EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology, 2025, 26(8), 130–143
https://doi.org/10.12912/27197050/207328
ISSN 2719–7050, License CC-BY 4.0

Received: 2025.06.04
Accepted: 2025.07.17
Published: 2025.08.01

Monitoring growth of *Sargassum aquifolium* in wet and dry seasons in Ekas Bay, Lombok, Indonesia

Nunik Cokrowati[1*], Alis Mukhlis[1], Salnida Yuniarti Lumbessy[1], Muhammad Marzuki[1], Laily Fitriani Mulyani[1], Adibi Rahiman Bin Md Nor[2]

[1] Aquaculture Study Program, Departement of Fisheries and Marine Science, Faculty of Agriculture, Universitas of Mataram, 83127, Indonesia
[2] Institute for Advance Studies, Universiti Malaya, Kuala Lumpur, Malaysia
* Corresponding author's e-mail: nunikcokrowati@unram.ac.id

ABSTRACT

Sargassum growth is strongly influenced by fluctuations in water quality that occur due to differences in environmental conditions between the rainy and dry seasons. Changes in temperature, salinity, and nutrient content during seasonal changes can affect *Sargassum* growth. The highlight of this research is monitoring the growth of *Sargassum* for one year in the waters of Ekas Bay, Lombok, Indonesia, to observe the algae's response to seasonal water quality dynamics. The growth and production of *Sargassum aquifolium*. are assumed to be different in each month due to the influence of different environmental conditions each month. So it is necessary to know the growth of *Sargassum aquifolium* to determine when the right time to get maximum productivity and for the sustainability of *Sargassum aquifolium* growing in nature and cultivated. The purpose of this study was to monitor environmental factors affecting the growth of *Sargassum aquifolium* over one year in order to provide information to farmers for determining cultivation management practices to increase productivity. The results of this study are expected to provide a reference for the right time to cultivate *Sargassum aquifolium* and its sustainability. This research was done from December 2023 to November 2024 used the observations method of cultivating using the floating raft with a size of 8 × 8 m. The sampling method of *Sargassum* sp. growth was carried out by weighing the cultivated *Sargassum* sp. The results showed that the highest absolute weight growth was obtained in January which was 135 g and the lowest was in November which was 11.8 g. The highest specific growth rate was obtained in January which was 135 g and the lowest in November which was 11.8 g. The highest specific growth rate was obtained in January which was 6.31% and the lowest was in November which was 1.005%. The conclusion of this study is that most of the growth rate in each month is more than 2%, so it can be said that *Sargassum* can grow optimally. Although this study did not control for any factors, it nevertheless provides information on the factors that influence the objective of the study The PCA analysis results show that growth is influenced by temperatures, salinity, pH, phosphate, and nitrate. This study is the first to report on the growth of *Sargassum* in floating net cages, where cultivation is influenced by the aquatic environment over a one-year period.

Keywords: *Sargassum* sp., cultivation, seaweed, alginate, Ekas Bay.

INTRODUCTION

Sargassum sp. has potential as a raw material for bioenergy and bioethanol. *Sargassum* sp, a macroalga, has substantial potential as a renewable feedstock for bioethanol production, as explained by Borines et al., (2013). *Sargassum* sp. is a brown macroalgae that is found in tropical and subtropical waters. It is the most prevalent and prolific alginophyte in the tropics. Owusu et al., 2024; Santanumurti et al., (2019) As an alternative to fossil fuels, *Sargassum* biomass can be converted into biofuel. The biochemical composition of *Sargassum* comprises proteins, carbohydrates, lipids, vitamins, antioxidants, minerals, and fiber, as described by Martinez et al., 2023; Yanuhar et al., (2024). Aparicio et al., (2021) An alternative feedstock for bioethanol production, *Sargassum* sp. is an invasive macroalga. *Sargassum* has the capacity to reproduce at an accelerated pace and frequently without control. This is believed to be a consequence of the global increase in carbon dioxide levels, as well as the rise in ocean temperatures and seawater acidity (Yanuhar et al., 2024).

Sargassum growth in floating net cages is strongly influenced by fluctuations in water quality, temperature, salinity, nutrients, and turbidity (Aprilia et al., 2023; Rosiana et al., 2022). Fluctuations increase at the transition of the wet and dry seasons, where heavy rainfall or drought can cause extreme changes in environmental parameters (Cokrowati et al., 2024). In the wet season, increased water volume from the land brings in a lot of sediment and nutrients that can trigger algal blooms or reduce water clarity, while in the dry season, increased salinity and temperature due to evaporation can suppress the photosynthetic rate and metabolism of *Sargassum*. The instability of these conditions can hinder the optimal growth of *Sargassum* and pose challenges in the management of aquaculture in floating net cages.

