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Short Communication: Growth of seaweed *Eucheuma cottonii* in multitrophic sea farming systems at Gerupuk Bay, Central Lombok, Indonesia

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Abstract. *Sukiman, Faturrahman, Rohyani IS, Ahyadi H. 2014. Growth of seaweed* Eucheuma cottonii *in multitrophic sea farming systems at Gerupuk Bay, Central Lombok, Indonesia. Nusantara Bioscience 6: 82-85. Eucheuma cottonii* is a seaweed commodity that has a high economic value because it contains compounds used as raw materials for industries. Various methods of seaweed farming have been developed, one of which is a system of cultivation Multi-Trophic Sea Farming. This study aimed to analyze the growth of *E. cottonii* by observing the production of biomass in four trophic combinations in the system Multi-Trophic Sea Farming. The study was conducted in the area of the marine aquaculture Gerupuk bay, Central Lombok, Indonesia. Experiments were performed on four plots cages with trophic combination treatment as follows: K1 (*E. cottonii*-lobster-abalone), K2 (*E. cottonii*-abalone-red carp), K3 (*E. cottonii*-abalone-grouper), and K4 (*E. cottonii*-abalone-pomfret fish). Seedling of *E. cottonii* weighing 50 g was tied to a rope and placed at a depth of 5 cm, 50 cm, 100 cm, and 150 cm. Measurement of biomass production was done every ten days until the thirtieth day. The highest biomass production of *E. cottonii* was obtained in K3 trophic combination (*E. cottonii*-abalone-grouper fish) with a depth of seedlings of 5 cm. The combination of K3 trophic is recommended for cultivation of seaweed in the MTSF system.

Keywords: *Eucheuma*, Multi-Trophic Sea Farming, MTSF, seaweed

INTRODUCTION

Seaweed is economically important commodities. Seaweed is widely used as food, medicine, and important materials in the food industry, cosmetics, and pharmaceuticals. Seaweed is traditionally mainly used as vegetables, ice mix, and cookies (Nontji 2007). Seaweed is used as medicine because it has the power of antiviral, antifouling, and anti-lung cancer, tumors and AIDS (Smith 2004). Seaweed is also used as a liquid fertilizer in some plant species (Sunarpi et al. 2011), and the source of agar (Widyastuti 2008). Some of seaweed that has been used in Indonesia are of the genus *Porphyra*, *Acanthophora*, *Catenella*, *Eucheuma*, *Gelidium* and *Gracilaria* (Nontji 2007).

Eucheuma cottonii is a seaweed commodity that has a high economic value because it contains compounds used as raw materials for industries. The important chemical constituents of *Eucheuma cottonii* are agar and carrageenan. Agar is widely used in food, pharmaceutical, and cosmetics. In the food industry, agar is used as a food additive, rehydrating food, a thickening agent, and viscosity controller (Reine and Trono 2002). Carrageenan is a hydrocolloid compound formed in the cell walls of red algae (Angka and Suhartono 2000). Carrageenan is used as a stabilizer, thickener, suspending agent, and a gelling agent in food. Carrageenan is also used in non-food products such as toothpaste, cosmetics, paints, and textile dyes (Angka and Suhartono 2000; Reine and Trono 2002).

West Nusa Tenggara is one of the centers of seaweed cultivation in Indonesia. One area that has been developed for marine aquaculture is Gerupuk bay. Various methods of seaweed farming have been developed in the area. One method of cultivation that is being developed is Multi Trophic Sea Farming (MTSF). Multi Trophic Sea Farming is a mariculture system that combines multiple commodities in the farming unit. Multi Trophic Sea Farming System (MTSF) that combines aquatic animal with marine plants potentially reduces costs and improves efficiency and productivity of a number of species and systems (Neori et al. 2004; Pereira et al. 2010). MTSF system has been successfully applied to the cultivation of seaweed *Ulva* sp. with Australian abalone (Boarder and Shpigel 2001). The cultivation of *Gracilaria* with abalone can significantly reduce pathogenic bacteria in abalone (Rebours 2010). This study aimed to analyze the growth of *E. cottonii* on a combination of different trophic and seed position by observing the production of biomass in the MTSF system.

