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# High Salinity Intensive Seaweed Growth Rate in Aquaponic Systems

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## Abstract

Aquaponics is a closed recirculating aquaculture method combined with hydroponics. This method is very alternative for raising fish while growing plants in specially designed media. The mechanism obtained is very effective and efficient, plants can utilize fish waste as nutrients for plant growth. Plants can reduce poisonous fish waste in ponds as nutrients for organic substances. This can enhance profitable bio-integrated food production systems. Plants will serve as vegetation filters. This study aimed to determine the effectiveness of aquaponic treatment in high-salinity water by observing the growth in three species of seaweed *Gracilaria* sp*.*, *Sargassum* sp., and *Kappaphycus alvarezii*. The research design used the LSD method and was carried out for 63 days. Data analysis using Analysis of Variance (ANOVA) then continued with Duncan's Multiple Range Test. The research method involved making aquaponic media including preparing containers for seaweed cultivation and fish and shrimp farming, observing seaweed growth rates, and measuring water quality. Aquaponic treatment can increase the growth rate of intensively cultivated seaweed. The results showed the best weight growth rate in the aquaponic treatment of *Gracilaria sp.* with a value of 12.33 grams than *K. alvarezii* at 11.33 grams and *Sargassum sp.* at 10.83 grams.

## INTRODUCTION

Indonesia is one of the countries that has the world's marine biodiversity, one of which, is seaweed. There was an increase in seaweed production by 4.11% and the export value of seaweed in Indonesia experienced an average growth during the 2013-2017 period of 3.09% per year (FAO, 2018; KKP, 2019). Indonesian waters which cover about 70% of the archipelago have the

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potential for marine cultivation, including seaweed cultivation.

Seaweed is generally a heterogeneous photosynthetic plant in nature. Seaweed is recognized as a prospective source of naturally occurring bioactive compounds (Rengasamy *et al*., 2020). Moreover, seaweed is widely used as an antibacterial (Suriya *et al*., 2012) and antifungal agent (Negara *et al*., 2021) in the treatment of diseases caused by effectively fighting gram-positive and gram-negative bacterial organisms (Gnanavel *et al*., 2019).

One way to increase the prospect of seaweed growth by utilizing limited land is an aquaponics system. Aquaponics is a bio-integrated system of food production, consisting of closed recirculation aquaculture combined with hydroponics (Estim *et al*., 2018). Furthermore, aquaponics is an alternative to raising fish and growing plants for one medium. The process by which plants make use of nutrients from fish feces at the bottom of the pond is toxic to fish (Hargreaves and Tucker, 2004).

Aquaponics continuously utilizes water from fish farming to plants and vice versa from plants to fish ponds. The essence of this technology system is the provision of optimum water for each commodity by utilizing a recirculation system (Martins *et al*., 2010). However, not only focusing on fish farming (Blidariu and Grozea, 2011) but also the aquaponics system is a combination of aquaculture and hydroponics, it must focus on cultivating plants that can be used for self-consumption (Suárez-Cáceres *et al*., 2021) or commercial use on a large scale (Palm *et al*., 2018).

This study is expected to provide information about the effectiveness of aquaponics treatment by analyzing the growth rate of daily-weight *Gracilaria sp, Sargassum sp*, and *K. alvarezii* which are cultivated intensively in high-salinity water.

## METHODOLOGY

### Ethical Approval

The research does not require ethical approval because it is not related to clinical trials on animals.

### Place and Time

The research was conducted at the Fish Anatomy and Rearing Laboratory, Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya. This research was done in January 2020.

### Research Materials

The main material used in this study includes: three types of seaweed, such as *Gracilaria* sp. obtained from seaweed farmers in the Samudera Hijau Sidoarjo group, while *Sargassum* sp. and *K. alvarezii* are obtained from Pamekasan-Madura, East Java. Each type of seaweed is weighed with a weight of 100 grams and then measured the length using a thread as a tool so that the seaweed does not break easily. The aquaponic system uses three types of fish and shrimp, namely vannamei shrimp (*Litopenaeus vannamei*), milkfish (*Chanos chanos*), and snapper (*Latidae calcarifer*) with an average length of 5-10 cm. Selection of fish and shrimp that are free from all diseases, and have healthy morphological characteristics. The fish and shrimp used were obtained from farmers in Sidoarjo City, East Java Province, Indonesia. Fertilizers are used to support the growth of seaweed, namely Urea and TSP, which are produced by commercial factories in Indonesia PT Trubus Swadaya.

