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Kaizen implementation in seaweed aquaculture (*Gracilaria* sp.) in Karawang, West Java: A productivity improvement case study

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Kaizen implementation in seaweed aquaculture (*Gracilaria* sp.) in Karawang, West Java: A productivity improvement case study

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Abstract. Seaweed is an important and high economy value commodity. There are various methods to increase the quality and productivity. The aim of the study was to improve the quality, quantity and production of seaweed (*Gracilaria* sp.) by using Kaizen approach. There were intervention ways; those were long line method, grouping method and charcoal pocket application. This study was conducted for 3 months from March 25, 2018 to May 25, 2018 (one cultivation cycle) in Tambaksari village, Karawang, West Java. Some parameters were observed during the study including daily growth rate (weight and length), water quality parameters (pH, temperature, salinity, dissolved oxygen, nitrate, high water), and productivity. The measurement of weight and length of thallus were conducted once a week, while for water quality parameters were once every three days. The long line method in deeper part of pond had higher profit (7.7% or IDR 12,451,200) than that of in shallower part of pond (IDR 11,195,200). Grouping method resulted better quality of harvested seaweed and led to get higher profit (17% or IDR 4,400,665) than that of without intervention (IDR 1,681,165). The charcoal pocket application influenced to the growth rate of non pocket treatment was about 416,46 g/week than that of with pocket (233.11 g/week) and with charcoal pocket treatment (304.33 g/week). So that the most effective method to be applied was the longline method in deep and grouping method gave more quality impact of harvest result.

Keywords: seaweed; aquacture; productivity; continuous improvement; planting method.

1. Introduction

The seaweed is one of the important potential commodities in the field of marine and fisheries. It has the ability to bind the air which is quite high [1] and supporting the growth of bacteria and as a biofilter in the cultivation of polyculture [2]. Erlania [3] suggested that seaweed is one of the coastal vegetation that can utilize CO2 through photosynthesis activities for application into biomass and agar [4, 5]. An important factor in seaweed farming activities is to produce high quality and productivity, which can be seen from the planting method. Rizqi [6] and Soegiarto et al. [7] explained that proper cultivation techniques (eg distance and height of seedlings) in the air will produce high productivity seaweed.

To increase the quality of Gracilaria sp. productivity and production can be applied with the kaizen approach or continuous improvement principles. Kaizen is an improvement made by eliminating waste, due to excessive work, and always improving product quality [8]. Ferdiansyah [9] states that the purpose of kaizen is to improve QCD (Quality, Cost & Delivery). Key indicator of this kaizen is on Quality Improvement, namely improvements that are carried out continuously (sustainable) and have a goal to increase productivity through meeting consumer expectations in terms of quality and time [10]. One of the goals is to produce high quality and quantity without high costs.

2. Material and Method

The data collection method that have been used is the survey/observation method of apprenticeship by participating in all activities related to seaweed cultivation (*Gracilaria* sp.). Growth data collection was done randomly as much as 10% of the total point (50 g/point) by weighing and measuring length every seven days during the maintenance period for each intervention. The yields of several interventions used were immediately dried use waring as a base with a drought rate of 25-15%. The research procedure was observed water quality every three days with several parameters (salinity, temperature, pH, DO, nitrate, and water level). The implementation of the intervention was carried out with several methods (longline in deep and shallow, grouping, and charcoal bag application), the following were the interventions carried out.

a) Grouping Method

The area of pond used for this study was 5 ha (deep of deep 93 cm, shallow 43 cm), divided by 5 plots (1 plot/ha) use stakes as markers with a difference in time spread 1-3 days. The method used was the basic stocking method or the method commonly used by farmers. Observations on this method are carried out by controlling every 3 days, namely thinning, moss cleaning and observing water quality.

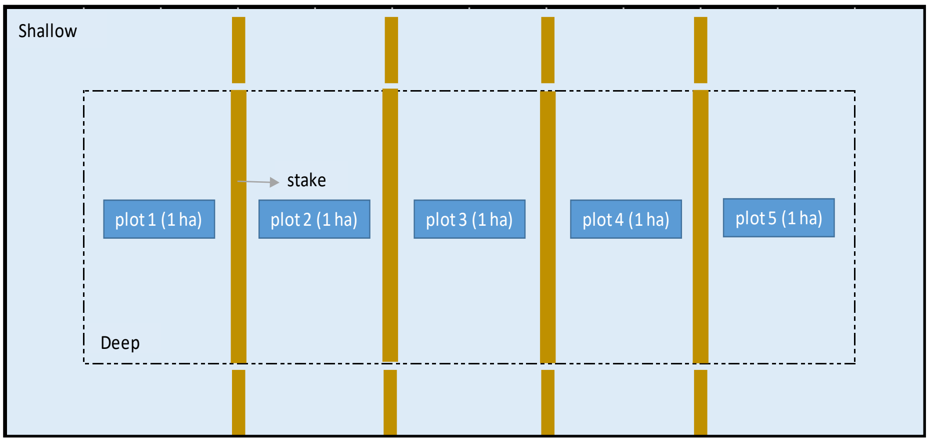

Figure 1. Schema of grouping method.

b) Longline method (deep and shallow)

Interventions in this method were carried out on farms covering an area of 6 ha and only used 1 ha for research with three spans. (Figure 2).

a. Top view b. Side view

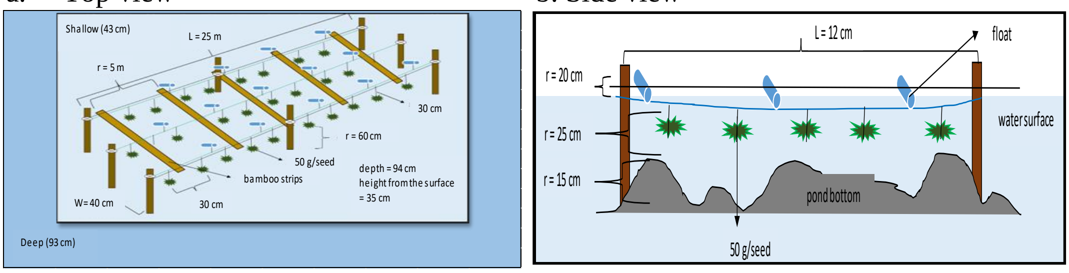

Figure 2. Longline visible intervention scheme of top view (a) and side view (b).

