Seaweed *Kappaphycus alvarezii* cultivation production based on season in Indari waters, West Bacan Subdistrict, Regency of South Halmahera, Province of North Mollucas, Indonesia

M Irfan¹, S Malan¹, F Muchdar¹, N Abdullah¹, Juharni¹

¹Department of Aquaculture Faculty of Fisheries and Marine Science, Khairun University, Ternate - Indonesia

Email: ifan_fanox@yahoo.co.id

Abstract. Indari is one of the coastal areas in the West Bacan Subdistrict, Regency of South Halmahera, Province of North Mollucas. Fisheries business activities that are quite popular in this region are aquaculture with seaweed commodities. Indari waters is also one of the areas designated as seaweed cultivation development zones in Province of North Mollucas. One of the factors that determine the success of a seaweed cultivation business is production. This is because production is the final result obtained from a cultivation business. The purpose of this research was to determine the production of seaweed *K. alvarezii* cultivation based on seasons. The method used in the survey is a method of interviewing using questionnaires to seaweed farmers as many as 30 people. Production data collected is wet and dry production data by season. The results showed that the highest seaweed *K. alvarezii* production was found in the dry season with wet production of 9.320 kg and dry production of 852.5 kg, whereas in the rainy season, wet production was 898.125 kg and dry production was 718.5 kg.

1. Introduction

Seaweed is a macroalga consisting of nearly 10,000 species and contributes about 10% of total world marine productivity, and is an important resource in marine waters that have been used by humans since the past [1,2]. Today seaweeds are used in a multitude of applications with expanding global industries based on hydrocolloids, cosmetics and food supplements, and also as a potential biofuel source [3]. Seaweed are a leading commodity in aquaculture in Indonesia. The development of seaweed cultivation areas can be caused by the biophysical environmental conditions of the waters and climatic conditions [4]. Planting season is one of the important factors in seaweed farming because it greatly influences the production or the end result produced. The response of seaweed growth varies over time and seasons of the year [5]. A cultivation approach based on change the season and the environmental conditions of its waters optimal for seaweed growth, is expected to be a reference for management and utilization of marine cultivation land for increase seaweed production optimally and productively [5,6]. Seaweed *K. alvarezii* is the leading export commodity for aquaculture products in Indonesia [7]. In 2014, Indonesia produced seaweed from cultivation of
more than 10 million tons [8]. Data from the Ministry of Maritime Affairs and Fisheries showed that the national seaweed production in 2017 was 22.17 million tons, in 2018 it was 26.23 million tons, and in 2019 it is estimated at 29.32 million tons [9].

Seaweed has a fairly complete nutritional content. Chemically seaweed consists of water (27.8%), protein (5.4%), carbohydrates (33.3%), fat (8.6%), crude fiber (3%), and ash (22.5%). Besides, seaweed also contains enzymes, nucleic acids, amino acids, vitamins A, B, C, D, E, and K, and macro minerals such as nitrogen, oxygen, calcium, and selenium, and micro minerals such as iron, magnesium and sodium. The content of amino acids, vitamins, and minerals seaweed reaches 10-20 times compared to land plants [10]. Seaweeds also contains all the micro and macro nutrient elements of plants, trace elements, vitamins, auxin, gibberellins and antibiotic compounds [1,11].

Indari is one of the coastal areas in the West Bacan Subdistrict, Regency of South Halmahera, Province of North Mollucas. Fisheries business activities which are quite popular in this region are aquaculture with seaweed commodities. Indari waters is also one of the areas designated as seaweed cultivation development zones in Province of North Mollucas [12].

Seaweed cultivation is much sought after by local people with consideration of easy cultivation technology, fairly short maintenance time, and competitive market prices. [6] Nowadays seaweed cultivation is increasingly encouraged, both intensively and extensively and cultivation activities are carried out by farmers in coastal areas as the main livelihood [5].

The success of cultivation achieved is inseparable from the suitability of the local climate, community interest, ease of cultivation, and the availability of raw materials [7]. One of the factors that determine the success of a seaweed cultivation business is production. This is because production is the final result obtained from a cultivation business. Seaweed production in Indari waters, West Bacan Subdistrict in particular and Regency of South Halmahera in general are still experiencing problems, especially season, because the season can affect the quality and quantity of seaweed production itself. The resulting production sometimes fluctuates both wet and dry production. Therefore, the seaweed planting process carry out needs to be considered the right or appropriate planting season.

This study aims to determine the production of seaweed *K. alvarezii* cultivation based on the season in Indari waters, West Bacan Subdistrict, Regency of South Halmahera, Province of North Mollucas.

2. Material and methods

2.1. Study area

This research was conducted in Indari waters, West Bacan Subdistrict, Regency of South Halmahera, Province of North Mollucas for one year (see Figure 1). Location at coordinates 00°025'13,45.8’ South latitude and 127°18'28.0’ east longitude.