The volume of seawater used is 500 liters with a depth of 50 cm from the lower limit of the fiberglass tub (Masser *et al.,* 1999). The tools used in this study (Cronin *et al.,* 2016) include the aquarium, aquaponics media, long line for seaweed growing media, aquaponics media rack, water pump Resun LG4000, air compressor, aerator Resun LP-100, ruler, measuring cup 5 liters, digital scale SF-400, and portable DO meter.

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## Research Design

The research design used was a Latin Square Design (LSD) consisting of three types of seaweed *Gracilaria* sp, *Sargassum* sp, and *K. alvarezii*. The variables studied were the growth of the three types of seaweed.

## Work Procedure

### Preparation of Aquaponics Media

The main preparation in this study is a fish pond or aquarium because this research uses high-salinity water media (Ytrestøyl *et al.,* 2020). The container for cultivating seaweed is a fiberglass tank with a height of one meter. After the seaweed plant is put into the fiberglass tank, an aquarium pump is attached to the pond, where the hose from the aquarium pump is inserted into the tank (Friedlander, 2008). However, the water from the fish pond flows into the tank containing the seaweed plants and returns to the fish pond again. The addition of new water (Alemañ *et al.,* 2019) is carried out to maintain the stability of the volume of water in the system which is lost due to evaporation (van Oirschot *et al.,* 2017), absorption by plants (Fei, 2004) and sampling. An aquaponic schematic image can be presented in Figure 1.

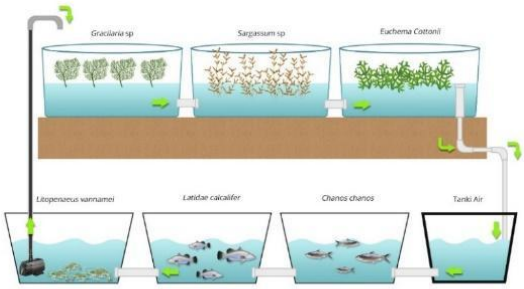


Figure 1. Aquaponics Schematic Illustration.

### Preparation of Seaweed Cultivation Construction

After determining the location, construction preparations (Gellenbeck *et al.,* 1988; Israel *et al.,* 2006) were carried out on a cultivation fiberglass tub measuring (diameter x height) 100 cm x 75 cm with a water volume of approximately 500 liters and a depth of approximately 50 cm from the bottom of the fiberglass tub. The length of the rope stretched one meter with the distance between the lines stretching 30 cm, to obtain two stretch ropes in one cultivation construction unit. For each stretching rope, the distance per bonding point is 20 cm, according to SNI (2011), the seeds are tied to a point rope with a distance of 25-30 cm to tie the clump rope. However, each stretch line contains three points of seed clumps. In one cultivation construction, one type of seaweed is made with a total of six clumping points. The weight of the talus per point is 100 gr and the distance between the clumps is the same so that the space for seedling growth can be maximized, including in obtaining nutrient supply in the water.

### Observation of Seaweed Weight Growth Rate

The growth observation is a measure of weight at a certain time, in this case, it is used to determine the weight gain of three types of seaweed for a total of 63 days, and the calculation is taken per week.

### Water Quality Measurement

The environmental parameters measured were water quality, including temperature, salinity, pH, dissolved oxygen, nitrate, and phosphate. Regular monitoring of pond salinity, pH, temperature, salinity, and dissolved oxygen in the pond. Checks are carried out every three days to ensure water quality is maintained so that the growth of seaweed remains stable and

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optimal. N and P values were tested at the beginning and end of the study.

## Data Analysis

The data analysis used is this Analysis of Variance (ANOVA) with a computer system (Cuevas *et al.,* 2004) to determine the effect of the treatment given, if the results show that the aquaponics treatment of three types of seaweed, such as *Gracilaria* sp *Sargassum* sp, and *K. alvarezii* shows significant results, then the calculation is continued with the test Duncan's Multiple Range Test (Duncan, 1957; Tallarida and Murray, 1987).

# RESULTS AND DISCUSSIONS

## Seaweed Weight Growth Rate

Observation of the growth yield of three types of seaweed was carried out every 1 week for 63 days or 9 weeks of maintenance. Moreover, the sampling for this research was taken from the total seaweed tied to all units by removing the rope that tied the seaweed and then weighing and calculating the weight growth rate. ANOVA data analysis was tested on each type of seaweed, using the maintenance time every week as treatment data and 6 sample point clumps of seaweed as replications.

