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THE ASSESSMENT OF SEAWEED (*Eucheuma cotonii*) GROWING PRACTICE OF DIFFERENT SYSTEMS AND PLANTING SEASONS IN BANGKEP REGENCY CENTRAL SULAWESI

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ABSTRACT

The assessment was conducted at Apal Village, Bangkep Regency, Central Sulawesi form March to November 2002, to find out information on seaweed growing practice and planting season suitable with the local waters, easily applicable, and enable to improve fishermen income. In addition, it was intended to create employment and a business practice, and explore coastal resources optimally. The assessment was carried out using split block design with three treatments, namely control (T0), usual planting row (T1), and three-furrow planting row (T2), each with five replications. Planting was carried out in four planting seasons, each representing west to east seasonal change (WE), east season (E), east to west seasonal change (EW), and west (W) which subsequently occurred in April-May, June-July, August-September, and October-November 2002. The average seaweed weight assessed for 50 days of cultivation showed that the T2 system produced the highest yields in almost all planting seasons. In the same planting seasons, T0 and T2 systems were not significantly different. Among the planting seasons, the highest average weights were found for planting in October-November 2002 for all treatments. Meanwhile, for each planting season, the highest average weight was obtained from the October-November planting period, namely 55.09, 52.99, and 55.09 kg for T0, T1, and T2, respectively. The productivities were 2.20, 2.12, and 2.20 kg/m^2 for T0, T1, and T2, respectively. The highest daily growth rates were achieved during October-November 2002 planting season, namely T0 4.4%, T1 4.4%, and T2 4.7%. Return to cost ratios of each treatment were 2.3 (T2), 2.2 (T0), and 1.6 (T1).

[**Keywords**: *Eucheuma cotonii*, growing practice, planting seasons]

INTRODUCTION

Entering the take off era and the second long term development, each subsector was expected to be able to improve or at least maintain its contribution to the sustainability of the national economic development. Off all development potencies, coastal and oceanic resources have quite significant roles for the national development. This is based on the physical fact that Indonesia is the largest archipelagic country in the world consisting of 17,508 islands with coastal lines of around 81,000 km. The oceanic area comprises 5.8 million km^2 or 70% of the total Indonesian territory (Dahuri *et al*. 2001). Along the coastal lines and sea water expense, abundant natural resources such as fish, seaweed, mangrove, and corals are found. In optimizing the fishery subsector, the government has made efforts to widely encourage the society to carry out development activities and the development of fishery subsector is believed to be able to improve and become the national economy development, especially to improve the welfare of fishery society.

The development paradigm of fishery subsector so far is still focused on activities in catching and collecting fishery products, thus these need to be altered to activities orienting to cultivation. Cultivating activities are possible to be realized as they are supported by the spreading Indonesian coastal waters and having bays with relatively calm waters condition. The condition is significantly potential for the development of seaweed cultivation.

Central Sulawesi has significantly potential resources for the development of sea cultivation, but they have not been used optimally. This can be seen from the economic contribution of oceanic section to Regional Gross Domestic Product (RGDP) just reaching 3.85% (Rp 2,283,594,000) of the total RGDP of Central Sulawesi amounting Rp7,342,714,000 (Dinas Perikanan dan Kelautan Provinsi Sulawesi Tengah 2000). One of the efforts to utilize the potency of resources is the implementation of specific technology packages in line with the agroeconomy of each developmental region.

Bangkep Regency is one of the regions sufficiently potential for the development of sea cultivation, especially seaweed, *Eucheuma cotonii* and *E. spinosu*. The potency of the available seaweed for cultivation along Tomini Bay and Peleng Strait is around + 2500 ha, and only about 500 ha have been utilized (Sangihe 2000). This shows that the

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opportunity for the development of this commodity is significantly promising. This is supported by the local practice where most of the coastal community has already cultivated seaweed. Up to the year 1999, the number of fishermen at Liang Subdistrict carrying on this commodity was 780 fishermen with a production of 1488.5 tons (Direktorat Jenderal Pesisir dan Pulau-pulau Kecil dan Yayasan Pemerhati Lingkungan 2001).