![Figure 1. Map of sampling location, Indari waters, West Bacan Subdistrict, Regency of South Halmahera, Province of North Mollucas](image-url)
2.2. Data collection
Determination of the season is done by following the data obtained from the Meteorology and Geophysics Agency (BMG) of Labuha-Bacan South Halmahera within 5 years. The rainy season is calculated based on the amount of rainfall that occurs in each year, while the dry season is seen based on the least amount of rainfall that occurs annually. Then the rainy season is determined in May, July, and December, while the dry season is in September, October, and November. Production data is recorded based on the season obtained from the local cultivator seaweed cultivation. The method used in this study is a survey method with interview techniques using questionnaires to seaweed farmers as many as 30 people [13]. Production data collected is wet and dry production data by season.

2.3. Data analysis
The data analysis technique used is descriptive analysis, describing the conditions of seaweed production obtained by local farmers, both wet and dry seaweed production. Furthermore, the data obtained, tabulated, and discussed descriptively.

3. Results and discussion
3.1. Seaweed production in the rainy season
The results of the analysis of seaweed *K. alvarezii* production during the rainy season are presented in Table 1.

| Season planting (month) | Wet production (kg) | Dry production (kg) |
|------------------------|---------------------|---------------------|
| Mey                    | 898.125             | 718.5               |
| July                   | 898.125             | 718.5               |
| December               | 898.125             | 718.5               |
| Total                  | 26,943.75           | 21,555              |
| Average                | 26,943.75           | 21,555              |

3.2. Seaweed production in the dry season
The results of the analysis of seaweed *K. alvarezii* production during the dry season are presented in Table 2.

| Season planting (month) | Wet production (kg) | Dry production (kg) |
|------------------------|---------------------|---------------------|
| September              | 9320                | 852.5               |
| October                | 9320                | 852.5               |
| November               | 9320                | 852.5               |
| Total                  | 279,600             | 255.75              |
| Average                | 9320                | 852.5               |

Data in Tables 1 and 2, shows that seaweed *K. alvarezii* cultivation have the same yield (production) based on the growing season. This caused used of seedlings and the number of planting points on each span rope is the same, with excellent water quality conditions so that the production
achieved is the same, but different in average production. The Average wet production was 898.25 kg and dry production was 718.5 kg in the rainy season (Table 1), and in the dry season the average wet production was 9320 kg and dry production was 852.5 kg (Table 2). This shows that the highest production is in the dry season. Season productive planting generally occurs in months where rainfall is low (dry season) and minimum wind speed conditions. Climatology conditions are very supportive to make the maximum planting so seaweed production is produced get the maximum. Conversely, the rainy season is considered to be less productive due to high rainfall and strong wind speeds and waves, which can directly affect the decline in seaweed production [14].

The high production achieved is related to better water quality in the dry season compared to the rainy season, especially salinity. In the dry season, the salinity of the waters is generally high, ranging from 33-35 ‰, (according to the life of seaweed) [15][16]. Conversely, in the rainy season, salinity decreases slightly due to the influence of freshwaters flow into sea waters. If rainfall is high then evaporation is reduced and salinity is low. When salinity goes down, the color of seaweed turned pale, easily broken, soft and eventually rot, so that it can reduce the production of seaweed cultivation [17]. Reduced water salinity (less than 20 ppt) can also trigger ice-ice disease [6]. Otherwise prolonged summer that is resulting in rising sea water temperatures reach around 33-35°C accompanied with current and brightness conditions that are lack of support can also cause the onset of ice-ice disease. Nevertheless water quality parameters such as temperature, brightness, and speed during the study are still within the limits of the feasibility of seaweed K.alvarezii [14].

In the dry season, the absorption of sunlight is higher which results in the process of photosynthesis taking place well so that it has an impact on increasing the growth of seaweed. Salinity plays an important role in the growth and development of seaweed, because it is direct related to osmoregulation that occurs in cells [18][19]. Different concentrations of fluid inside and or outside of the cell encourage cause golgi bodies always try always try to be balanced to isotonic. Such condition, causing greater energy to be utilized so that it affects the low growth and development of seaweed. The high salinity causes the golgi bodies, unable to balance the concentration of fluid inside the cell with the concentration of fluid outside the cell, in the end, the cell fluid is absorbed into the environment, so the cells shrink from size [14].

Based on the results of interviews with seaweed farmers at the study site, seaweed farmers generally do not know and pay attention to the planting season appropriately, and each change of seasons often causes problems for seaweed cultivation, so that the seaweed yield sometimes decreases so that the income of farmers also becomes reduced. Problems that arise along with the change of seasons include: in the long dry season, making seaweed become easily broken and fall out because it is directly exposed to the heat of the sun at low tide. The rainy season will disrupt the drying process due to the lack of sunlight. Seaweed in a long time is not dried in the sun will become rotten and if dried will make the weightless. The rainy season causes the wind and beach waves to become large so that the seaweed becomes damaged and is easily broken by the waves crashing [20].

4. Conclusion
The highest seaweed K.alvarezii production is found in the dry season compared to the wet season with the production achieved, namely: the dry season, wet production of 9320 kg and dry production of 852.5 kg and wet season, wet production of 898,125 kg and dry production of 718.5 kg.

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