Aaron-Amper et al., 2020; Panasani et al., (2024) conducted research on laboratory-scale cultivation aquaponic of *Sargassum* sp. with different substrate treatments, with the results of their research being that clay substrates provide optimal growth. It explained the results of their research that the depth of *Sargassum* sp. cultivation using the longline method affects growth. The optimal depth in this study was 25 cm below sea level resulting in a final weight of 659.03% of the initial weight with a specific growth rate of 6.73%/day. Gallegos et al., 2023; Wahyuningtyas et al., (2020) *Sargassum* growth is influenced by environmental temperature, optimal growth is obtained at a temperature of 28–31. Ko et al., (2020) explained that *Sargassum fulvellum* is a species cultivated to meet the needs of consumption and reforestation of the Jeju Sea in Korea. Cokrowati et al. (2021) explained that *Sargassum* sp. cultivated with a seed weight of 150 g provides optimal growth compared to a seed weight of 50 g to 125 g. The absolute growth produced was 39.75 g with a growth rate of 36.81%.

Sargassum in Indonesia is currently not utilized for bioethanol feedstock purposes. *Sargassum* sp. is utilized as raw material for the food wrapping paper industry. *Sargassum* sp. that is currently utilized comes from nature or grows wild in coastal waters. If the utilization of *Sargassum* sp. only relies on nature, it can disrupt the sustainability of *Sargassum* sp. availability in nature. Cultivation of *Sargassum* sp. needs to be done to fulfill the needs of *Sargassum* sp. and maintain the sustainability of *Sargassum* sp. in nature. The utilization of *Sargassum* sp. as bioenergy and bioethanol certainly requires a large biomass by knowing the growth and growth rate. The growth needs to be analyzed every month for a period of one year. So that it can be known in which month *Sargassum* sp. can grow optimally. The purpose of this study was to monitor environmental factors affecting the growth of *Sargassum aquifolium* over one year in order to provide information to farmers for determining cultivation management practices to increase productivity. The novelty of this study is the growth pattern of *Sargassum* sp. in the rainy season and dry season in tropical waters observations of seaweed farming production for one year.

MATERIALS AND METHODS

Research design

The research method used was the observations method of cultivating *Sargassum* sp. directly at sea in a 250 m^2 cultivation area. The equipment used are out using a brand Dissolved Oxygen Meter Lutron, digital pH pen, boat, Lux meter, 1000 g manual scale, 100 kg manual scale, binocular microscope, camera, ruler, pen, scuba set, tweezers and cutter. The materials used in this activity are *Sargassum* sp. seeds, bamboo, 3 mm polyethylene rope, 5 mm polyethylene rope, nails, raffia, sacks, aquades, tissue, Hanna brand nitrate kit, Hanna brand phosphate kit, paper, and preparate glass. *Sargassum* sp. cultivation was carried out using the floating raft method with a size of 8 × 8 m. The number of rope rafts in one raft was 24 rafts, with the number of clump ties per raft being 26 clumps. The sampling method of *Sargassum* sp. growth was carried out by weighing the cultivated *Sargassum* sp. The number of samples weighed was 4 samples of each raft, a total of 4 raft samples were 16 samples. Weighing of *Sargassum* sp. was done at the beginning of planting (Day 0), day 10, and day 20. The following is the growth calculation formula which includes absolute weight and specific growth rate. The location can be seen in Figure 1.