The number of ropes on the construction of longline deep and the plots were the same, namely 1100 m (rope and main rope), 134 m (raffia rope for buoys), seedling ropes (1000 m). 200 pieces of floating bamboo and 118 fruit bottles as buoys, as well as 150 pieces (wooden stakes) with an initial weight of 50 g/bundle were 30 cm/point, 40 cm distance/stakes, and 30 cm distance from the surface to the seeds. This longline method was used by hanging seaweed bonds (50 g/bundle). Observation on this method was done by sampling growth once a week by weighing the initial weight of 50 g used a digital scale (accuracy of 0.1) and a ruler to measure the length of thallus.

c) Charcoal Bag Application

The intervention with the charcoal bag application aims to produce good quality seaweed with a clean and long thallus. This intervention was divided into three treatments, namely PNK (Non-Pouch Treatment), PK (Treatment with Pouches) and PKA (Treatment of Charcoal Bag). The planting method used was by the longline in deep and the yard by hanging seaweed on the rope. Samples were taken randomly by weighing the initial weight of 144 g /bunch (Figure 3).

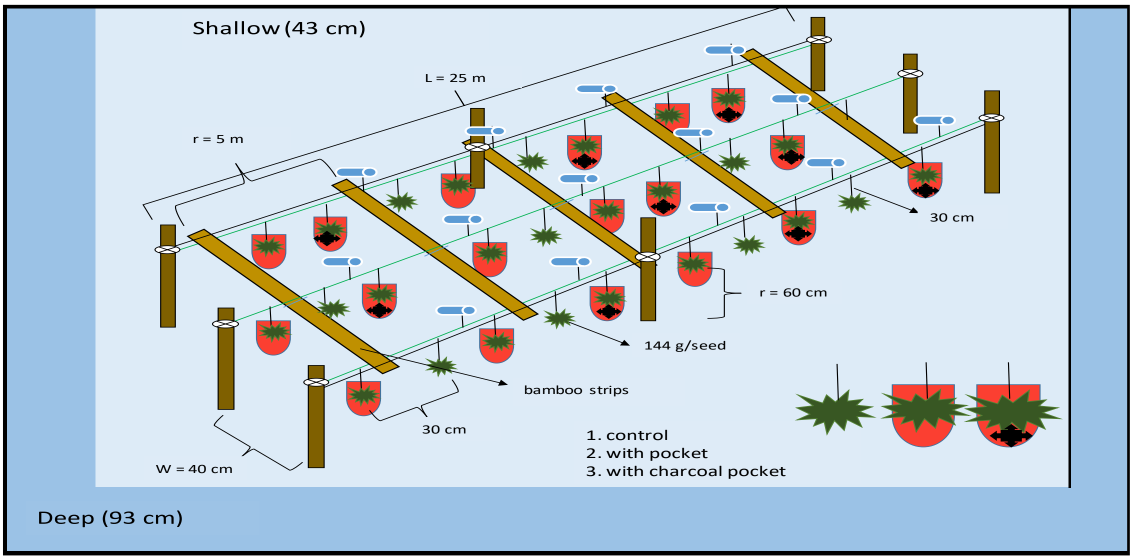

Figure 3. Intervention scheme of charcoal bag applications.

2.1. *Data Processing Methods*

a) Technical

Growth analysis on each intervention observed included specific growth rates, productivity and water quality. Specific growth rates can be carried out using equations (Surono et al., 2009).

$$G = \{(Wt / Wo)^{1/t} - 1\} \times 100\%$$

Note:

G = daily growth rate (%/day)
Wo = initial average weight (g)
Wt = final average weight (g)
T = age of plants

2.2. *Problems Identification*

Identifying the problem in the study in the Kaizen approach served to find out the root causes of the company in order to find a solution to the improvement with the 4M parameter (Man, Method, Material, Machine). How to identify the problem using the question "why and why".

2.3. *Problem Formulation and Intervention*

Problem interventions are obtained if the root cause of the problem is identified from the results of identifying secondary and primary data which are then identified and mapped based on their level. Priority interventions take precedence to be implemented as soon as possible.

2.4. Data Analysis Method

Data processing methods begin by processing data through sorting and tabulation. Furthermore, the analytical activities used are descriptive analysis methods (exposure to research activities) and quantitative (technical and financial caculations). The data taken is one year of production data. Furthermore, problem identification was analyzed using a fish bone analysis diagram to find the root of the existing problems. Growth (specific weight and length growth) is caLDulated using a formula from the specific growth rate by applying several interventions/improvements.

3. Result

3.1. Problem Identification

Based on the data that has been observed, there were several factors that a problem in this seaweed cultivation activity. The first was in the post-harvest handling process that did not pay attention and synchronize the harvest time and age of seaweed. secondly, the method of planting that did not produce good quality seaweed and less caring workers. Following these various analyzes of fish bones that show the root causes (Figure 4).

