A preliminary study of the effect of different seedling sources on growth of seaweed *Kappaphycus alvarezii* cultivated in Konawe Selatan and Bombana Regency, Southeast (SE) Sulawesi, Indonesia

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Abstract. The purpose of this preliminary study was to determine the effect of different seedling sources on growth of *K. alvarezii*. There were three seedling sources used in this study: local strain, tissue-cultured seedlings, and seedlings resulting from mass selection combined with tissue-cultured method called “prof”. This research was conducted for 6 months in two regencies, Konawe Selatan and Bombana, SE Sulawesi, Indonesia, using the longline seaweed culture method. The results showed that the daily growth rate (DGR) during this study tended to fluctuate within each treatment, but tissue-cultured and “prof” seedlings had higher mean DGRs than local strain seedlings. In Konawe Selatan, the mean of DGR was highest in tissue-cultured seedlings (5.72 ±0.13%/day), followed by prof seedlings (5.21 ±0.26%/day) and local strain seedlings (4.58±0.23%/day). In addition, the DGRs peaked in November when the tissue-cultured seedlings had the highest DGR (6.20 ±0.35%/day) followed by prof seedlings (5.92 ±1.03%/day) and local strain seedlings (5.39±0.67%/day). In Bombana, the tissue-cultured seedlings had higher DGRs than prof and local strain seedlings. The mean DGR of tissue-cultured seedlings was 4.61 ±0.19%/day followed by prof seedlings (4.18 ±0.13%/day) and local strain seedlings (3.61±0.19%/day). However, in contrast to the results obtained from Selatan Konawe, the DGRs peaked in September, when tissue-cultured seedlings had the highest DGR (4.61 ±0.14%/day) followed by prof seedlings (4.49 ±0.15%/day) and local strain seedlings (4.11±0.05%/day). This study shows that tissue-cultured and prof seedlings have the potential to increase seaweed farming production.

1. Introduction

*Kappaphycus* and *Eucheuma* have been farmed mostly in Indonesia (more than 9.0 MT, over 83% of global production), followed by the Philippines (nearly 1.4 MT, 13% of global production [1]. This seaweed is widely farmed in Indonesia especially in Southeast (SE) Sulawesi [2–5] because of its ease in cultivating [6] with short period of cultivation [7], relatively low financial required, [8], accessible economic activity for many farmers and their families [9], and huge international market share [10].
However, in the last 3 years, Indonesian seaweed production has decreased. In 2016, seaweed production reached 11.27 MT, but in 2016 and 2017, it was 10.55 MT and 9.32 MT, respectively [10]. Therefore, urgent action needs to be done for increasing the production.

There are three methods are frequently used to improve the seaweed seedling productivity. They are mass selection [6], tissue-culture method [7] and grafting [11–13] of seedlings. Mass selection and tissue-culture method are method which prominently could produce better quality of seaweed seedlings. Moreover, a new approach to produce better quality of seedlings combined mass selection and tissue-cultured seedlings has been developed since 2013. This method have produced seedlings which morphologically different from tissue-cultured seedlings. The seedlings are then commonly called by local farmers as “Prof”[14]. Main thalli of “prof” seedlings is shorter than the tissue-cultured seedlings and they tend to have higher branching frequency than tissue-cultured seedlings.

The “prof” seedlings are expected to produce higher growth than tissue-cultured seedlings. Unfortunately, until now, few studies were done to examine comparatively the growth using different sources (local strain, tissue-cultured and “prof”) of the seedlings [14–16].

2. Methods
This study was done in 2 areas from September 2016- February 2017. They were located in the waters of Bungin permai, Tinanggea district, Konawe Selatan Regency (4°29’19.93” S and 122°13’3.76” E) and and in Lemo, Poleang Tenggara District, Bombana Regency, (4°52’48.69” S and 121°55’44.33” E) SE Sulawesi. The steps of this study were:

2.1. Seedling Preparation
There were three different sources of seedlings were prepared and used in this study: local strain, tissue-cultured and prof seedlings. All seedlings were collected from local farmers. After collection, the seedlings were cleaned from attached organisms, epiphytes or dirt.

2.2. Planting of Seaweed Seedlings
Seaweed seedlings of different seedling sources were cut and then they were weighed with initial clump weight (W₀) 10 g. Planting distances (PD) between seedlings used in this study were 10-cm. Long line method used to cultivate all seedlings. The seedlings were placed at ± 20-25 cm from water surface.

2.3. Cultivating the seedlings
Cultivation was carried out for 30 days of each cycle. Planting distances (PD) used in this study were 10-cm. Seaweed seedlings with initial clump weight of 10 g was tied to the rope. The seedlings were placed at ± 20-25 cm from water surface. Each clump was weighed at the end of each cultivation cycle. Seedlings had >3.5%/day of the highest Daily growth rate (DGR) value were selected for next cycle.

