Improvement of Growth and Mass of Kappaphycus Striatum *var*. Sacol by Using Plant Density Study at Selakan Island in Semporna Malaysia

M.K. M Ali, J.V.H. Wong, J. Sulaiman, J. L. Juli, and S. Md. Yasir

***Abstract*—** The growth experiment of seaweed using cage system was conducted in Semporna, Sabah under the metrological condition in Malaysia. The experiment was conduct from September until May 2013. Seaweeds were cultivated on floating cage near of mussel farms. Salinity ranged from 29 to 36 psu and temperature from 28.5 to 32.5°C. Present study of the seaweed *Kappaphycus Striatum var. Sacol* aims to determine the growth rate of five different densities cultured in a cage of 9 meter^2. There were 4 kg cage^{-1}, 20kg cage^{-1}, 40 kg cage^{-1}, 60 kg cage^{-1}, and 80 kg cage^{-1}. The densities had been distributed into a cage by using 3 meter length line containing 20 points for seedling attachment. The 4 kg cage^{-1} contains 1 line in a cage, 20 kg cage^{-1} contain 5 lines in a cage, 40 kg cage^{-1} contain 10 lines in a cage, 60 kg cage^{-1} contain 15 lines in a cage, and 80 kg cage^{-1} contain 20 lines in a cage. Growth rate are varied between five different densities studied. The density of 40 kg cage^{-1}(percentage daily growth rate, 1.39±0.31) were identified as effective density. Higher growth rates (2.8-3.5% day^{-1}) were measured in day 35, showing a positive correlation between growth rate and water temperature. Line 5 could be practice on commercial cultivation of *Kappaphycus Striatum var. Sacol* in a cage.

***Keywords*—**Cage Culture; Daily Growth Rate; Density; *Kappaphycus Striatum*.

I. Introduction

SEAWEED becomes one of important agricultural crop in Malaysia that really concern by the government. It is proven by the government allocation RM 58.87M for year of 2011 and 2012 and more money being invested in this year to boost more this sector [16]. Moreover, there is a lot of strategies and incentives be taken under Third Economic Transformation Programme (3ETP). Such us strategies are Algae Farming via Mini Estate System in Sabah [18], Seaweed Identification Grant, Seaweed Cultivation Grant and Grant from National Key Economic Area (NKEA).

The demand of carrageenan is increasing worldwide but there is insufficient supply of dried seaweeds in the market. (Ask and Azanza, 2002; Pickering *et al*. 2007; Castelar *et al*. 2009; Bixler and Porse, 2011).). Rhodophyta divisions contain the largest amount of amorphous embedding matrix polysaccharides as in fig. 1, whereas fig. 2 shows the Morphology *Kappaphycus Striatum* variaty *Sacol*. This characteristic, combined with their well known ability to bind metals, makes them potentially excellent heavy metal biosorbents (Majid et al; 2013).

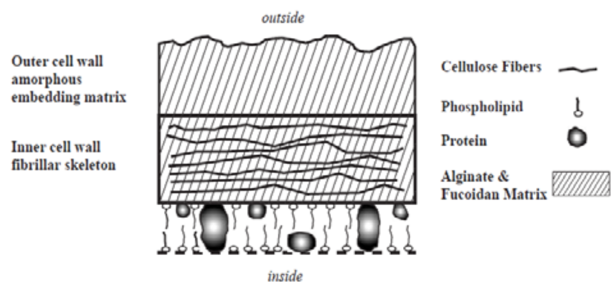

Fig. 1 Cell wall structure in the red algae (Volesky, 2003)

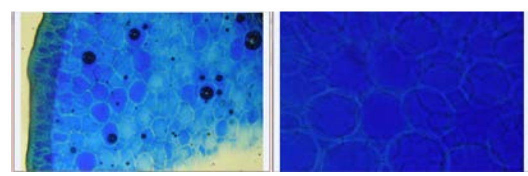

Fig. 2 Morphology *Kappaphycus Striatum* variety *Sacol* (Majid khan et al., 2013)