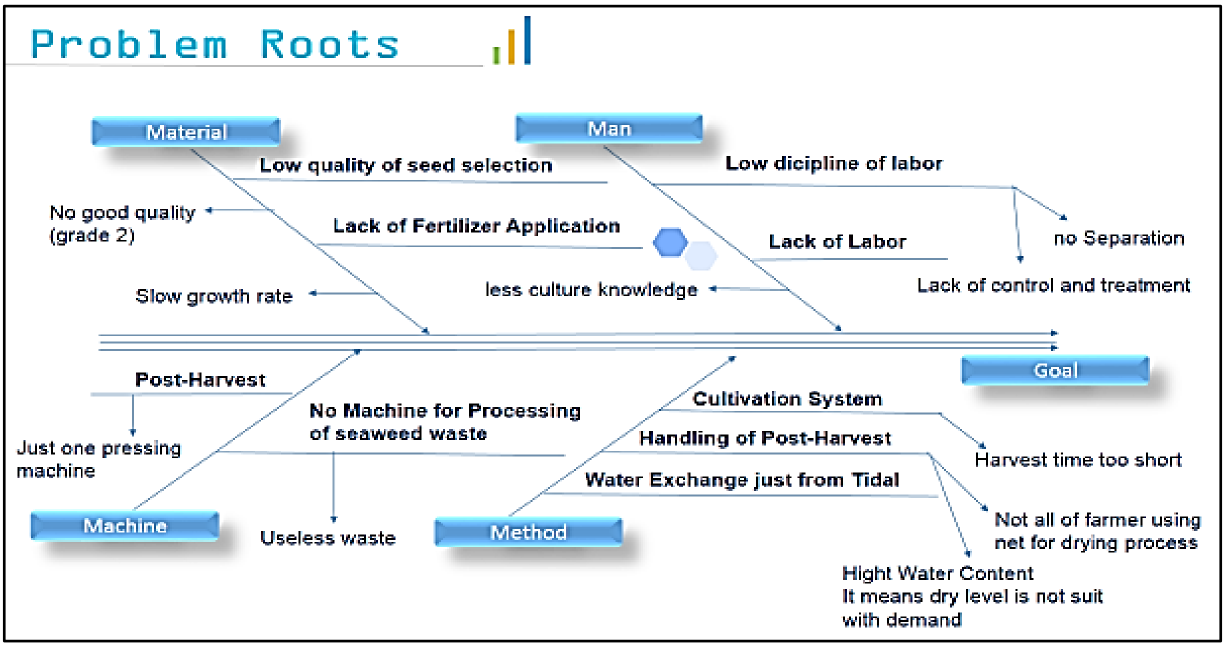

Figure 4. Fish bone analysis.

The man and method elements were the main factors inhibited the production of seaweed cultivation. The process of post-harvest handling (method) was a problem that did not yet achieved the company's standard drought level. In addition, the cultivation system seen at harvest time also did not in accordance with the harvest age standards, as a result the quality of the harvest will be bad.

The method element in the diagram above was used as material for interventions/improvements use longline, grouping and charcoal bags. This because the planting method was the most important factor that affects the quality and growth rate of seaweed. In accordance with the opinion of Soegiarto et al. [11], that in order to achieve production results the maximum was seen in the selection of cultivation techniques or planting methods to be applied.

3.2. Intervention Result

The growth rate on seaweed (weight and length) shows the results that all interventions applied as improvements provide results that quite influential on both the yield and productivity. Parenrengi et al. (2011) say that seaweed growth can to be good if the daily growth rate is not <3%.

3.3. Growth

a) Grouping Method

Seaweed growth in grouping intervention with this basic stocking method was indicated by the final weight of the harvest produced. This intervention was carried out by carrying out seaweed treatments, namely by thinning and cleaning moss pests. Thinning activities were important for seaweed, because seaweed gets enough space to get nutrients from the waters in carrying out their development and growth. This will be related to the production and quality of seaweed produced.

b) Longline Method (deep and shallow)

The average daily growth rate (weight and length) of the highest LD (longline deep) at week 4 was 3.83% (5.6 g / day) and 2.25% (0.54 cm / day). The results of the LS method (longline shallow) were the highest on the 5th (heavy) and 3rd (long) weeks, ie 2.78% (3.71 g / day) and 2.57% (0.66 cm)./day). these results can be seen in Figure 5.

