The Impact of Seasonal Changes on the Production of seaweed (*Eucheuma cottonii*) in Teluk Tamiang Village, Tanjung Selayar District, Kotabaru Regency

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Abstract. Kotabaru Regency is one of the regencies in South Kalimantan Province, Indonesia, with significant potential for seaweed cultivation activities. However, the production of *Eucheuma cottonii* seaweed in Kotabaru Regency has been decreasing annually. Notably, since 2010, there has been no seaweed production in Teluk Tamiang Village, Pulau Laut Tanjung Selayar Subdistrict. The development of seaweed cultivation areas can be influenced by the biophysical environmental conditions of the waters and climatic conditions. This research aims to determine the influence of seasonal variations on the level production of *Eucheuma cottonii* seaweed in Teluk Tamiang Village, Tanjung Selayar Subdistrict, Kotabaru Regency, based on different seasons. The research method involves cultivating *Eucheuma cottonii* seaweed in the research area, specifically in the waters of Teluk Tamiang Village. Cultivation locations were categorized according to different seasons: west monsoon, southeast monsoon, and transitional season. Seaweed production was measured or weighed from the harvested seaweed cultivated in each location. The results indicate that seasonal variations significantly impact the production of *Eucheuma cottonii* seaweed in Teluk Tamiang Village, Tanjung Selayar Subdistrict, Kotabaru Regency. Optimal seaweed production occurred during the transitional season, reaching 895 kg/m. Meanwhile, during the west monsoon season, the seaweed production obtained was 723 kg/m; during the east monsoon season, the obtained seaweed production was 22 kg/m.

Keywords: Cultivation, seaweed, production, season.

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A. Hidayat et al. (eds.), *Proceedings of the International Conference on Multidisciplinary Studies (ICoMSi 2023)*,
Advances in Social Science, Education and Humanities Research 829,
https://doi.org/10.2991/978-2-38476-228-6_33

1 Introduction

Seaweed is one of the crucial economic commodities that Indonesia excels in. According to the FAO statistics 2010, Indonesia ranks second in seaweed production after China, contributing 3.90 million tons or 20.60% of the world's seaweed production [1]. The predominant seaweed species cultivated in Indonesian waters include Eucheuma cottonii, Eucheuma spinosum, and Gracillaria sp [2]. This is due to their ease of cultivation and the high market demand. Seaweed cultivation has emerged as a shining prospect within the fisheries sector, offering not only high market value both locally and internationally but also a wide range of applications through processing, such as in the food industry, pharmaceuticals, cosmetics, health foods, and bioactive substances, thus presenting opportunities for discoveries in medicine.

Kotabaru Regency is one of the regencies in South Kalimantan Province that holds potential for seaweed cultivation activities. This region boasts a coastline length of 923.53 km^2 and a marine area of 384,900 hectares [3]. According to data from the Department of Marine and Fisheries of Kotabaru Regency, the seaweed (*Eucheuma cottonii*) production in the regency was 398.01 tons in 2001, 465.10 tons in 2002, and 2,403.7 tons in 2003. Although the annual seaweed production increased during that period, it fell short of meeting market demands. Starting in 2005, seaweed production in this area began to decline each year, and since 2010, there has been no seaweed production in Teluk Tamiang Village, Pulau Laut Tanjung Selayar Subdistrict.

One of the keys to the success of seaweed cultivation lies in the appropriate selection of cultivation areas. This is because ecological factors (oceanographic and water quality parameters) influence seaweed production and quality. The development of seaweed cultivation areas can be affected by the bio-physical environmental conditions of the waters and climatic conditions. Feasibility studies of seaweed cultivation areas have been conducted extensively through manual analysis and spatial approaches [4]. Still, they may only partially guarantee the success of seaweed cultivation in a given region. This is due to oceanographic factors, including highly dynamic water quality parameters and the influence of seasons, which have become increasingly difficult to predict (seasonal anomalies). Frequent harvest failures experienced by seaweed cultivators are often attributed to the impact of large waves that destroy the cultivation media and biota, as well as seasonal anomalies such as excessively high rainfall or prolonged periods of heat, leading to the emergence of diseases (ice-ice) or the rotting of cultivated seaweed [5]. Based on these conditions, it is evident that seasons are a crucial factor that needs to be carefully considered for the sustainability of seaweed cultivation endeavors. The environmental resources that support seaweed cultivation in Tanjung Selayar have experienced degradation, rendering the existing seaweed cultivation unable to be further developed due to suboptimal results. The region of Teluk Tamiang Village, Tanjung Selayar, is bordered by the Java Sea to the south and the Makassar Strait to the east. The east monsoon, transitional season, and west monsoon influence its oceanographic conditions. The east monsoon occurs from May to September, while the west monsoon occurs from December to April. The transitional season falls in October and November. Currently, no research has been conducted to assess the level of seaweed production during different seasons in the Teluk Tamiang area. Oceano-