The production of *Kappaphycus (cottoni)* in Malaysia, mostly at Sabah contributes to only 2.5% (4,000 tonnes dry weight) in total world production of *Kappaphycus (cottoni)* at 2006 (Hurtado, 2007). The cultivation of *Kappaphycus Striatum* variety *Sacol* by fixed long line and fixed bottom line which had been long practiced by the local people at Sabah is exposed to predators such as turtles and fishes. The attack from the predators could greatly decrease the production of the seaweeds. In order to reduce the risk of that matter, the cage culture had been introduced for cultivating the *Kappaphycus Striatum* variety *Sacol* at Semporna, Sabah. The use of cage had been practiced by other researchers and proven as significantly effective as long line or bottom line (Hurtado-Ponce, 1992; Dawes *et al*. 1994; Gerung and Ohno, 1997; Paula *et al*. 2002; Bulboa and Paula, 2005; Msuya and Kyewalyanga, 2006; Hayashi *et al*. 2007).

The present study was carried out to investigate the optimum density of seedlings could be cultured at a cage of 9 meter^2 and stocking density of 100 gram per seedling. Besides,

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the present study also conducted in order to adapt the cage culture technique to suit the local condition besides calculate the net production and productivity from the cultivation technique in Selakan Island at Semporna, Sabah.

II. Materials And Methods

On this study, each of the 5 densities 4 kg cage^{-1}, 20 kg cage^{-1}, 40 kg cage^{-1}, 60 kg cage^{-1}, and 80 kg cage^{-1} had been investigated at similar type of cages. Every density had been replicated with 4 replicates and using approximately 100 gram of stocking density. For density 4 kg cage^{-1}, the weight had been distributed to 20 points at single line of 3 meter long. Each of the point was attached with 2 stocking density of 100 gram. For density 20 kg cage^{-1}, the weight was equally distributed to 100 points at 5 lines of 3 meter long. Each of the point was attached with 2 stocking density of 100 gram. For density 40 kg cage^{-1}, the weight was equally distributed to 200 points at 10 lines of 3 meter long. Each of the point was attached with 2 stocking density of 100 gram. Whereas, the density 60 kg cage^{-1} was equally distributed to 300 points at 15 lines of 3 meter long. Each of the point was attached with 2 stocking density of 100 gram. Finally, the 80 kg cage^{-1} density was equally distributed to 400 points at 20 lines of 3 meter long. Each of the point was attached with 2 stocking density of 100 gram.

A. Cage preparation

The cage was made from 4 PVC pipes which had been attached with each other and form square shape of 9 meter^2. This cage was a modified version from previous researchers (Thirumaran and Anantharaman, 2009; Lombardi *et al*. 2006; Hurtado-Ponce, 1992, 1994, 1995; Hayashi *et al*. 2007).

Four PVC pipes of 4 inches diameter and 3 meter length would be arranged into square shape and each of the corners were connected with pipe elbow. The connection between the pipe and elbow was tightened with pipe's glue then rubbed with silicon to prevent the water from flowing into the pipe.

Fig. 3 Example PVC Diagram of 10 lines density

The net was installed under the main frame of PVC pipe by using the ropes. 4 anchors of iron rod about 1 ft in length were installed at the bottom of the cage to prevent the net from floating at the surface of the seawater.

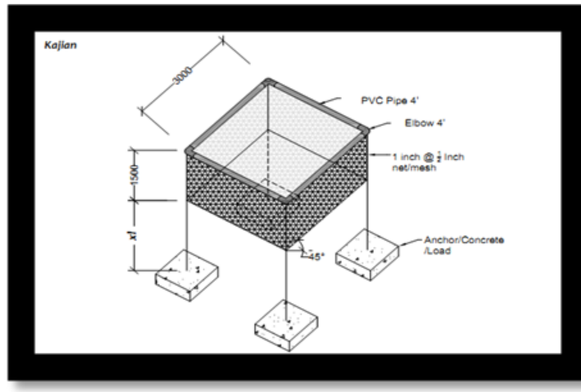


Fig. 4 PVC Schematic Diagram Using AUTOCAD

B. Preparation of seedling at the line

Young thalli of *K. Striatum var. Sacol* which was about 30 days old were bought from the local villagers at Semporna, Sabah. The selected fresh thalli were weighed approximately 100 grams for each seedling.