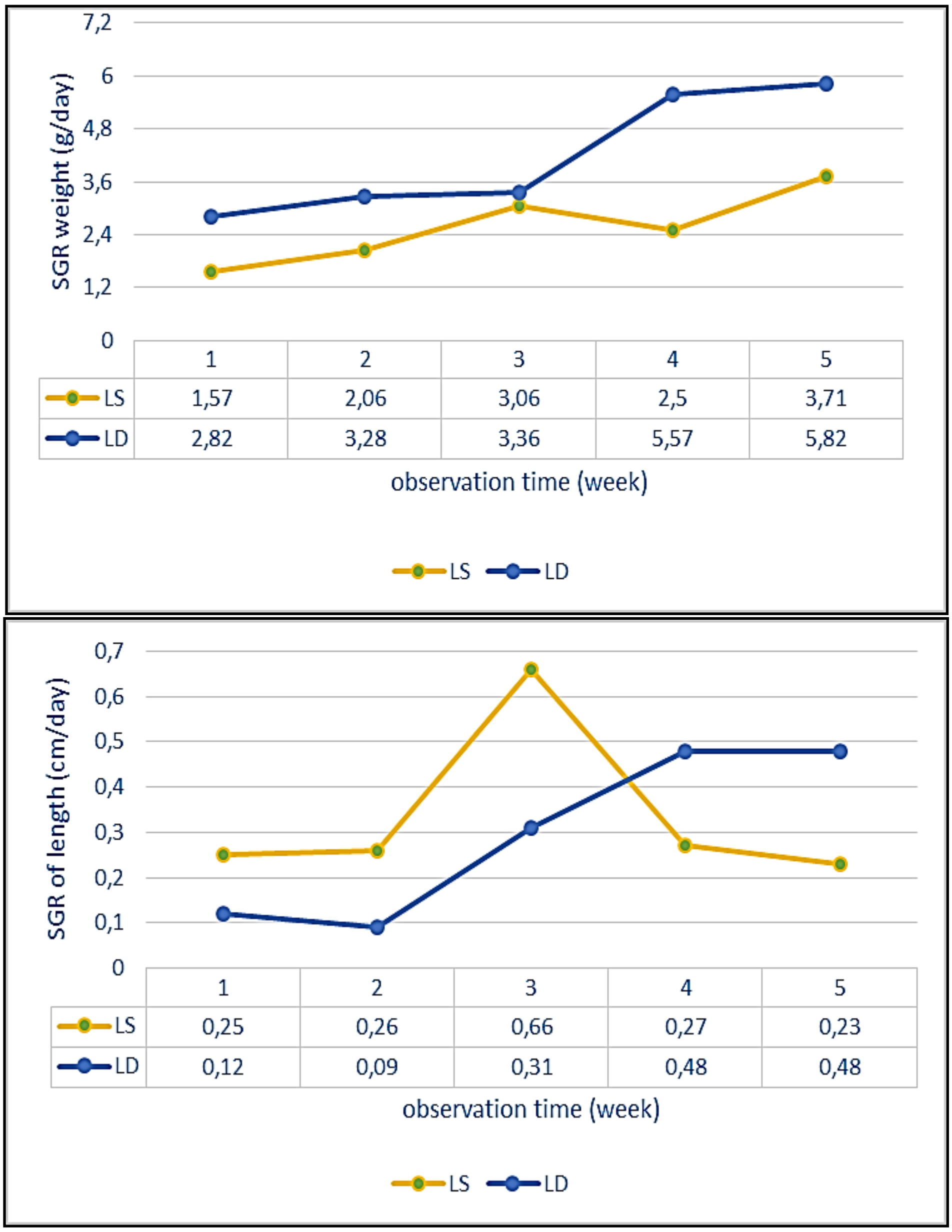

Figure 5. Growth per day (weight and length) in the longline deep (LD) method and shallow (LS).

Based on the data above, it can be seen that the longline method used gives more influence on the increase in length and weight of seaweed both in deep and the yard in the last 3 weeks.

Growth rates that considered to be profitable are above 3% [12], with growth control that can be done using a square net to decide the right harvest time [13, 14], or even by re-aligning the location of seaweed so that growth remains good [15]. More seedlings and a greater distance will affect the growth of seaweed [16], and it will be better if the waters are not murky because it will interfere with photosynthesis.

c) Application of Charcoal Bags (deep and shallow)

The average growth rate in deep with the Non-Pockets Treatment (PNK) showed higher results after Pockets Treatment (PK) ie 416.46 g (PNK) and 304.23 g (PK) (Fig 5). The highest growth results in deep with PNK treatment were 44 cm/week and weighed 437 g/week.