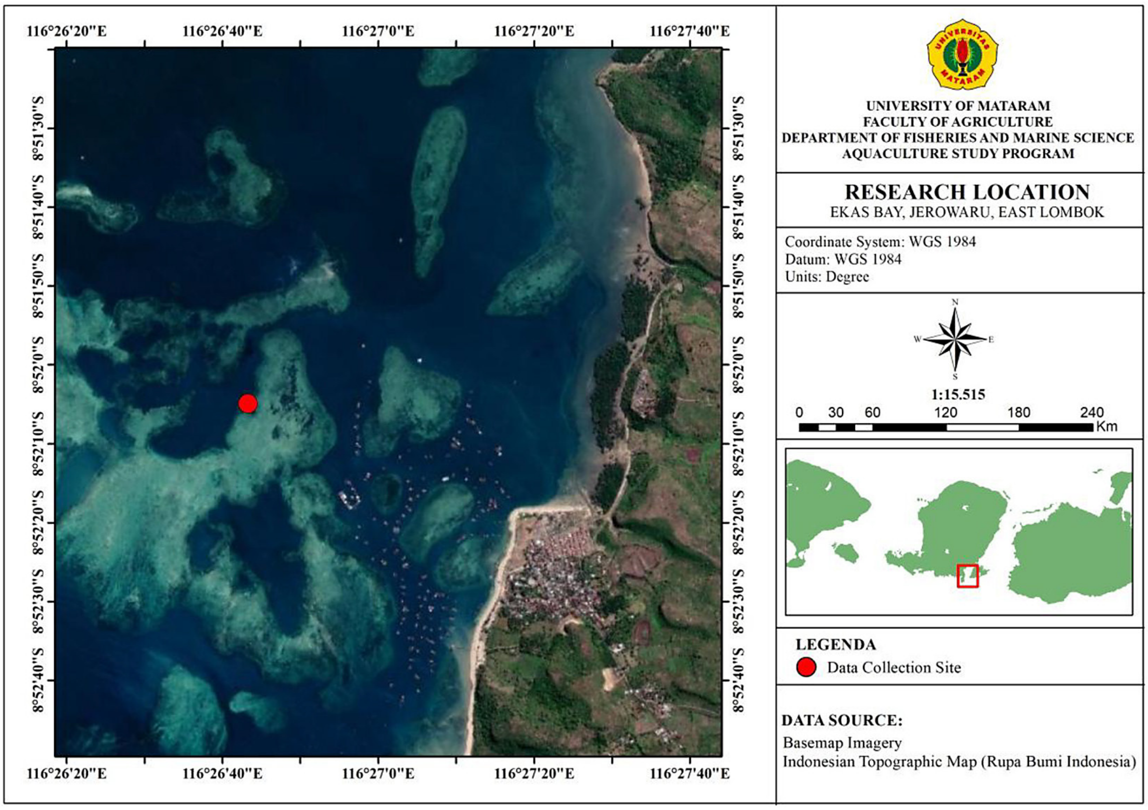


Figure 1. Research location in Ekas Bay, Lombok, Indonesia

Site selection

Site selection is based on the suitability of waters for the growth of *Sargassum* sp. The suitability of Ekas Bay waters for the growth of *Sargassum* sp. can be indicated by the presence of *Sargassum* sp. that grows wild and the presence of seaweed cultivation activities carried out by residents. Floating raft construction.

The initial stage for seaweed farming is the preparation of the floating raft. The construction is made of bamboo and polyethylene rope glued together using nails. Floating rafts are made square so that the required bamboo as many as 4 pieces with a length of 8 meters each. After the floating rafts were made, they were then moved to the water where the seaweed cultivation site was located. The transfer was done using a boat. Upon arrival at the location, weights were lowered so that the raft would not be carried away by the current.

Planting Sargassum sp.

Sargassum seedlings that have been tied to the ris rope, then planted on the floating raft. The seaweed is brought to the planting site using a boat, then each end of the ris rope is tied to a construction bamboo. Planting is done preferably in the morning so that the seaweed does not experience stress.

Monitoring Sargassum aquifolium and water quality

Monitoring activities are carried out once a week, the purpose of this activity is to ensure that the seaweed cultivated remains in good condition. Monitoring activities include cleaning seaweed from dirt, pests, checking water quality and weighing *Sargassum aquifolium* Weighing is done to determine the growth rate of seaweed by sampling at each point taken randomly.

Harvesting

The harvesting process is carried out when the seaweed planting age reaches 20 days. The seaweed was lifted as a whole and then released from the ties either from the construction ties or from the ris rope ties. Next, the seaweed was weighed to determine the final biomass weight. The last step was drying to reduce the water content in *Sargassum* sp. seaweed.

The cultivation method of *Sargassum aquifolium* can be described in the Figure 2.

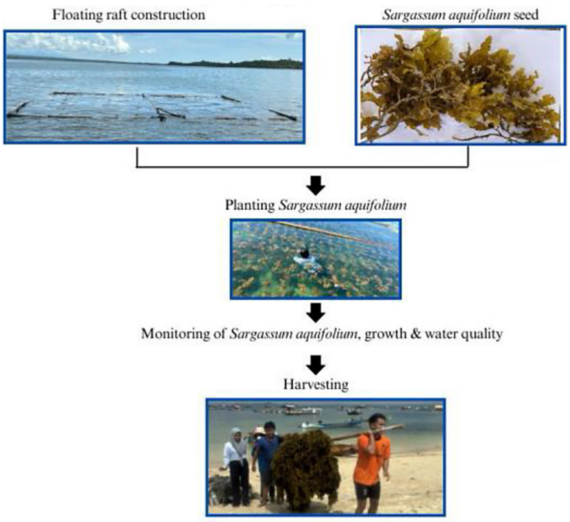


Figure 2. *Sargassum aquifolium* cultivation method

Parameters

Absolute weight

$$G = Wt - W_0 \quad (1)$$

where: G – average absolute growth (g); Wt – seedling weight at the conclusion of the study (g); W_0 – seedling weight at the commencement of the study (g).