The line used on this study was PE line which had been cut into about 11 feet to 12 feet length. Each of the line then was made 20 points with similar distance of 6 inches from one point to another point. At a point, 2 tiny ropes were attached for seedlings tie up purpose and each point was tied with 2 seedlings which were called 'double seedling'. Distance between the binding point of the seedling and the main line was approximately 2 inches. So, there would be 40 seedlings of 100 gram which was equal to 4 kg of seedling per line. Buoy had been attached at the middle of each line.

C. The density study

The study was conducted for 60 days from 20 Sep 2013 and finished on 15 November 2013. There were 5 types of densities had been studied which were 4 kg cage^{-1}, 20 kg cage^{-1}, 40 kg cage^{-1}, 60 kg cage^{-1}, and 80 kg cage^{-1}. Four kg cage^{-1} consists of 1 seedling filled - line, 20 kg cage^{-1} consist of 5 seedling filled - lines, 40 kg cage^{-1} consist of 10 seedling filled - lines, 60 kg cage^{-1} consist of 15 seedling filled - lines, and 80 kg cage^{-1} consist of 20 seedling filled - lines. 1 line study (4 kg cage^{-1}) acted as a control.

Each of the density study will be replicated into 4 cages replicate. Data had been collected every 5 days by weighing the 100 gram seedling at each of the cage density until 60th day.

D. The density Formulae

a. Daily growth rate (DGR %) was calculated according to [Dawes et al. (1993)]

$$\mathrm{DGR}(\%\,\mathrm{day}^{-1}) = \left(\left(\frac{W_t}{W_0}\right)^{1/n} - 1\right) \mathrm{x}\,100\%$$

Where:

W_t = weight at time t (g)

W_0 = initial weight (g)

n = number of days

b. Growth rates were calculated according to [10][11][12] described before, and net production (NP) was estimated as

$$\text{Net Production(NP) (kgm}^{-2}\text{)} = \left(\frac{W_f - W_i}{A} \right)$$

Where:

W_f = weight at harvesting time t (kg)

W_0 = initial weight (kg)

A = surface area of cultivation (m^2)

c. Productivity were calculated according to [12] was estimated as

$$\text{Productivity (gdwtm}^{-2}\text{day}^{-1}\text{\%)} = \frac{\left[\dfrac{\mathrm{N_t} - N_0}{t * \left(\dfrac{dwt}{fwt} \right)} \right]}{A} \text{ x } 100\%$$

Where:

$\mathrm{N_t}$ = Final mean weight (g)

N_0 = intial mean weight (g)

A = surface area of cultivation (m^2)

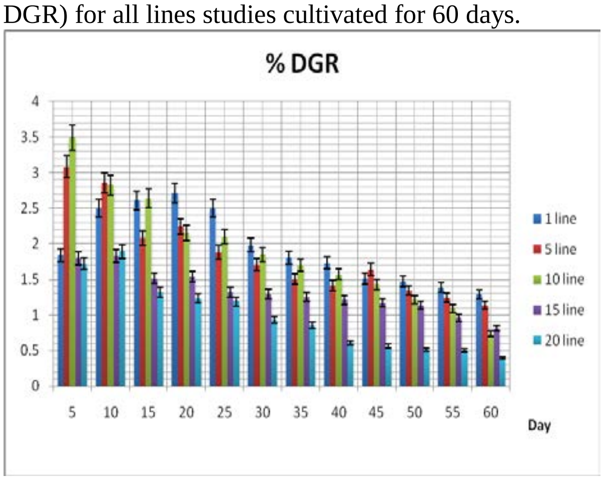
t = time in days

dwt = dry weight (g)

fwt = fresh weight (g)