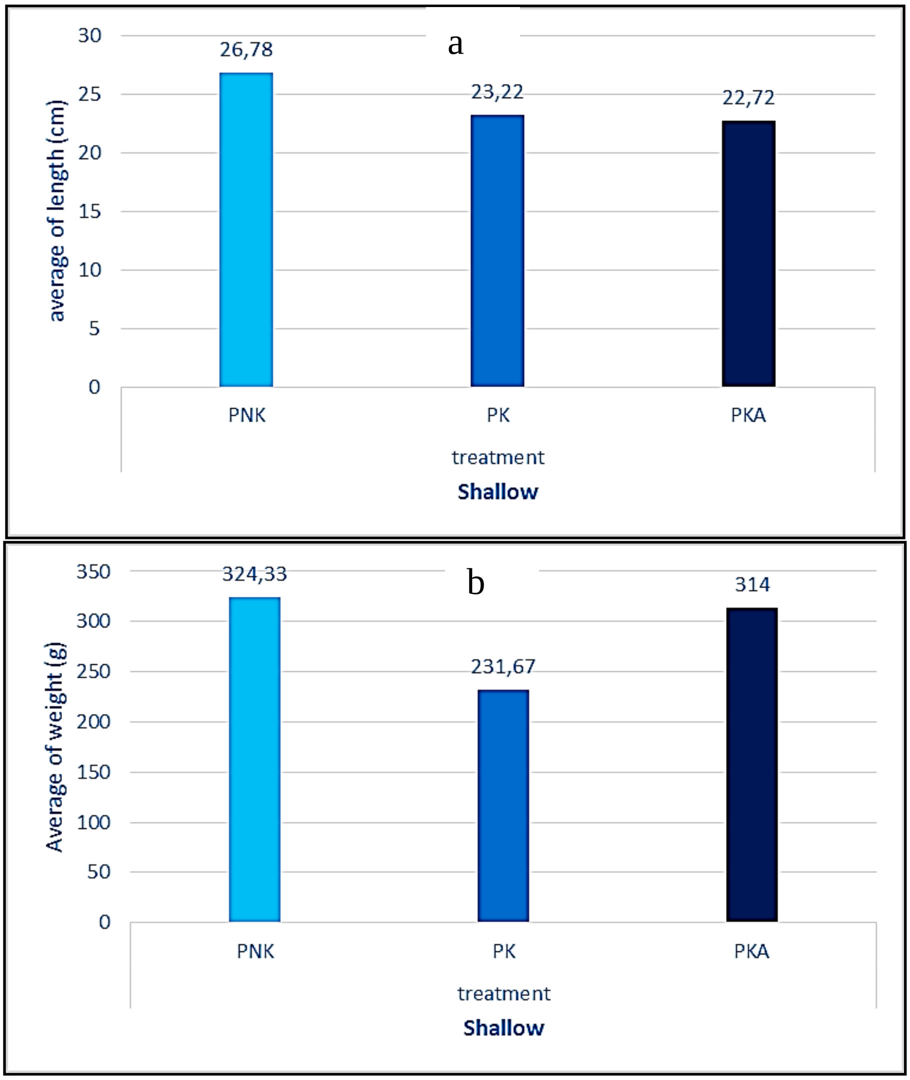

Figure 6. Comparison of growth in average weight (a), and average length (b) of bag application namely PNK (Non-Bagging Treatment), PK (Treatment with Bag), PKA (Treatment of Charcoal Bag) in shallow.

The data also shows that there were differences in results with the basic methods commonly applied by farmers (Figure 6), where longline results give a lot of influence on the rate of grass growth. This happened because during that week, the rainfall was low enough to accelerate its growth and result in high salinity.

According to Mubarok et al. [17], seaweed can be abundant in waters with high salinity. The incoming sunlight is also a factor that affects the growth of seaweed. Growth will increase if the light intensity enters higher according to the standard optimum value (0.5 cm deep). Strengthened by the opinion of Niniek Widyorini, the growth of Gracilaria sp will be better if the waters are not cloudy because turbidity will cover the plants so that the photosynthesis process is disrupted. The planting method also affects growth to get enough space and get nutrients.

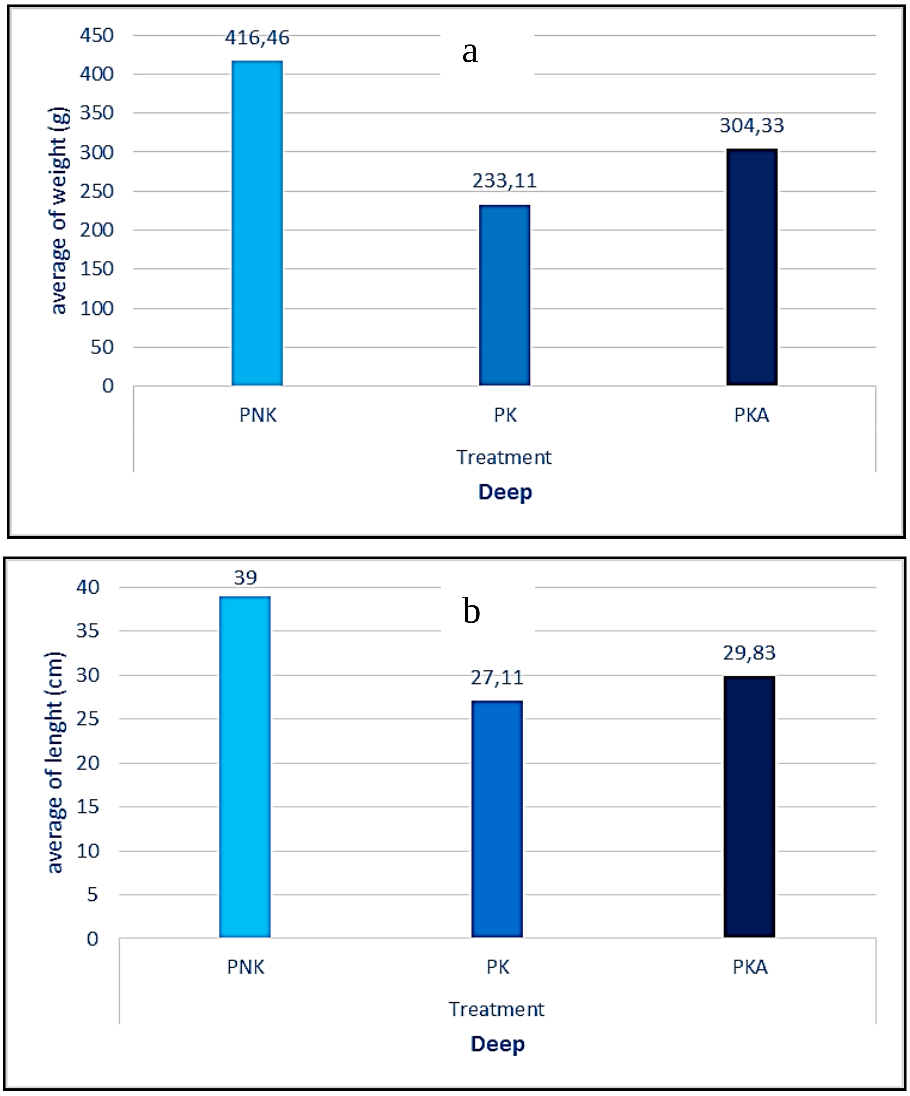

Figure 7. Comparison of growth in average weight (a), and average length (b) of bag application namely PNK (Non-Bagging Treatment), PK (Treatment with Bag), PKA (Treatment of Charcoal Bag) in deep.

The highest growth results in the shallow with PNK treatment, namely 29 cm/week (length) and 374 g/week (weight). The lowest results in PNK in deep were 24 cm/week (length) and 251 g/week (weight).