Specific growth rate

$$LPS = \frac{(Ln\,Wt - Ln\,Wo)}{t} \times 100\% \quad (2)$$

where: LPS – Growth rate in percentage per day; Wo – Seaweed's initial weight (g); Wt – Seaweed's final weight (g); T – Maintenance Time (day).

Water quality

Water quality parameters observed were temperature, salinity, pH, *dissolved oxygen*, phosphate, and nitrate. Water quality measurements were carried out at the time of planting, maintenance, and harvesting of *Sargassum* sp. every month.

Thallus slices

Thallus *Sargassum* sp. which has a shape resembling a leaf or called a phyllo, is cleaned from the attached dirt. Then thinly slice using a stainless-steel cutter horizontally. The slices were placed on the preparate glass then given one drop of seawater using a drop pipette and covered using a cover glass. Preparate was observed using a microscope. The observation results were photographed using a camera.

Analysis data

Mutual growth data and specific growth rates were analyzed statistically and Duncan's further test. Water quality data were presented in tabular form and analyzed descriptively based on references related to the water quality parameters. Thallus slice data are presented in the form of images and analyzed descriptively. The next analysis is to relate one parameter to another. The next analysis is to relate one parameter to another using principal component analysis (PCA). PCA is a statistical analysis tool that aims to classify the relationship between parameters based on closeness. The parameters are correlated so as to bring out the line whether they are interconnected or not.

RESULTS AND DISCUSSION

Results

Absolute growth

The results of the maintenance of *Sargassum* sp. seaweed for 20 days in different months conducted in Ekas Bay, East Lombok with the Floating Raft method showed the highest average absolute weight growth obtained in January which was 135 g and the lowest was in November which was 11.8 g presented in the Figure 3.

Specific growth rate

The results of maintenance of seaweed *Sargassum* sp. showed the highest average specific growth rate obtained in January (Table 1 and 2), namely 6.31% and the lowest was in November, namely 1.005% presented in the Figure 4.

Analysis data principal component analysis

PCA results stated that in January, February, October, November and December Absolute Weight Growth was influenced by Temperatures, Phosphate and Nitrate (Figure 5). During this period, rainfall is high, affecting water quality. Rainfall affects the diversity of aquatic organisms. Higher rainfall promotes greater biomass production and genetic information in aquatic organism, while lower rainfall increases energy storage in macroinvertebrates (Aprilia et al., 2023).

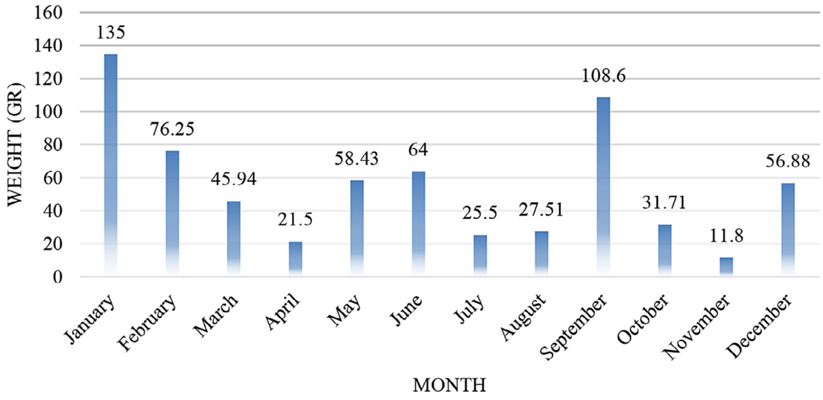


Figure 3. Absolute weight growth of *Sargassum* sp.

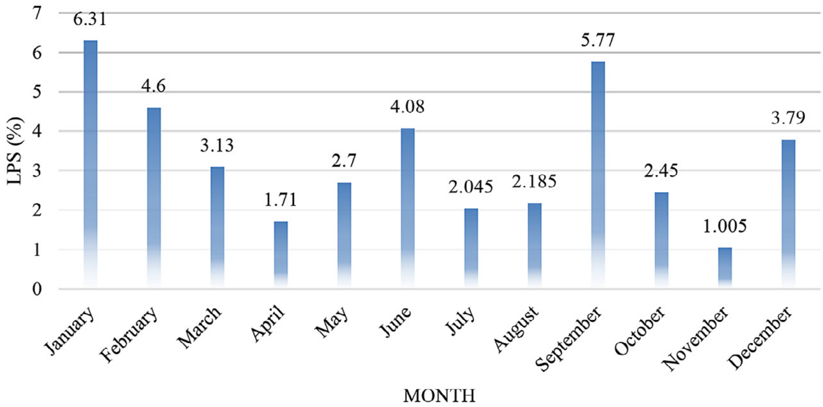


Figure 4. Spesific growth rate of *Sargassum* sp.

