameters should be maintained within reasonable limits for the survival and growth of the aquatic macrophytes. The management strategies for duckweed culture should focus on the time of manure application and harvesting [5]. A rise in the concentration of N and P showed a positive correlation with the nutritional composition of duckweed [6].

Table 1. Water parameter of duckweed culturing media.

Water Parameter	Treatment A (Goat Manure)	Treatment B (Chicken Manure)	Treatment C (Organic Fertilizer)	Treatment D (Control)
Temperature (°C)	25.5 - 27.5	25.5 - 27.5	25.5 - 27.5	25.5 - 27.5
pH	7.7 – 8.4	7.7 – 7.9	7.7 – 8.8	7.7 – 8.7
Ammonia (ppm)	0.40 - 2.69	0.06 – 0.16	0.43 – 4.63	0.00
Nitrate (ppm)	0.24 - 1.99	0.01 – 0.73	0.24 - 0.69	0.14 - 0.24
Phosphate (ppm)	2.40 – 7.71	0.20 – 8.20	0.06 – 0.32	0.03 – 0.32

The growth of duckweed species is exponential and faster than most other plants under appropriate carbon dioxide, light, pH, temperature, and nutrient supply conditions. As this plant is easily reproduced and less maintenance required, thus the utilization of duckweeds as protein sources can help to reduce environmental pollution created by expanding other crop cultivation. Duckweeds can be used as a source of protein in fish feed as they have high protein content and complete amino acids [7, 8]. Study conducted revealed that blanched duckweed meal has great potential in feed sector and can serves as an alternative to soybean meal in the *O. niloticus* diet at 75% and also will reduce the cost of feed production and maximize profit. It also was stated that duckweed as an underutilized species that having

potential in feed sector [9]. The used of duckweed as fish feed can be explored and implemented.

4 Conclusion and recommendation

In this context, duckweed presents a protein source that has great potential for fish feeding and emerges as a promising solution to mitigate feed cost challenges while simultaneously enhancing the sustainability of tilapia aquaculture. The result of duckweed growth is very encouraging to use duckweed in fish feeding. It was interesting to note that fish fed diets containing varying amounts of duckweed considered a highly nutritious vegetative food meal could support fish growth. As the natural growth aquatic sources, duckweed would be advisable for commercial common feed or as an alternative diet for tilapias. This can create awareness to change the perception among farmers to change from highly cost very demanding fish meal to duckweed as the main leading fish feed. By other chance increasing the knowledge of duckweed cultivation among farmers will have a big impact on food productivity, reduce the impact on the environment, and increase the demand for farmed tilapia fish.

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