Based on the results diagram (Figure. 7), this shows that the more that does not the charcoal treatment used, is the better for growth. Seen in deep and shallow with PNK and PKA treatment (without bags, charcoal bags) have results that are not much different and are an effective method for giving effect to weight gain of seaweed compared to PK treatment (with bags). This is because carbon-containing charcoal has an important role in photosynthesis for absorption of nutrients, so it will affect the growth of seaweed. According to Packer's opinion, seaweed has properties as carbon sinks and is used for photosynthesis which will be converted into biomass [18].

PNK treatment (without pockets) showed more significant results than other treatments. This is because the treatment of PNK provides more space for the growth of seaweed to get a lot of nutrients. In the PK treatment (with Pockets) the results were not too influential, because it was suspected that this could prevent the entry of nutrients in seaweed and not have enough space so that the growth of seaweed is hampered. According to Byrne, increasing CO2 concentration will lead to an increase in the rate of photosynthesis in plants including seaweed [19].

3.4. Productivity

a) Produced Production

- Maitenance : 45 days (1 cycle)
- Wet Weight**:**
  - Deep = 85 kg/25 m = 1,020 kg (assumption 1 Ha)
  - Shallow = 46 kg/25 m = 552 kg (assumtion 1 Ha)
  - Control =71.6 kg/13.8 kg (plain) =859 kg (assumtion)
  - Grouping = 5,700 kg (5 Ha) = 28,500 kg/year = 1,140 kg (1 Ha) = 5.700 kg/year
- Dry Weight (1:8):
  - Deep = 10 kg/25 m = 120 kg (assumption 1 Ha) = 71.586 kg/year(total)
  - Shallow = 6 kg/25 m = 72 kg (assumption 1 Ha) = 71.298 kg/year (total)
  - Control = 8 kg/13.8 kg wet = 96 kg (assumption) = 71.422 kg/year (total)
  - Grouping = 713 kg (5 Ha) = 2,852 kg/year = 162 kg/plot = 810 kg/year

Seen from the production data, it is said that the longline in deep and grouping method gives the highest yield compared to the others for a period of 1 year with assumptions per hectare. This's because the intervention designed was said to be successful in improving production on seaweed both in cultivation techniques and management.

Based on the results of wet and dry weight from the grouping method also gives significantly different results, namely the results of shrinking dry weight. This is because at that time there was an attack of moss which disrupted growth, so that it would affect the yield of the weight of the harvest.

b) Cost Impact

i. *Longline* (deep and shallow) with control

Total of pond area : 6 Ha minus 1 Ha (for field)
Intervention of longline : 1 Ha
Broadcast Method : 4 Ha = IDR 131,464,400 (seaweed &milkfish/year)
Maintenance : 45 days (1 cycle)
Price : IDR 5,000/kg

Based on the table below, it can be seen that the most influential price advantage is intervention in longline deep (LD) of 7.7% or IDR 12,451,200 with the total operational costs equal to shallow (LS), which is IDR 121,451,200.

Tabel 1. Cost impact comparison of *Longline* Deep (LD), Shallow (LS) and Broadcast Method (LB).

No	Indicators	Cost Impact (IDR)		
		LD	LS	LB
1	Total	122.713.000	122.713.000	122.160.400
2	Income	2.400.000	1.144.000	1.920.000
3	Profit (5 Ha)	12.451.200	11.195.200	10.671.400

These results, indirectly explain that the intervention used is quite beneficial for the company.

ii. Grouping Method

Total of pond area : 5 Ha (seaweed farm)
Intervention of grouping : 1 Ha/plot
Maintenance : 45 days (1 cycle)
Price : IDR 5,000/kg

Tabel 2. Cos impact comparison of Non Grouping (NG) and Grouping Method (GM).

No	Indiators	Cost Impact (IDR)	
		NG	GM
1	Total	2.903.767	2.903.767
2	Income	3.240.000	3.240.000
3	Profit (5 Ha/year)	1.681.165	4.400.665

The final results of the harvest in comparison of interventions with non grouping can be said that using intervention grouping has a considerable influence on productivity, which is about 17% compared to without intervention. The main factors that most influence this are found in the workforce such as the number of workers and understanding and concern for the care of seaweed itself.

3.5. Water Quality Monitoring

The parameters of salinity, pH, dissolved oxygen, temperature, nitrate and water level contributed greatly to the growth rate and seaweed production [20]. Monitoring water quality during the study, carried out once in three days in deep and shallow. The first month there is application of fertilizer, namely NPK with a dose of ± 2 kg.

a. pH

The deep and shallow pH values during the study ranged from 6-7. This value is quite supportive in seaweed farming. Prabowo and Farchan suggested that pH value which is good for seaweed ranged from 6.8 to 8.2 [13]. Water pH can increase during the day and decrease at night because of the large amount of CO2 needed and CO2 from respiration to be taken by phytoplankton and aquatic plants for photosynthesis.

b. Salinity

Seaweed growth is greatly influenced by salinity and incoming light. Salinity obtained during the study ranged from 7-28 g / l. The highest results were shown at 7th week (deep and shallow), 28-29 g/l. While the lowest results are shown in weeks 1-3 (deep and shallow) which is 7 g/l. The results of the observations can be seen in the following picture.