Table 1. Cultivation site water quality data

Month	Parameter					
	Temperatures °C	Salinity (ppt)	pH	Dissolved oxygen (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)
January	29–32	30–31	7.8–7.9	6–7.5	<10	<10
February	28.2–29.3	29–30	7.9–8	6.0–6.6	<10	<10
March	28–29	30–31	7–7.8	6–6.5	0.19–0.8	0.01–0.03
April	27–28	30–31	7–7.2	6–8.5	0.19–0.5	0.01–0.02
May	27.8–28.3	31–31.6	7.8–8.1	4.5–7.8	0.19–0.6	0.01–0.02
June	28–30	30–34	6.8–7.3	5.1–7.8	0.1	0.1
July	27.1–27.7	34	7.7–8.5	6.5–7.3	0.18	0.01–0.03
August	29–30.2	36	7.6–7.9	5.8–7.4	0.13	<10
September	28.1–28.9	34–35	7.7–8.6	6.9–7.2	<0.01	<10
October	29.5–32.7	29–31	7.9–8.15	6.7–8.5	<1	<10
November	28–30	29	7.9	5.4	<10	<10
December	28.7–30	29–30	7.8–7.9	5.5–8.3	<10	<10

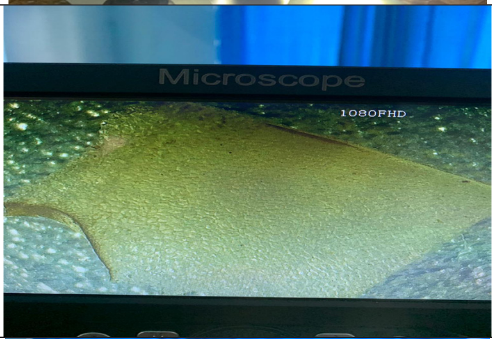
Discussion

Absolute weight

The month of January gave the highest absolute weight production. This is believed to be caused by weather conditions that encourage the growth process. In cultivation in the January period in favorable weather conditions for the cultivation process. This is because the optimal distribution of sunlight allows the photosynthesis process of *Sargassum* algae to take place optimally and affects the growth of *Sargassum*. According

Table 2. Morphology of *Sargassum* sp. talus slices

Month	Figure	Description
January		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
February		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
March		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
April		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
May		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
June		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)

July		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
August		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
September		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
October		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
November		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)
December		C: Cortex (cells on the edge of the tissue) M: Medular (cells that are in the middle of the tissue)

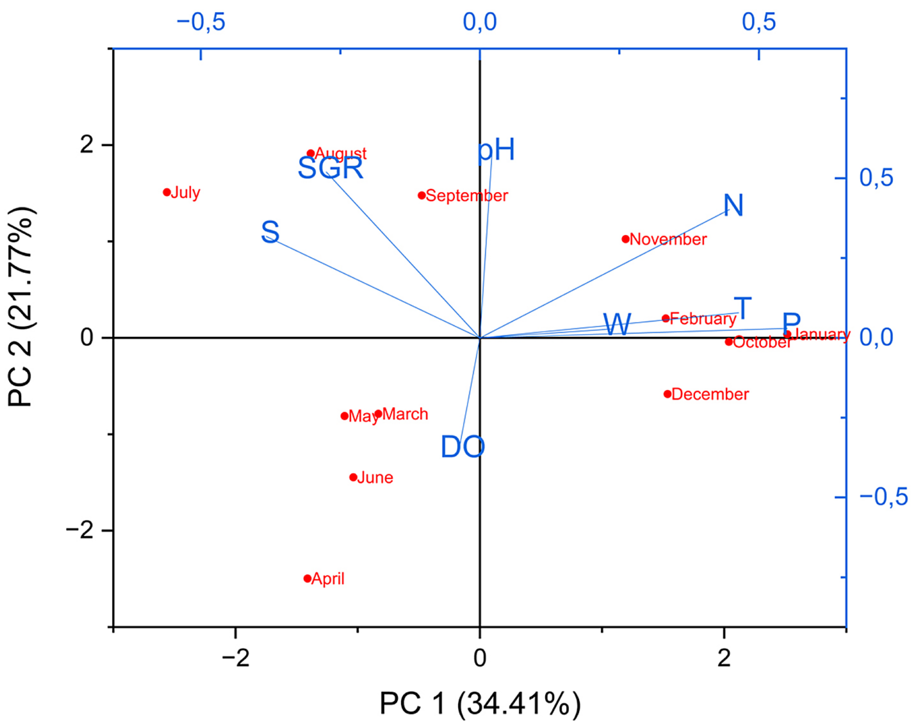


Figure 5. Principal component analysis

to Radiarta and Erlania (2016), the productive growing season usually occurs in months with low rainfall. These climatic conditions are favorable for maximum seeding, which in turn will maximize algae production. Fajri et al., (2020) found that the method of placing algae on the water surface can achieve higher growth rates than other methods. This is because the method of placing algae on the surface of the water is more effective in absorbing sunlight which is used for photosynthesis and then used as food.