The seaweed cultivation does not require high skills and large capital, thus it can be done by all of the fisherman family members including housewives and children. However, the seaweed cultivated is often attacked by diseases such as ice-ice and other predators leading to a decline in the product quality. One of the causes of seaweed cultivation failure is the implementation of cultivation systems that are not in the proper time and unsuitable planting systems (Pusat Penelitian dan Pengembangan Perikanan 1990). An inappropriate implementation results in cultivated seaweed that is often attacked by diseases and fish predators and the productivity is low.

Ecologically, the seaweed commodity provides a number of benefits to the surrounding environment like conserving the coastal areas against various environmental unfriendly catching activities, such the use of poisons/bombs in catching fish. Biologically, seaweed plays an important role as the primary producer of organic materials and oxygen at the coastal environment. Economically, this is a potential commodity to be developed considering the nutrient content. Furthermore, seaweed can be used as foodstuffs such as agar, vegetables, and snacks and it produces algin materials, karaginan and fluseran used in pharmaceutical, cosmetic, and textile industries.

This research aimed to find out the information on the seaweed planting system and season using the raft method suitable for the local waters and easily conducted by the fishermen. In addition, from this research it is expected that fishermen cultivating seaweed can continuously increase their income, create work opportunities and business, and utilize the coastal resources optimally.

MATERIALS AND METHODS

Location

The research on seaweed cultivation technologies was carried out at Apal Village in Liang Subdistrict of Banggai Kepulauan Regency. This was supported by the regional conditions having potencies and great opportunities for various fishery activities including seaweed cultivation. Furthermore, almost 80% of the populations of Banggai Kepulauan are fishermen with daily activities of catching and cultivating seaweed.

Research Design

Seaweed type *E. cotonii* was cultivated using line method with different planting systems, i.e. control (T0), usual planting row (T1), and three-furrow planting row systems (T2). Fifteen rafts were made; each system consisted of 5 rafts of 2.5 m x 100.0 m. Planting was conducted for four planting seasons (factor) each representing the change of west to east season (WE), west season (E), the change of east to west season (EW), and west season (W) that consecutively occurred in April-May, June-July, August-September, and October-November 2002.

This research was conducted using a split block design with three treatments and five replications. Observations were conducted for 50 days with an interval of 10 days.

Data Collecting and Procedures

Data collected in this research were (a) types of pests and diseases in each planting season; (b) waters supporting capacity for seaweed cultivation, including depth, current speed, salinity, temperature, and water clearness; and (c) growth parameters comprising daily growth rate (length and weight), dry matter production, and productivity. Observations were conducted with a 10 day interval. The daily growth rate was measured using the formula:

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

where:
Wt = plant weight after t days
Wo = initial plant weight
t = planting period per days.

Data Analysis

This research was conducted to find out the effects of treatments during the research. Meanwhile, financial analysis to find out economic feasibility of each technology was conducted using the analysis of R/C.

RESULTS AND DISCUSSION

The Condition of Cultivation Location

Apal Village waters are significantly suitable for seaweed cultivation, both technologically and ecologically as it is located among several small islands, thus it is protected from direct damages caused by waves. The waters base is a mix of sand and coral, the current speed is 20-40 cm/second, the salinity is 29-33 ppt, the temperature ranges between 28-33°C, and water clearness is up to 6 m. Mubarak (1999) stated that the optimum waters for the cultivation of *Eucheuma* sp. is that with water speed of 20-40 cm/second, sufficiently hard water base, not muddy, salinity between 28-34 ppt (optimum 33 ppt), water temperature of 20-28°C, and clearness not less than 5 m.

Apal Village is influenced by two seasons, i.e. wet season occurring from February to August and dry season from October to December, though occasionally there is rain (Direktorat Jenderal Pesisir dan Pulau-pulau Kecil dan Yayasan Pemerhati Lingkungan 2001). These significantly influence the seaweed production.

Seaweed Weight Gain

The average final weight of seaweed for 50 days rearing showed that visually the three-furrow system produced the highest yield in almost all seasons, except in planting season of April-May. Then it was followed by those of usual planting row system and control (Table 1).

Analysis of variance showed that planting systems and time resulted in significantly different seaweed growth at the level of 95%. This could be seen from the higher $F_{calc.}$ of $F_{tab.}$ In addition, the significance for planting season and planting system is more than 0.05. Meanwhile, further test using the least significant test showed that the usual planting and three furrow system were not significantly different for the same planting season, but those two

Table 1. The average seaweed weight gain (g) reared for 50 days based on treatments and planting, Bangkep Regency, 2002.