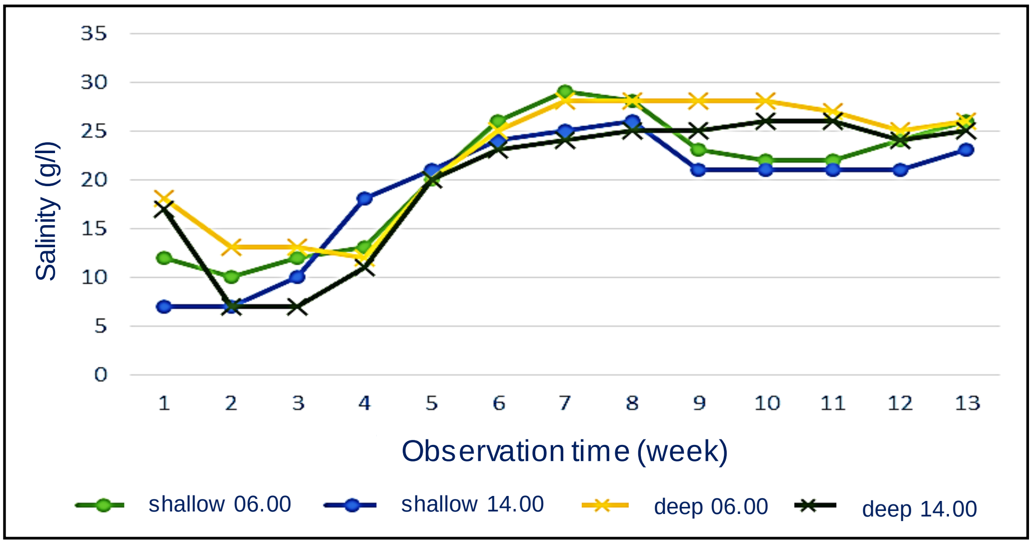

Figure 8. Observation result of deep and shallow.

Based on the graph above, the highest yield is affected due to low rainfall. Yong et al., suggests that salinity is too low (5‰) or too high (45‰) to give a very low growth rate of 1.30% and 0.05% [21]. Different from the opinion of Ihsan et al. [22], that Gracilaria sp. is seaweed that can survive in the narrow range of salinity (stenohaline). This is corroborated by the opinion of Amalia [23], that good salinity for the growth of seaweed between 15-30 g/l where the optimal salinity is 15-23 g/l [13], 15-30 g / l for salinity [24]. So the results of increased salinity in the study this can still be tolerated and can support the growth rate of seaweed.

c. Temperature

The water temperature obtained during the study ranged from 28-34 ºC. The lowest temperature in shallow is 27 ºC and the highest in deep is 34 ºC. (Figure 9.)

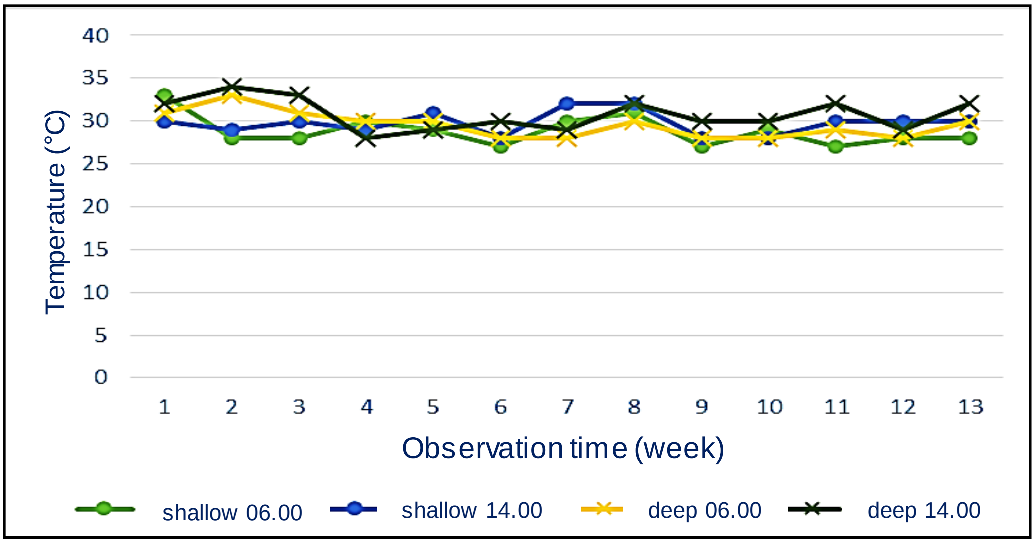

Figure 9. Observation result of temperature in deep and shallow.

Based on the diagram above, the highest temperature reaches 34ºC in deep, because at that time the waters are experiencing receding. According to SNI CBIB [25] and Kordi [26], that water temperature is suitable for seaweed *Gacialaria* sp. between 26-32 ºC. Supriyaningum, said that high temperatures are due to the general nature of waters caused by the presence of water from the land. Water temperatures range from 20-28℃ [27] or 26-32℃ [28]. Although it's found in the range of 34 ºC but is still tolerated and still supports the growth of seaweed.

d. Water Level

The diagram below shows that the water level during this study ranged from 33-54 cm in shallow and 60-103 cm in deep. The highest results are shown in deep at week 5 which is 103 cm.