The optimal photosynthesis process in the cultivation of *Sargassum* species results in faster growth. This is characterized by the shape of the talus and leaves that look thick and wide at the time of observation. Meanwhile, in November, the rainy season began to enter. According to Radiarta and Erlania, (2016), from eight years of observation, high rainfall generally occurs in November-March. While low rainfall occurs around June-October. However, in 2024, January has started to enter the dry season. This is also thought to be due to the cultivation carried out during this period in uncertain weather conditions and sometimes rain. This causes the growth of *Sargassum* to not be optimal. So it has an impact on the conditions of water movement and higher waves which cause the talus and leaves of *Sargassum* sp. to fall off. Less than optimal water conditions will allow *Sargassum* species to proliferate. The growth process does not run optimally because the talus experiences shrinkage and expends energy to survive. This is following the statement of Supiandi et al., (2020) which states that waves and currents that are strong enough can cause seaweed talus to fall off.

Specific growth rate

It can be seen from the results of the specific growth rate show a less-than-optimal number, whereas a seaweed cultivation activity can be said to be optimal if the growth rate value exceeds 2%. In accordance with the statement of Putri et al., (2022) which states that the daily growth of seaweed above 2% / day has shown the best growth while the growth below 2% / day shows less optimal growth. Some factors that can affect the low specific growth rate are waves and the entry of sunlight into the waters. According to Afifilah et al., (2021) in addition to the quality of seeds, it is also due to the adequacy of nutrients in the waters and a result of physical factors such as temperature and sunlight intensity. that the presence of nutrients from nitrate and phosphate levels can affect algal reproduction if these nutrients are abundant. Sangkia et al., (2024) said that seaweed growth is also influenced by currents that function to carry nutrients and nutrients in the waters, where these nutrients and nutrients are trapped on the thallus and used by seaweed for optimal growth processes.

Ekas Bay experiences unpredictable temperature fluctuations. Changes in water temperature not only affect the physical and chemical processes of water but also aquatic biota. The high temperature has an impact on the slow growth of algae which tend to shrink or stunt, and the condition of algae is also affected by pests. Umasugi et al., (2021) the temperature of water bodies is influenced by various factors, such as the duration of sunlight. This is also explained by Madina et al., (2022) explaining that temperature affects the photosynthetic capacity of algae and indirectly affects the solubility of oxygen used by marine organisms for respiration. According to Zou et al., (2014) temperatures that are too low can inhibit the metabolic process and growth of *Sargassum*. Marine plants are generally more active at warm temperatures, so cold temperatures can slow their growth. In addition, the photosynthesis process usually occurs more efficiently at high temperatures, so low temperatures can reduce the photosynthetic activity of *Sargassum*. Temperatures that are too low can stress *Sargassum* and disrupt hormonal balance and other biochemical processes that are essential for healthy growth. This can cause damage to plant tissues such as freezing or cell damage due to intracellular water crystallization (Chen et al., 2014).

Roleda and Hurd (2019) assert that temperature regulates enzyme activity, chemical reaction rate constants, and the rate of nutrient diffusion across boundary layers, thereby impacting all facets of seaweed physiology. Temperature is likely to influence growth rates for nutrients that are absorbed through active transport, as it will affect the activity of membrane transporters. Conversely, passive diffusion may have a less significant impact on nutrient uptake. Kumar et al., (2020) conducted research that demonstrated that the proliferation of *K. alvarezii* seaweed will decrease as temperatures exceed 28 °C. Seaweed is believed to adapt to environmental changes gradually over time. The growth and photosynthetic rate of seaweed generally increase at normal temperatures until the optimum temperature is attained, and then rapidly decrease at temperatures above the optimum. While certain seaweeds can tolerate specific levels of heat stress, prolonged exposure to high temperatures will result in disruptive stress in the form of cellular and subcellular damage. This has an effect on the limited growth and development of seaweed, which is a result of the increased energy utilization (Yuliyana et al., 2015). The function and development of metabolic cycles will be irreversibly damaged if they are exposed to high temperatures above a threshold value.