The selected seedling clumps were then cut into new seedlings and tied to the new rope, and they were cultivated with similar protocols, processes and period as previous cycles. Selected seedlings resulted from each cycle of mass selection was referred to a generation. The selection was conducted until 6 period correspond with September-February, respectively. The DGR of seaweed cultivated for 30 days was calculated using the formula recommended by [17]: GR(%)= [(Wt/W0)1/t– 1] ×100%
where W₀ is the initial fresh weight, and Wt is the final fresh weight of the seedlings after t days of culture. All data were expressed as mean ± SD. During the cultivation period, regular control was done by cleaning the dirt on the rope and seaweed from epiphyte or other organisms twice a week. Measurement of water quality parameters (salinity and temperature) was done every 15 days.

2.4. Data Analysis
Statistical analyses of DGRs were determined using ANOVA. If the analysis showed significant effect, it was continued with Tukey test using SPSS version 16 statistical software at the p<0.05 level.
3. Results and Discussion

3.1. Daily Growth Rate (DGR)

The DGRs from prof and tissue-cultured seedlings had higher DGRs and significantly different from seedlings from local strain cultivated in both areas, Konawe selatan and Bombana regencies (Figure 1).

![Figure 1](image.png)

**Figure 1.** The DGRs from tissue-cultured (TC), Prof seedlings (Prof) and Local strain (LOC) in Konawe Selatan (A) and Bombana (B) regencies.

Tissue-cultured seedlings had the highest DGRs followed by prof and local strain seedlings. In Konawe Selatan regency, the DGR range of tissue cultured seedlings, prof and local strain was $5.31 \pm 0.025$-$6.20 \pm 0.354\% \text{day}^{-1}$, $4.12 \pm 0.023$-$5.92 \pm 1.026\% \text{day}^{-1}$, $3.29 \pm 0.015$-$5.36 \pm 0.672\% \text{day}^{-1}$, respectively. In addition, the mean of DGR was highest in tissue-cultured seedlings ($5.72 \pm 0.13\% \text{day}^{-1}$), followed by prof seedlings ($5.21 \pm 0.26\% \text{day}^{-1}$) and local strain seedlings...
(4.58±0.23%/day). In addition, the DGRs peaked in November when the tissue-cultured seedlings had the highest DGR (6.20 ±0.35%/day) followed by prof seedlings (5.92 ±1.03%/day) and local strain seedlings (5.39±0.67%/day).

In Bombana, the tissue-cultured seedlings had higher DGRs than prof and local strain seedlings. The mean DGR of tissue-cultured seedlings was 4.61 ±0.19%/day followed by prof seedlings (4.18 ±0.13%/day) and local strain seedlings (3.61±0.19%/day). The mean DGR of tissue-cultured seedlings was4.61 ±0.19%/day followed by prof seedlings (4.18 ±0.13%/day) and local strain seedlings (3.61±0.19%/day). However, in contrast to the results obtained from Selatan Konawe, the DGRs peaked in September, when tissue-cultured seedlings had the highest DGR (4.61 ±0.14%/day) followed by prof seedlings (4.49 ±0.15%/day) and local strain seedlings (4.11±0.05%/day).

The DGRs variations found study might be influenced by the culture sites in Konawe Selatan and Bombana coastal waters. These DGRs were comparatively higher than the other DGRs recorded from Muna regency, Indonesia (4.84 ± 1.22%/day) [14] and other region for the similar Kappaphycus species: in Madagascar DGR was 5.46 ± 0.09%/day [18] while in India was 3.76 ± 0.07 [19]. In addition, the DGRs found in this study were comparable with the previous studies using tissue-cultured seedlings reported in Philippines (5.8-7.2%/day) [20] and in Malaysia (6.3 ± 0.1%/day) [17]. Tissue cultured-seedlings and prof seedlings used in this study had the mean DGRs mostly > 3.5%. They certainly are very reliable to be used for seaweed farming commercially [21]. Therefore, tissue-cultured and prof seedlings could be a prominent seedlings for future seaweed farming.

3.2. Water qualities

Salinity and temperature observed during this study were in suitable range for seaweed farming (Figure 2). In Konawe Selatan and Bombana, the lowest salinity occurred in February 2017 was 32.33±0.577 ppt and 31.34±0.310 ppt, respectively. The highest salinity in Konawe Selatan and Bombana was 32.93±0.115 ppt and 34.30±1.020 occurred in October 2016, respectively. For temperature in Konawe Selatan, the lowest was 28.70±0.513°C occurred in January 2017 and the highest was 30.60±0.529 °C occurred in October 2016. In Bombana, the lowest temperature occurred in December 2016 was 29.84±0.032 °C while the highest was 31.34±0.421 °C occurred in October 2016.

The results indicated that these two main water quality parameters were constantly occurred and nearly similar in two sampling farming sites. High DGRs found in September or November were nearly coincided with higher seawater temperature and salinity found from the study done in India at October [21] and in Philippines at September [22].

![Salinity vs Month](image-url)
Figure 2. Water parameters observed during this study in Konawe selatan (Konsel) and Bombana regencies from September 2016-February 2017. (A) Salinity and (B) temperature.

4. Conclusion

The present study indicated prospects and feasibility of prof seedlings for commercial farming. However more prolonged and detailed studies should be done to examine growth, epiphyte infection and ice-ice disease, carrageenan yield, gel strength and viscosity, for at least one year.

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