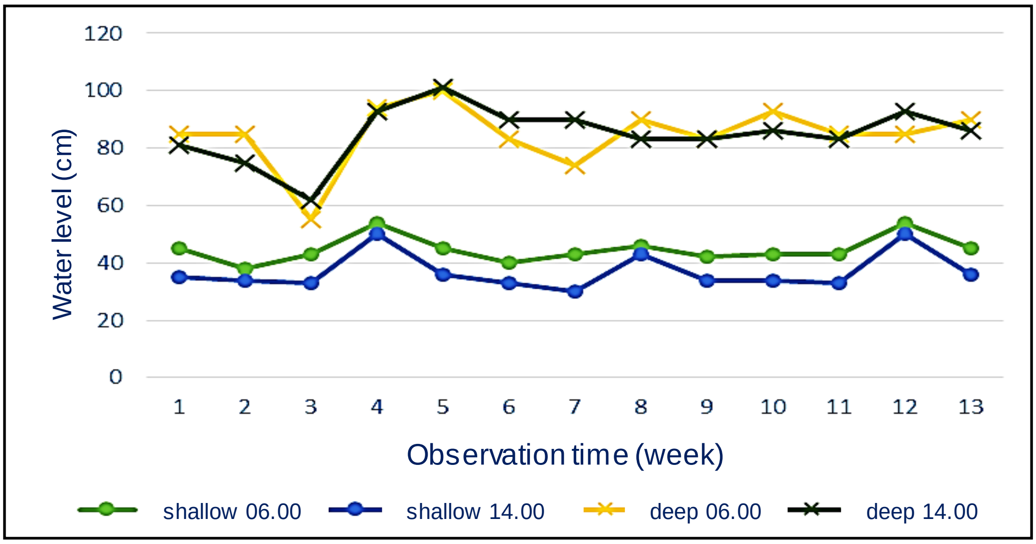

Figure 10. Observation result of water level in deep and shallow.

Growth of *Gracilaria* sp. can be better if the water is not turbid because turbidity will cover the plant so that the profession of photosynthesis is disturbed. As it is known that the penetration of sunlight into turbid water will decrease very quickly compared to clear water. This will affect the production of *Gracilaria* sp. to be reduced in murky waters due to photosynthetic disturbances. Therefore, in the statement of Mubarak [29], the depth that suitable for the cultivation of *Gracilaria* sp. was 0.5 m.

e. Nitrate (NO_3^-)

Nitrate concentration during the study tends to be stable both deep and shallow, which is 0.5 mg /l. According to Effendi [30], suggesting that nitrate-nitrogen levels> 0.2 mg/l will result in eutrophication (enrichment) which then stimulates the growth of *Gracilaria* sp. rapidly. in accordance with the opinion of Effendi [30];[31] that nitrate levels in natural waters are almost never more than 0.1 mg / l, or in the range of 0.06-0 [32].

f. DO (*Dissolved Oxygen*)

The main source of oxygen in a movement from a process of diffusion of free air and photosynthesis results that live in these waters [33]. The Dissolved Oxygen content (DO) in deep and shallow ranges from 5-11 mg/l (Figure 11). Seen in the deep and shallow on March 10, 2018 (at 14.00 WIB) is the highest oxygen content of 11 mg/l. This because the condition of the waters in the ponds experiences a tide of water. According to Aslan [34], the optimum limit for dissolved oxygen is> 4 mg/l and an increase in O_2 consumption due to accumulation of organic matter.

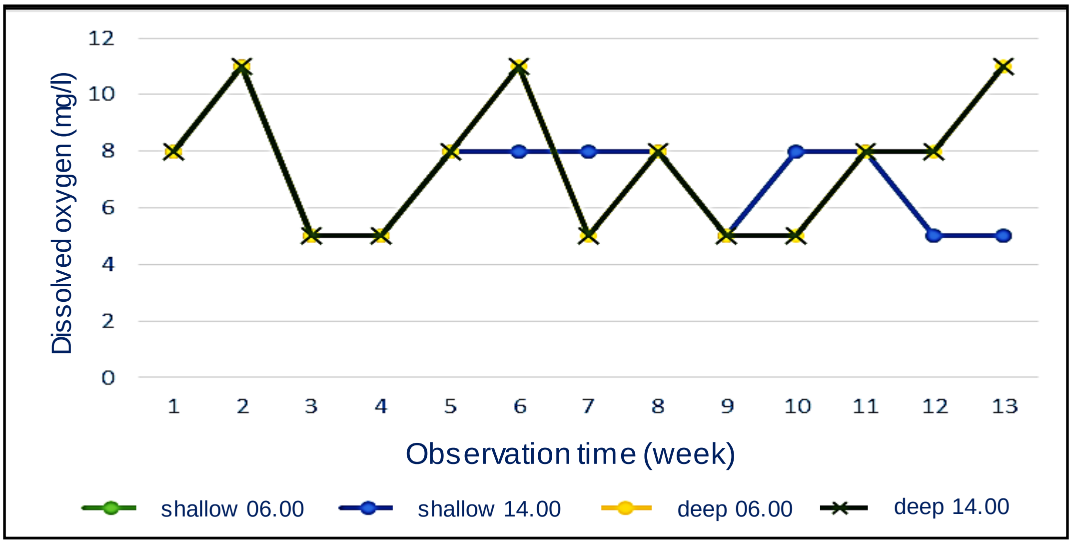

Figure 11. Observation resul of Dissolved Oxygen (DO) in deep and shallow.

4. Conclusions

Metabolites In the efforts to improve the quality, quantity and produce seaweed (*Gracilaria* sp.), in this study it can be seen that:

1) The most effective method to be applied is the longline method in deep, because it has a higher profit of 7.7% or IDR 12,451,200/year and has an influence on the growth and quantity of seaweed produced which is 71,586 kg/year (weight dry) in 1 hectare.
2) Whereas for results on better quality seaweed that is by using grouping methods that provide an increase in yield of 17% from before.

4.1. Suggestion

Suggestions that can be given by the author on the study with this kaizen approach are the interventions that has been done, it must be developed again in order to be better and the simpler the method so that it is easy to implement by the community/farmers in Tambakasari Village. In addition, knowledge of how to cultivate well must also be socialized so that workers can also prepare to carry out maintenance and control and care more about seaweed

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