Planting season (A)	Cultivation technology							Total	Average
		Long line (B1)		Usual planting row (B2)		Three-furrow planting row (B3)			
West to east seasonal		590		570		580			
change (A1)		600		580		600			
(April-May)		595		560		570			
		595		570		610			
		625		590		640			
Total		3005		2870		3000			
Average	A1B1	601	A1B2	574	A1B3	600	A1	1775	592
East season (A2)		660		650		680			
(June-July)		650		650		670			
		670		650		650			
		700		635		680			
		680		640		690			
Total		3360		3225		3370			
Average	A2B1	672	A2B2	645	A2B3	674	A2	1991	664
East to west seasonal		710		680		710			
change (A3)		700		660		710			
(August-September)		690		650		690			
		685		630		700			
		700		640		700			
Total		3485		3260		3510			
Average	A3B1	697		652		702			
West season (A4)		800		765		790			
(October-November)		785	A3B2	760	A3B3	785	A3	2051	684
		780		750		780			
		780		760		785			
		790		750		795			
Total		3935		3785		3935			
Average	A4B1	787	A4B2	757	A4B3	787	A4	2331	777
Total		2757		2628		2763			
Average	B1	689.3	B2	657.0	B3	690.8			

treatments were significantly different with the control. For the planting seasons, the seaweed weight gains for all planting seasons were significantly different.

This is assumed to be caused by the presence of significantly wide paths between a rope stretches to another in the usual planting row system. It also happened to three-furrow system, in which for three ropes occurred an empty space, thus it can create a quite spacious room for currents to enter the middle parts of the rafts. Currents play an important role in seaweed growth as the presence of currents will bring nutrient talus. Larger water movement will create more diffusion that causes quicker metabolism process. In addition, the currents function to homogenize the water mass, hence the fluctuations of salinity, temperature, pH, and solved substances can be prevented (Trono 1974). If the currents obtained are equal in all parts of the rope stretches, the chances to grow well will be the same for taluses on the side and in the middle parts. Therefore, the growth of taluses will relatively be uniformed in a unit of rafts of the three furrow system.

For the planting seasons it can be seen that the usual planting row and three-furrow system were not influenced by the same planting time, except for planting season at the change of west to east season. Meanwhile, for each planting time, the research result showed that the average highest weight was obtained from the planting period of October-November for each treatment of the three systems. It was followed by the planting period of August-September, June-July, and April-May. This is assumed to be related to the oceanographic factors of the waters, in this case the temperature, salinity, and currents (Table 2). In the planting period of April-May in the surrounding research areas there were rains stimulating the growth of pest plants such as mold that could inhibit the seaweed growth. Other effects were the emergence of ice-ice disease causing the young talus tips became white hence they were easily broken and taluses could not develop further. Furthermore, during the April-May planting season, the level of pest attacks such small *baronang* fish (*Siganus* sp) was significantly high reaching 20% (Table 3). Then the attacks gradually decreased and until the planting period ended they only reached 5%.

The best weight gain was obtained from the October-November planting period. This is presumed to be closely related to the currents, which in this planting period, the currents started to be fast as it entered the west season, but it was still possible to plant the seaweed. Sufficient current have positive effects on the growth of seaweed taluses. In the research location, seaweed planting is generally stopped entering December-February due to huge currents and waves.

Production Performance

The observation results of the 50 day rearing showed that visually the production and productivity of seaweed with the long line and three-furrow planting systems were not significantly different in all planting seasons. These two systems provided the highest production compared to that of the usual planting row. For all planting systems, the highest production was obtained from the October-November planting season with production of 55.09 kg for both long line and three-furrow systems and 52.99 kg for the usual planting row system (Table 4). Meanwhile, the productivities were 2.20 kg/m^2 for the long line and three furrow system and 2.12 kg/m^2 for the usual planting row (Table 5).

Analysis of variance showed that planting seasons and systems had a significant difference on seaweed production and productivity. This can be seen from the $F_{calc.}$ value which was larger than that of F_{tab}. In addition, the significance of planting season is more than 0.05. Meanwhile, the results of further test using the least significant difference showed that usual planting row and three-furrow planting row systems were not significantly

Table 2. Oceanographic parameter based on planting season, Bangkep Regency, 2002.