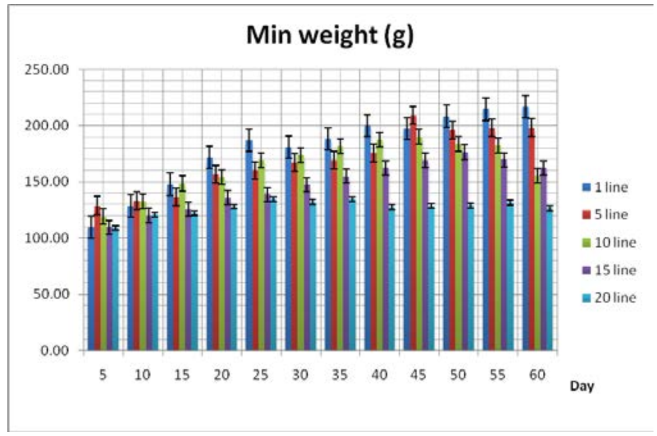
III. Result And Discussion

1. Graph 3.1 shows the percentage daily growth rate (% DGR) for all lines studies cultivated for 60 days.



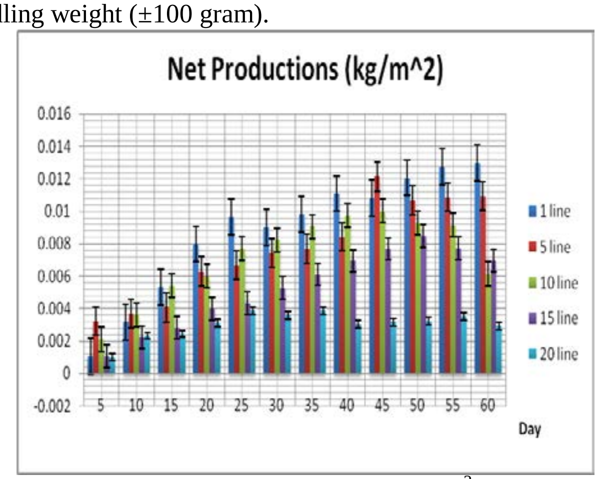
Graph 3.1: percentage daily growth rate (% DGR)

2. Graph 3.2 shows the min weight (g) for all line studies cultivated for 60 days. Day 1 was the initial seedling weight (±100 gram).



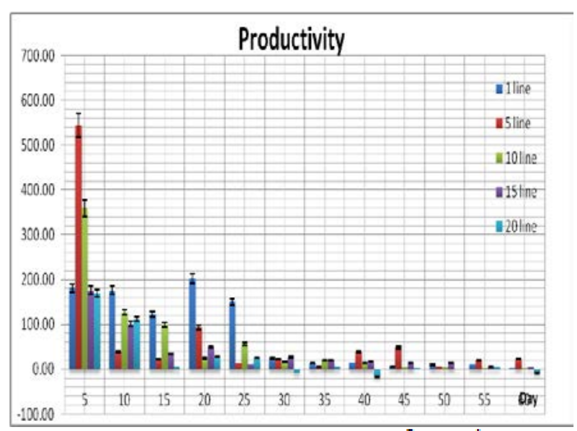
Graph 3.2: the min weight (g)

3. Graph 3.3 shows the net productions (kg/m2) for all line studies cultivated for 60 days. Day 1 was the initial seedling weight (±100 gram).



Graph 3.3: Net productions (kg/m^2)

4. Graph 3.4 shows the productivity ($\text{gdwtm}^{-2}\text{day}^{-1}\%$) for all line studies cultivated for 60 days. Day 1 was the initial seedling weight (±100 gram).



Graph 3.4: productivity ($\text{gdwt m}^{-2}\text{day}^{-1}\%$)

In the study conducted within 60 days at Pulau Selakan, Semporna generally all the 5 lines of density study had shown their increase in weight from their initial seedling weight which is ±100 gram.

On this study, we were investigating the effect of different density of seedling cultivated in a cage to the development of their growth and mass so that we can optimize the production of seaweed in a single cage for commercial purpose. The densities that we had investigated were 4kg cage^{-1}, 20kg cage^{-1}, 40kg cage^{-1}, 60kg cage^{-1}, and 80kg cage^{-1} in a single cage respectively.

In order to know which density was the best among the 5 densities, we had recorded their fresh weight at every 5 days consecutively until 60th day. The average weight (min) and percentage daily growth rate (%DGR) then were calculated based on their every 5 days weight.

The initial fresh weights for the entire 5 densities are±100 gram and the final fresh weight is the average weight for the seedling at every 5 days. We had plotted graph of percentage daily growth rate as in Graph 3.1.

Through the result shown at Graph 3.1, we can see that for the 5th day data collection all of the density studies show significantly large difference in their percentage growth rate among them. The ranges of the data are from 1.72% to 3.45% and the difference is about 1.73%. This result shows that all of the 5 line studies perform their growth in different rate for the first 5 days.