Temperature

The value of temperature in the waters of Ekas Bay from January to February ranged from 29–32 °C. When compared with the optimal value the value is still in the optimal range for seaweed cultivation. According to SNI (2010), the location of algae cultivation is planned to support its growth in the temperature range of 26–32 °C. Rodríguez-Quesada et al., (2024) researched *Sargassum* cultivation, and temperature measurements during the study period were between 25–31 ° C. Bui et al., (2018) also stated that research on *Sargassum* cultivation revealed that the temperature value during maintenance ranged from 26–27 °C. The rainy season in Indonesia usually starts from October to March. However, in 2024 the West Nusa Tenggara (NTB) region, precisely in the waters of Ekas Bay, the rainy season began in November. This means that in October the region is still experiencing the dry season as evidenced by the highest water temperature reaching 32.7 °C. According to research by Patty and Huwae (2023), the water temperature obtained in the Western season ranged from 28.2–30.3 °C and the East season temperature ranged from 28.7–30.8 °C. This condition may arise due to the frequent occurrence of rainfall and wind during measurements in the western season, resulting in a low water temperature. In contrast, the East season's measurement results indicate elevated water temperatures due to the efficient heating of water volumes in the surface layer by solar irradiation, which is facilitated by the sunny weather. Algae growth is significantly influenced by temperature, which is one of the water parameters that influences the process of photosynthesis, respiration, growth, and reproduction. According to Magaña-Gallegos et al., (2023), the formation of sufficiently large *K. alvarezii* spores can be impeded by excessively high seawater temperatures. *K. alvarezii*'s proliferation is significantly influenced by temperature. *K. alvarezii* may be killed, their reproduction may be disrupted, and their growth may be impeded by extreme temperature fluctuations.

Salinity

Salinity is an important factor for algae growth. Low salinity can cause abnormal algal growth (Dewi and Ekawaty, 2018). Salinity measurements in Ekas Bay waters from January to December ranged from 29 to 34 ppt. These results are under Indonesian National Standard (2010) which states that the appropriate salinity value for algae growth ranges from 28 to 34 ppt. Vindy et al., (2021) A good salinity value for the growth of *Sargassum* sp. is at 30 ppt. Along with temperature, salinity also changes when the season changes. In the rainy season, salinity has a lower value than in the dry season. The factor that influences the different salinity values is the weather because, during observations in the rainy season, namely in November, rainfall was quite high. Patty et al., (2020) said that the high and low value of salinity in the sea is influenced by various factors, such as water circulation patterns, evaporation, rainfall, and river flow. The size of salinity fluctuations is thought to be influenced by several factors, including water circulation patterns, evaporation, rainfall (precipitation), and the presence of river flow (runoff).

pH

The study conducted from January to December, the pH value ranged from 6.8 to 7.9. This pH is optimal for the cultivation of *Sargassum* sp. The pH range that is optimal for the proliferation of *Sargassum* sp. is 5 to 9, as per Hwang et al. (2015). Osmotic stress in algae can be induced by high pH. This occurs when the algae cell's water assimilation fails due to the discrepancy in ion concentration between the inside and outside. Additionally, the pH of the water surrounding the seaweed cultivation site was measured by Cokrowati et al. (2024), and the results ranged from 7.9 to 8.15. This suggests that the pH of the waters in the vicinity of the seaweed plantation is quite conducive to its growth.

Dissolved oxygen

The assessment of dissolved oxygen in Ekas waters indicated a level conducive to the proliferation of *Sargassum* algae. Specifically, it varies from 4.5 ppm to 7.4 mg/l. This number is below the natural quality guidelines for marine biota, which is greater than 5 mg/L. Kokubu et al., (2015) indicate that the ideal dissolved oxygen (DO) value for *Sargassum* is 7.37 mg/L. Coastal waters necessitate a minimum dissolved oxygen content of 4.0 mg/L, with levels of 5.0 mg/L or above being optimal for enhancing ecosystem functionality and carrying capacity. Oedjoe et al., (2022) indicate that the ideal dissolved oxygen concentration for seaweed is 7.37 mg/L. Coastal waters necessitate a minimum oxygen level of 4.0 mg/L, however dissolved oxygen concentrations exceeding 5.0 mg/L are ideal for optimal ecosystem function and carrying capacity. The research indicates that dissolved oxygen levels during the rainy season are lower than those in the dry season. Reduced dissolved oxygen levels during the rainy season result from turbid seawater caused by significant rainfall, which facilitates the entry of refuse or organic waste from terrestrial sources into the ocean. In the East season, oxygen levels are comparatively elevated because to the clarity and purity of the saltwater, facilitating an effective photosynthetic process. Temperature and salinity significantly influence dissolved oxygen levels; as temperature and salinity increase, oxygen solubility diminishes, and vice versa (Patty and Huwae, 2023).