Materials and methods

The study was conducted in the area of the marine aquaculture Gerupuk bay, Central Lombok, West Nusa Tenggara, Indonesia. Experiments were performed on four plots floating cages with trophic combination treatment as follows: K1 (*E. cottonii*-abalone-lobster), K2 (*E. cottonii*-abalone-red carp), K3 (*E. cottonii*-abalone-grouper), and K4 (*E. cottonii*-abalone-pomfret fish). Seedling of *E. cottonii* weighing 50 g was tied to a rope and placed at a depth of 5 cm, 50 cm, 100 cm, and 150 cm. Measurement of biomass production was done every ten days until the thirtieth day.

Analyses of the quality of sea water in the Gerupuk bay were conducted to assess the feasibility of these waters as a cultivated area of some commodities such as seaweed, abalone, grouper, red carp, pomfret, and lobster. In this study, water quality sampling was conducted at locations that may represent other areas. Physical and chemical qualities of the water measured were pH, temperature, salinity, levels of nitrite and ammonia.

Results and discussion

Analyses of the quality of sea water in the Gulf Gerupuk were conducted to assess the feasibility of these waters as seaweed farming area with MTSF system. The results of measurements of physical and chemical properties of water were presented in the following table:

Table 1. Physical and chemical quality of the water of Gerupuk bay

Parameters	Ho	H_{27}	Standard *
Temperature	28-29 ºC	28-30 ºC	28-32
Brightness	1.82 m	1.82m	3-4m
Salinity	33-37 ppt	34-36 ppt	30-40ppt
pH	7.8-8.4	7.5-8.4	6-8
NH_3	0.03 mg/L	0.03-0.05	<1
NO_3	0.07 mg/L	0.07-0.08	0.06
DO	4.82	4.82	6-8

Note: * MoE (1988)

At baseline, the pH was 7.8-8.4, temperature 28-29 °C, salinity 33-37 ppt, ammonia 0.03 mg/L and nitrite 0.07 mg/L. After a month-long study, the data were not very different from that at baseline and inter-basin water quality or between treatments, i.e. pH 7.5-8.4, temperature 28-30°C, salinity 34-36 ppt, ammonia 0.03-0.05 mg/L and nitrite 0.07-0.08 mg/L.

Physical and chemical parameters that should be considered include flow, temperature, brightness, pH, salinity, dissolved oxygen and nitrogen compounds. Achmad et al. (1991) stated that balk flow velocity for marine fish farming in floating cage is 5-15 cm/sec, pH 6.5 to 9.0 (Boyd and Lichtkoppler 1979) and brightness of > 3 m (MoE 1988). Furthermore Anon. (1986) and Achmad et al. (1991) stated that good oxygen is 5-8 ppm, while the ammonia concentration is less than 0.1 ppm. Glenn and Dotty (1990) suggested that a range of condition under which the eucheumatoides can be productive in farm setting are: maximum temperature of 24-30ºC, minimum temperature of 21-22ºC, nitrogen of 2-4 µ-atm/L, phosphate of 0.5-1.0 µ-atm/L, and high solar energy level. In addition, Glenn and Dotty (1992) concluded that culture of eucheumatoids species requires a high level of water motion.

To optimize the seaweed component of an integrated aquaculture system, particular attention should be given not only to physical and chemical factors (such as light, temperature, effluent nutrient concentration and flux, water motion, etc.) but also to biological factors such as interplant variability, nutrient prehistory, type of tissue in culture, control of parameters triggering reproduction stages, surface area to volume ratio of thalli, and morphological changes induced by cultivation techniques (Chopin et al. 2001).

Eucheuma cottonii is one of seaweed species that can be cultured in the MTSF system (Figure 1.A, 1.B). Seaweeds are the short term commodity in MTSF system because they can be harvested faster than any other components in the MTSF system The growth of *E. cottonii* for 30 days of observation can be seen in Table 1. Based on the results of the measurement of biomass conducted every 10 days, the highest biomass production of *E. cottonii* was obtained in combination trophic K3 (*E. cottonii*-abalone-groper) with the position of the seeds at a depth of 5 cm. While, the lowest biomass was obtained in combination trophic K4 (*E. cottonii*-abalone-red crap).