The results showed that the types of seaweed *Gracilaria* sp, *K. alvarezii*, and *Sargassum* sp gave insignificantly different effects (p>0.05) on high salinity aquaponics treatment. Based on the results of the Duncan Multiple Range test, the effect of period on seaweed growth gave significantly different results (p <0.05). The treatment of the three types of seaweed used did not cause a significant difference in the growth of seaweed this could be because the three types of seaweed had different physiological characteristics (Choi *et al.*, 2008; Faria *et al.*, 2017; Roleda and Hurd, 2019). The maintenance period gave a significant difference to the growth rate of seaweed, which means that the period used to plant seaweed was appropriate.

Table 1. Seaweed growth rate.

| Period | *Gracilaria* sp | *Kappaphycus alvarezii* | *Sargassum* sp |
|---|---|---|---|
| $1^{b}$ | 3.33 | 3.00 | 3.00 |
| $2^{a}$ | 4.17 | 4.00 | 3.67 |
| $3^{a}$ | 4.83 | 4.33 | 4.17 |
| Total | 12.33 | 11.33 | 10.83 |

Note: Different superscripts in the same column indicate the growth rate between periods has a significant difference (p<0.05).

The growth value obtained during the maintenance period for three types of seaweed, the highest value of aquaponics treatment for *Gracilaria* sp, which is 12.33 grams, this value follows the opinion of Budiyani *et al.* (2012) which states that the best growth rate is 1.183% per day within 42 days. The daily weight growth rate is achieved due to the carrying capacity of the aquaponics recirculation system which is designed and expected to improve water quality. Furthermore, the environment is maintained and suitable for seaweed life.

Seaweed production tends to increase from year to year because seaweed cultivation can be done using relatively simple technology, labor can be done from various groups, and the production period. With the short experiment, which is only 45 days. In addition, the harvesting process is easy with low cost, and the production of raw materials can be stored for a long time.

## Water Quality Measurement

The results of water quality parameters in the form of temperature, pH, ammonia, DO, and water salinity in each tub, showed the normal range for seaweed growth. The water temperature ranges from 29-30°C, so the measured temperature shows a range that is similar to the research of Setiaji *et al.* (2012) where normal temperatures range from 25-28°C. The temperature in this study reached 30°C but

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still tolerable and still supported seaweed growth (Ruslaini, 2017).

SNI (2011) states that the optimum pH of water quality for seaweed growth ranges from 7 to 8.5. This is following the pH of the research results ranging from 7.5 to 8.2. DO measured during the study showed a normal range of 4.8-5 mg/l. Research by Nur *et al.* (2016) produced DO measurements ranging from 4.34-5.94 mg/l which are ideal for seaweed growth. This is related to the lower the water temperature, the higher the oxygen concentration. The salinity suitable for seaweed growth ranges from 28-35 ppt (Radiarta and Erlania, 2015). Salinity conditions during the study ranged from 29-30 ppt ideal for the growth of other seaweed.

Table 2. Data on average water quality.

| Water quality parameters | *Gracilaria* sp. | *Kappaphycus alvarezii* | *Sargassum* sp. | Quality Standard (SNI, 2011) |
|---|---|---|---|---|
| Temperature (°C) | 29 | 29 | 30 | 24-32 |
| pH | 7.8 | 8.2 | 8.1 | 7-8.5 |
| DO (mg/l) | 4.8 | 4.9 | 4.9 | 4-5 |
| Salinity (‰) | 30 | 30 | 30 | 28-33 |

N and P values were tested at the beginning and end of the study, namely at the beginning of 0.61 and 0.11 mg/l, while at the end they were 1.43 and 0.33 mg/l. In this research, the amount of nitrogen and phosphorus at the end of the study had a higher value than the initial level examination, namely 1.43 and 0.33 mg/l. This can be presumed due to the addition of Urea and TSP fertilizers at a dose of 50%:50%, fecal residue, and fish feed. Nitrogen and phosphorus levels during this study can still be said to be within safe limits (Astuti *et al.*, 2016). The Nitrate value for cultivation activities is 0.89 mg/l while the phosphate level is between 0.33-0.78 mg/l. The amount of N and P during the maintenance period is needed to support the growth of seaweed thallus.

## CONCLUSION

Aquaponic treatment can increase the growth rate of intensively cultivated seaweed. The average growth rate of seaweed has increased for each seaweed, namely *Gracilaria* sp. 12.33 grams, *K. alvarezii* 11.33 grams, and *Sargassum* sp. 10.83 grams.

## CONFLICT OF INTEREST

There is no conflict of interest in the research or publication of this article.

## AUTHOR CONTRIBUTION

Manella Nurul Uma Panasani: author, compiler, implementer, and analyzer of the research. Moch. Amin Alamsjah is the director of the framework. Mirni Lamid is the director of the framework. Ami Shaumi as a director in the preparation of the article. Mohammad Rozaimi proofread and improved the article.

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