graphic factors, coastal area conditions, and the influence of seasonal variations are studied to determine land suitability for seaweed cultivation, aiming to achieve optimal production results [6]. According to Maryunus et al. (2019), there are several factors that need to be considered in seaweed cultivation production, one of the most important factors is selecting the location or land that will be used in seaweed cultivation. The potential revival of Teluk Tamiang Village as a seaweed cultivation center would undoubtedly enhance the coastal economy of Tanjung Selayar.

The problems and core issues related to the development of seaweed cultivation businesses in the waters of Teluk Tamiang Village, Tanjung Selayar, encompass (1) The lack of knowledge about the suitable seasons to achieve optimal seaweed production results for cultivation in the waters of Tanjung Selayar. To address this issue, a study is needed to understand the influence of seasonal variations on the production of *Eucheuma cottonii* seaweed.

This research aims to determine the effect of seasonal variations on the level production of *Eucheuma cottonii* seaweed in Teluk Tamiang Village, Tanjung Selayar Subdistrict, Kotabaru Regency, based on different seasons. The research method involves cultivating Eucheuma cottonii seaweed in the research area, specifically in the waters of Teluk Tamiang Village. The technique of seaweed planting used is the long-line system. Cultivation locations were categorized according to different seasons: west monsoon, southeast monsoon, and transitional season. Seaweed production was measured or weighed from the harvested seaweed cultivated in each location for each season. From the results of weighing the harvested seaweed, the optimal season and production of seaweed cultivated in the waters of Tanjung Selayar will be known.

2 Materials and Research Methodology

2.1 Materials

Seaweed. The seaweed seedlings used in the research were *Eucheuma cottonii* seaweed sourced from Takalar, South Sulawesi. Approximately 50 kg of seaweed seedlings are required for each study season.

Long-line. The long line is made of nylon and measures 150 meters long. The long-line system employed consists of 20-meter sections per lane**.** This long line was used to secure the seaweed seedlings for cultivation. In each season, six routes of seaweed seedlings were planted using the long-line system.

Bamboo poles. Bamboo poles were used to anchor the long line during seaweed cultivation. Each lane was fastened to bamboo poles at its ends. Bamboo poles must arrive in a long line of approximately 12-20 poles.

Digital scale. This scale weighed the seaweed seedlings for each lane before planting. Hanging scale. This scale was used to consider the harvested seaweed production for each route after each harvest.

2.2 Research Methodology

Research Procedure. In this study, the cultivation of *Eucheuma cottonii* seaweed was conducted in the research area, Teluk Tamiang Village's waters. The cultivation locations were categorized into appropriate categories, and the planting was done during the west monsoon, transitional season, and east monsoon.

Cultivation Method. The cultivation method employed in this research is the long-line system. This method is a variant of the floating long-line method. It offers several advantages, including ample plant sunlight exposure, resilience to water quality changes, protection from bottom-dwelling pests, faster growth, high-quality yield, and cost-effectiveness. Bamboo poles were used to secure the ends and base of the long line. The length of each long line is 20 meters. This research conducted seaweed cultivation in areas that fall under the appropriate category. The cultivated seaweed variety is *Eucheuma cottonii*.

Seaweed Production. Production was measured or weighed based on the harvested seaweed from locations that fell under the appropriate category. Observations and measurements of seaweed production were conducted during different seasons: west monsoon, southeast monsoon, and transitional season. Seaweed production was calculated using the formula from Samawi and Zainudin [7] as follows:

$$Pr = \frac{(Wt-Wo)B}{A} \quad (1)$$

Explanation:
Pr = Seaweed production (g/m)
Wo = Initial weight of seaweed seedlings (g)
Wt = Final weight of cultivated seaweed (g)
A = Length of the long-line (m)
B = Number of planting points

3 Results and Discussion

The calculated seaweed production data for Eucheuma cottonii seaweed, during different seasons are presented in Tables 1, 2, and 3. The seaweed production rates were obtained from cultivation in suitable locations based on land suitability maps for different seasons.