Table 2. *E. cottonii* growth with four trophic combinations in MTSF

Trophic combination	Seedling position	W0 (g)	W10 (g)	W20 (g)	W30 (g)
Control	Long line	50.6	106.15	151.15	250
K1	Horiculture 5 cm	49.8	84.35	110.5	164.65
	Verticulture 50 cm	50.5	69.15	74.3	89
	Verticulture 100 cm	50.3	56.65	56.3	66.5
	Verticulture 150 cm	50.05	60.75	53	55.75
K2	Horiculture 5 cm	50.3	110.5	159.85	237.9
	Verticulture 50 cm	50.15	86.15	151.5	145.75
	Verticulture 100 cm	50.5	67.65	102.6	91.35
	Verticulture 150 cm	49.75	65.65	76	80
K3	Horiculture 5 cm	50.1	101.7	170	259.15
	Verticulture 50 cm	50.3	80.65	82.25	128.4
	Verticulture 100 cm	49.75	77.05	99.3	92
	Verticulture 150 cm	50	62.75	53.8	32.5
K4	Horiculture 5 cm	50.6	78.2	109.5	122.2
	Verticulture 50 cm	50.3	75.5	95.05	80.75
	Verticulture 100 cm	50.55	69.15	57.8	38.15
	Verticulture 150 cm	49.9	61.55	47.15	33.5

Note: Verticulture: vertical line culture, Horiculture: horizontal line culture. K1: *E. cottonii*-abalone-lobster, K2: *E. cottonii*-abalone-red carp, K3: *E. cottonii*-abalone-grouper, and K4: *E. cottonii*-abalone-pomfret fish. W0: 0th days, W10: 10th days, W20: 20th days, W30: 30th days.

The biomass growth of *E. cottonii* on MTSF system showed a different pattern among the trophic combinations and depths of seeds. The biomass growth of *E. cottonii* in K1 trophic combination can be seen in Figure 2.A The highest biomass growth of *E. cottonii* was obtained at seedlings at a depth of 5 cm with an average of 164 g. While, the lowest biomass production of seeds was at a depth of 150 cm with 55.7 g of total biomass for 30 days. At combination of K2 trophic growth, the highest biomass was obtained from the seeds that were placed at a depth of 5 cm with an average biomass production of 238 g. While, the lowest biomass production was obtained at the seed position of 150 cm with the biomass production of 80 g (Figure 2.B). The biomass growth of *E. cottonii* on K3 trophic combination can be seen in Figure 2.C. The highest biomass growth of *E. cottonii* obtained at seedlings at a depth of 5 cm with an average of 260 g of biomass produced after 30 days of observation. Biomass production on a combination of trophic and depth of the seedling was the largest biomass production of the entire treatment. The lowest biomass production on a combination of K3 was at a depth of 150 cm with total seed biomass is 32.5 g.

Figure 1. A. Position of *E. cottonii* seedling in floating cages, B. Growth of *E. cottonii* in MTSF system

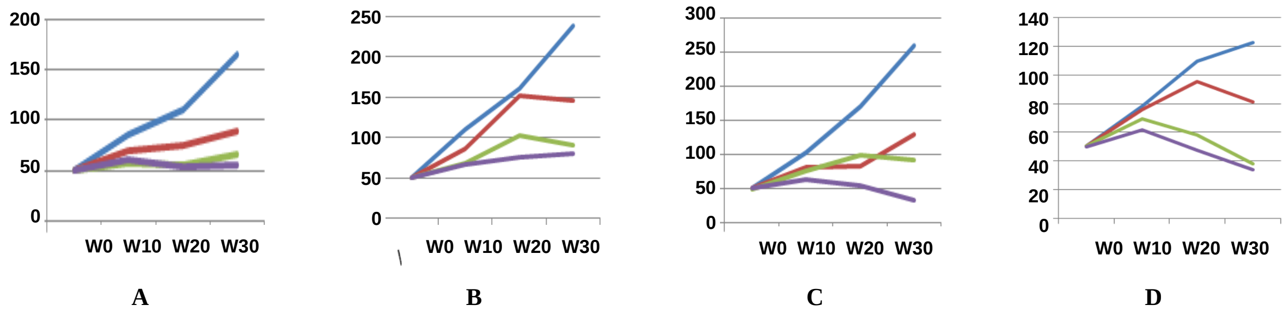

Figure 2. Growth of *E. cottonii* in combination of K1 trophic (A), K2 trophic (B), K3 trophic (C), and K4 trophic (D). Note: blue = horiculture 5 cm, red = verticulture 50 cm, green = verticulture 100 cm, purple = verticulture 150 cm

On the combination of trophic K4 the highest biomass growth was obtained from seeds placed at a depth of 5 cm with an average biomass production of 122 g. While, the lowest biomass production was obtained at the seed position of 150 cm with biomass production of 33 g (Figure 2.D). Biomass production of seaweed in the combination of trophic K4 decreased after 20 days.