Phosphate

Phosphate in water is closely related to the photosynthesis process. The reduced phosphate content in the waters is thought to have been utilized by seaweed as an essential nutrient that plays a role in the photosynthesis process (Rosmiati et al., 2019). The value of phosphate measurements in Ekas Bay Waters resulted in values ranging from 0.01- < 10 mg/l. These results are less appropriate when referring to Indonesian National Standard (2010) which states the value of phosphate that is good for seaweed growth is > 0.1 mg/l. Good phosphate value for the maintenance of *Sargassum* is 0.14–0.72 mg/l (Hoang et al., 2016). Good phosphate levels to support the growth of *Sargassum* henslowianum are in the range of 0.38–0.66 mg/l (Yu et al., 2019). Nitrate and phosphate levels in marine waters can fluctuate depending on various factors, one of which is the rainy season. High rainfall can increase nutrient inputs to waters through river flow. When examined from recent climatic conditions that are often erratic and changeable, the measured water quality values follow weather changes. According to Edward and Tarigan (2003), changes in the timing of upwelling may occur due to erratic weather changes, considering that upwelling is strongly influenced by climatic conditions. When examined also from depth, it can be seen that phosphate levels tend to increase with increasing depth.

Nitrate

Sargassum need nitrate as its primary nutrient for growth and development. Nitrate contributes to the synthesis of proteins, nucleic acids, and several other chemical compounds. The nitrate content levels reported in this investigation ranged from 0.01 to less than 10 mg/l. Widyartini et al., (2017) indicate that the ideal nitrate concentration for *Sargassum* growth is between 0.200 and 0.420 ppm. Elevated nitrate levels in the cultivation environment might lead to many issues. Elevated nitrate levels can induce rampant algal proliferation, including undesirable species.

Thallus slices

The results of research that has been done, the cells in the talus tissue of *Sargassum* sp. seaweed showed parts that can be observed, namely cortex cells and medulla cells. Cortex cells are cells that are on the edge of the tissue that has a round shape and are small while medulla cells are cells that are in the middle of the tissue with an oval shape and enlarged. According to Hernández-Cruz et al., (2022), the cell structure consists of three layers: meristoderm cells arranged on the periphery (as epidermis), parenchyma (cortex cells) cells that are small in size are on the edge of the tissue, and elongated and large medulla cells are in the center of the tissue. In general anatomy, there are three types of constituent cells from the outside to the inside, namely the epidermis, cortex, and the largest medulla) (Pramesti *et al.,* 2016). His research explains that the cortex cells are star-shaped in the subcortex and the medulla cells are filamentous. Research by Raimundo et al., 2016; Aris and Labenua, (2020) also shows that observations made on the cortex are at the edge of the tissue and the medulla is in the middle of the tissue. In line with the research of Lestari et al., 2023; Oryza et al., (2015) The tissue structure consists of cortex and medulla tissue. Part of the cortex with a dense and small cell arrangement. While the medulla consists of cells with large sizes.

The observations indicate that the size and shape of the cells differ in each instance. This indicates that the disparity is believed to arise from variations in the cultivation season. Mahmudi et al., (2025) Seasonal variations in biotic and abiotic interactions result in alterations in ecological conditions that can either enhance or impede mineral absorption, as well as influence the formation of primary and secondary metabolites. Seasonal changes may alter the biochemical components of seaweeds. This alteration may serve as an indicator included among the criteria. In contrast to the study by Triastinurmiatiningsih et al., (2011), which examined the differences in cell quantity among several *Sargassum* species, it concluded that anatomical features exhibit distinct changes in the size, shape, and number of cells for each *Sargassum* type. This indicates that anatomical variances also facilitate morphological variations. The cellular tissue seems compact yet robust, signifying the vitality of the cells. According to the research conducted by Maulani et al., (2018), under healthy settings, the intercellular distance appears minimal, indicating that the talus tissue is not severely compromised, as there are no gaps between adjacent cells. Talus expansion refers to an augmentation in cellular size or alterations in cell quantity characterized by distinct structures and functions. The growth pattern results in an augmentation of the cellular composition of the talus.

Sargassum thallus has a morphology that is rough-textured, tapered rounded serrations, and small disk-shaped anchors. *Sargassum* muticum can grow in soft substrate habitats. *Sargassum* growth and biomass can vary seasonally. *Sargassum* ilicifolium shows significant seasonal variation in thallus density and size in winter. Similarly, *Sargassum* baccularia, S. binderi, and S. siliquosum show changes in biomass and thallus length over time. *Sargassum* thallus contains bioactive compounds, *Sargassum* latifolium contains high sugar, *Sargassum* polycystum contains alkaloids, flavonoids, saponins, and steroids (Meinita et al., 2024).

CONCLUSION

The conclusion of this study is that most of the growth rate in each month is more than 2%, so it can be said that *Sargassum* can grow optimally.

Acknowledgement

The authors would like to thank University of Mataram who funding and supporting this research. This research was supported by Universitas Mataram with grant number: 1818/UN18.L1/PP/2024.

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