Table 1. Seaweed Production Rates during the West Monsoon Season

No	Seaweed Type	Category		
		Seedling Weight (kg)	**Final Harvest Weight (kg)**	**Production Rate (kg/m)**
1	***Eucheuma cottonii***	2.4	15.3	129
		1.5	13.2	117
		3.0	15.1	121
		1.8	12.8	110
		2.0	14.2	122
		2.2	14.6	124
Total		**12.9**	**85.2**	**723**

Table 2. Seaweed Production Rates during the Transitional Season

No	Seaweed Type	Category		
		Seedling Weight (kg)	**Final Harvest Weight (kg)**	**Production Rate (kg/m)**
1	***Eucheuma cottonii***	2.4	18.23	158
		1.5	16.1	146
		3	18.3	153
		1.8	16.6	148
		2	16.5	145
		2.2	16.7	145
Total		**12.9**	**102.43**	**895**

Table 3. Seaweed Production Rates during the East Monsoon Season

No	Seaweed Type	Category		
		Seedling Weight (kg)	**Final Harvest Weight (kg)**	**Production Rate (kg/m)**
1	***Eucheuma cottonii***	2.4	3.1	7
		1.5	1.1	-4
		3	4.2	12
		1.8	0.8	-10
		2	2.5	5
		2.2	3.4	12
Total		**12.9**	**15.1**	**22**

Tables 1, 2, and 3 show that the highest production of Eucheuma cottonii seaweed was achieved when cultivated during the transitional season. The selection of seaweed

cultivation locations is also based on the study's suitable category, situated further offshore from the coast. The substrate at this location consists of sandy sediment mixed with coral fragments, providing a suitable environment for seaweed cultivation. The most favorable substrate type for seaweed growth is a combination of sand and coral fragments, as such waters are typically traversed by currents conducive to seaweed growth. Substrates that are muddy and shallow can easily be stirred by strong winds and waves, resulting in water turbidity. [8] states that seaweed growth thrives when cultivated in shallow waters with substrates such as coral, coral fragments, sand, or a mix of these three.

During the west monsoon season, the production of Eucheuma cottonii seaweed is also favorable, although less optimal than during the transitional season. During this transitional period, there is a reduction in rainfall, and although currents are present, they are not as strong as during the east monsoon. Seaweeds perform photosynthesis to obtain energy, thus making light an essential requirement for growth [8]. In contrast, the east monsoon season experiences heavy rainfall and strong ocean currents. According to [9], currents significantly influence seaweed fertility as they facilitate the movement and distribution of vital nutrients required for growth, which are absorbed through the thallus.

To support the growth of seaweed, the availability of nutrients in the water is crucial. [10] explain that the growth process of seaweed is highly dependent on the intensity of sunlight for photosynthesis. Seaweed cells absorb nutrients through this process, driving daily growth through cell division.

The cultivation system using long-line during maintenance up to the fifth week demonstrates a significant increase in growth rate for Eucheuma cottonii seaweed, both during the transitional and west monsoon seasons. This is due to the favorable nutrient-carrying currents during these seasons, facilitating effective nutrient absorption. However, swift winds or high waves can result in plant damage, such as breakage, tearing, or detachment from the substrate. Additionally, nutrient absorption might be hindered when the water carries nutrients away before absorption. [11] explain that more significant water movement accelerates growth by increasing nutrient diffusion, thus enhancing metabolic processes. Regular water exchange benefits algae by supplying much-needed nutrients for seaweed growth. Nutrient supply is aided by wave movement and currents, which assist seaweed in nutrient absorption, waste elimination, and the exchange of CO2 with O2 [12].

4 Conclusion

The season variations significantly impact the production of Eucheuma cottonii seaweed in Teluk Tamiang Village, Tanjung Selayar Subdistrict, Kotabaru Regency. Seasonal changes will influence changes in water quality parameters in Tanjung Selayar waters. The optimal seaweed production occurs during the transitional season, amounting to 895 kg/m. This is because during the transition season, the currents in the waters of Tamiyang Bay are moderate. And also during the transition season, rainfall starts to become scarce. On the other hand, during the west monsoon season,

the obtained seaweed production is 723 kg/m. As for the east monsoon season, the seaweed production acquired is 22 kg/m. In the west season, there are almost no currents, while in the east season, the currents in the waters of Tanjung Selayar are very high, disrupting the growth of seaweed.

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