The results showed that the growth of seaweed was different for each treatment. In general, the growth of seaweed grown on shallower position was higher than that at deeper position. The highest increase in biomass was achieved in seedlings at a depth of 5 cm in K2 (seaweed-abalone-red snapper), while the lowest occurred in K1 and K4 150 cm treatment. This indicates that horizontal line has a better growth rate compared with vertical line culture.

The growth of seaweed on MTSF abalone-lobster (K1) and MTSF abalone-pomfret fish (K4) was very low. This is thought to be caused by the nature of lobster and pomfret fish that like to eat seaweed, where the tips of seaweed are found cut by pomfret fish and lobster bites. Thus seaweed cultivation is not suitable to be integrated with pomfret fish and lobster.

There is a tendency that the deeper the planting position, the lower the growth of biomass obtained. Seaweed cultivated on the horizontal line (5 cm) and the strap length of 50 cm verticulture will grow faster than the length of the rope verticulture of 100 cm and 150 cm. Seaweed can optimally utilize sunlight as an energy source for photosynthesis and to obtain nutrients. In addition to temperature, light plays a major role in conditioning the performance of seaweed. These are usually the most important environmental parameters affecting growth and nutrient uptake of seaweed (Maria et al 2011). At verticulture of 5 cm long strap the currents and wave movements are optimal for the growth of seaweed so it has a big opportunity to absorb nutrients. Increased uptake of nutrients and photosynthetic activity led to increased production of biomass in K3 trophic combination. This is in accordance with the statement of Glenn and Dotty (1990) that a range of condition under which eucheumatoids can be productive in farm is in high solar energy.

The results of this study differ from those reported by Syahlun et al. (2013) which stated that the verticulture of 100 cm was better than other treatments. The position of 100 cm verticulture is parallel to abalone baskets and has a greater opportunity to be exposed to the nutrients from the abalone metabolic outcomes, but, it is unable to promote the better growth of seaweed because the brightness level of water at the MTSF location is only 1.82 m and this disrupts photosynthesis. Thus, these results are not in accordance with the results of the study Pereira et al. (2010) which showed that the growth of seaweed in an integrated system with abalone MTSF was better than those in the monoculture method.

In general, the growth of seaweed in MTSF system was lower than in longline method in the mouth of the Gulf Gerupuk that can reach 250 g in 30 days. Low yield is presumably due to the low water movement, low water levels of brightness and a lot of muddy water as a result of the destruction of mangrove forests. Instead Gracilaria growth in floating cage was very good and has the potential to be developed with MTSF pattern. Application of method-vertical line (verticulture) at MTSF is a strategy to maximize the function of space and increase efficiency.

Aquaculture is an essential activity in the economy of Gerupuk bay, with seaweed farming being the most important commodity. MTSF system may be part of the solution in marine aquaculture at Gerupuk bay, because integrated multi-trophic aquaculture has ecological and socio-economic advantages, relative to single-species aquaculture (Nobre et al. 2010). Maria et al. (2011) have reported clear advantages of growing seaweeds near the fish. Seaweed is efficient biofilters due to their ability to efficiently remove both ammonia and nitrate from the culture. Beside its biofiltration efficacy, Nobre et al. 2010, said that integrated multi-trophic aquaculture indicates a decrease in the aquaculture generated ecological pressures with the incorporation of seaweeds, mainly a reduction in nitrogen discharges into the adjacent coastal and raised farm profits by 1.4 to 5%.

Eucheuma cottonii can be cultivated through a combination with other commodities in the Multi Trophic Sea Farming Systems. The highest biomass production of *E. cottonii* was obtained in K3 trophic combination (*E. cottonii*-abalone-grouper) with a depth of seedlings of 5 cm. The combination of *E. cottonii*, abalone, and grouper fish are recommended for cultivation of seaweed in the system MTSF.

In conclusion, *E. cottonii* can be cultivated through a combination with other commodities in the Multi Tropic Sea Farming Systems. The highest Biomass production of *E. cottonii* obtained in combination tropic K3 (*E. cottonii*-abalone-grouper) and depth of seedlings 5 cm. The combination of *E. cottonii*, abalone and grouper fish is suggested for cultivation of seaweed on the system MTSF.

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