For the next 10 days data collection, we could see significance difference between the higher and the lower percentage growth rate with 15 line study recorded the highest growth rate (1.83%) and 15 line study recorded the lowest growth rate (2.86%).

Based on the Graph 3.1 also, we can see that 5th day data collection was the highest % DGR among the other days of data collection for all line studies. After 5th day the trend slowly dropped until their 60th day of data collection. Through the graph also we can see that the lowest growth rate for each of the lines study were on the 60th day.

On the Graph of 3.2, the increasing trend of fresh weight could be seen on all the densities study until 55th day. On the 60th day of cultivation, each of the density study had decreased significantly in their fresh weight from their previous 55th day of cultivation especially the 4 kg cage^{-1}, 20 kg cage^{-1}, 40 kg cage^{-1}, 60 kg cage^{-1}, and 80 kg cage^{-1}.

This study had been conducted by the end of Sep 2013 and end by the mid of Nov 2013. In terms of growth rate, there is a similarity with the study of the Hurtado *et al.* (2000) on their study on the seasonality and economic feasibility of cultivating *K. Striatum var. Sacol* in Panagatan Cays, Caluya, and Antique, Philippines also reported that the period of Sep and Nov were the highest growth rate of *K. Striatum var. Sacol* which are up 3.5% DGR.

The *ice-ice* disease phenomenon also contributed to low growth rate on *K. Striatum var. Sacol*. The disease which is characterized by whitening and softening of the infected part (Doty and Alvarez, 1975; Trono 1993) could leads to fragmentation and eventual loss of biomass. The occurrence of the disease had been linked to adverse effects of ecological conditions (Trono, 1993; Uyenco *et al*. 1981) and the presence of pathogenic bacteria on ice-ice branches (Largo *et al*. 1995, 1999).

Figure 5 and 6 show the incidence of *ice-ice* disease in cultivation of *K. Striatum var. Sacol*. In high-density cultivation such as 15 and 20 lines, there were branches softening tips whitening as a result of suffering stress of space and temperature where some of them were not completely submerged into the seawater. This result consistent with the study by Vairappan *et al*., 2008, which reported that *ice-ice* disease, can be frequently observed in high-density commercial farming.

In addition, Graph of 3.3 shows the increasing trend of Net production could be seen as highest in line 5 but still not as much as line. on the densities study until 45th day, it shows the line 5 exceed line 1 with 0.045% difference. this suggest that the line is best optimized for farming the seaweed for commercialization.

Moreover, the earlier conclusion that made of the line 5 supported by Graph of 3.4. Graph of 3.4 shows the decreasing trend of productivity could be seen as highest in line 5 but still not as much as line 20. On the densities study until 60th day, it shows the line 5 still productive compare other lines. Besides that, the line 10 also shows positive production but still below the line 5. Overall, this suggest that the line 5 is best optimized for farming the seaweed for *K. Striatum var. Sacol* and ready for commercialization using cage systems..

IV. Conclusion

In this study,the main factor that affects the growth performance of *K. Striatum var. Sacol* cultivated in a cage is grazing of the small fishes. Even though we succeed to eliminate the threat of large herbivores such as turtles, the evidence of grazing on the seaweeds were still occurred. So, further study on the cage materials and design needed so that it can meet complete requirement for *K. Striatum var. Sacol* to grow perfectly.

The period of September to November seem really suitable in growing *K. Striatum var. Sacol* in cage culture at Selakan Island but in order to get more efficient result of data, a whole year data that compromise every month in that year need to be taken. From that data, we can conclude and take action to solve the cultivation problem. The one year data also can be resembles the trend of cultivation and their growth rate.

The study conducted suggest that effective density could be applied on commercial farming *K. Striatum var. Sacol* in a cage of 9 meter^2 and stocking density ±100 gram are 40 kg cage^{-1}(line 5). The net production and productivity in line 5 also shown as the highest and this supported the idea as the best optimization.

APPENDIX

Fig. 5 Incidence of *Ice-Ice* Disease in Line 15

Fig. 6 Incidence of *Ice-Ice* Disease in Line 20

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