Oceanographic parameter	Planting season			
	WE	E	EW	W
Temperature (^{0}C)	29	29	29	28
Salinity (ppt)	29	30	31	33
Current speed (cm/sec)	34	30	35	38
Water speed (m)	3	4	4	5

WE = the seasonal change from West to East; E = East season; EW = the seasonal change from East to West; W=West season.

Table 3. Percentage of pest and disease attacks on seaweed based on planting season, Bangkep Regency, 2002.

Types of pests and diseases	Planting season			
	WE	E	EW	W
Pests				
Baronang (*Siganus* sp.) fish	30.0	15.0	10.0	5.0
Brown mold	0.8	2.0	2.0	0.5
Silk mold	35.0	20.0	16.0	8.0
Disease				
ice-ice	25.0	15.0	0.0	0.0

WE = the seasonal change from West to East; E = East season; EW = the seasonal change from East to West; W=West season.

Table 4. Dry production of seaweed based on treatment and planting systems, Bangkep Regency, 2002.

Planting season (A)	Production (kg/raft/50 days)							Total production	Average
		Long line (B1)		Usual planting row (B2)		Three-furrow planting row (B3)			
West to east seasonal change (A1) (April-May)		41.30		39.90		40.60			
		41.25		40.60		42.00			
		41.65		39.20		39.90			
		41.65		39.20		42.70			
		43.75		41.30		44.80			
Total		209.60		200.90		210.00			
Average	A1B1	41.92	A1B2	40.18	A1B3	42.00	A1	124	41.37
East season (A2) (June-July)		46.20		45.50		47.60			
		45.50		45.50		46.90			
		46.90		45.50		45.50			
		49.00		44.45		47.60			
		47.60		44.80		48.30			
Total		235.20		225.75		235.90			
Average	A2B1	47.04	A2B2	45.15	A2B3	47.18	A2	139	46.46
East to west seasonal change (A3) (August-September)		49.70		47.60		49.70			
		49.00		46.20		49.70			
		48.30		45.50		48.30			
		47.95		44.10		49.00			
		49.00		44.80		49.00			
Total		243.95		228.20		245.70			
Average	A3B1	48.79	A3B2	45.64	A3B3	49.14	A3	144	47.86
West season (A4) (October-November)		56.00		53.55		55.30			
		54.95		53.20		54.95			
		54.60		52.50		54.60			
		54.60		53.20		54.95			
		55.30		52.50		55.65			
Total		275.45		264.95		275.45			
Average	A4B1	55.09	A4B2	52.99	A4B3	55.09	A4	63	54.39
Total		193.00		184.00		193.00			
Average	B1	48.21	B2	45.99	B3	48.35			

different at the same planting period, but the two treatments were significantly different from the usual planting row system.

For the four planting periods, the best average production was from the October-November period, i.e. 52.99 kg from the usual planting row and 55.9 kg from the three furrow planting row followed by that planted in August-September for each technology, and in April-May. The same phenomena were seen in the productivity.

The high average production, productivity, and daily growth rate for the October-November planting season were supported by stimulating oceanographic factors (Table 2) in which temperature, salinity, and current speed were in optimal ranges for seaweed growth. In those months, the movements of water/wave were sufficiently good. Although it was the beginning of the west season, the research location was prevented by several small islands. In the east season, the research location was significantly affected by strong waves as it is located in an open area. Seaweed is an organism obtaining its nutrient from the water flow passing it. Sufficient water movement will prevent the accumulation of waste on taluses, help the aeration, and prevent a large fluctuation on the water salinity and temperature (Puja *et al.* 2001). Meanwhile, the April-May planting did not produce sufficiently good yields for each technology. This may be caused by high rainfall accompanied by the pest and disease attacks in those months (Table 3).

Similar result was obtained on the daily growth rate. The October-November planting showed the best result for each technology, i.e. 4.4% for the long line system, 4.7% for the usual planting row system, and 4.7% for the

Table 5. Average seaweed productivity based on treatment and planting system, Bangkep Regency, 2002.

Planting season (A)	Average productivity (kg/m^2/50 days)							Total	Average
		Long line (B1)		Usual planting row (B2)		Three-furrow planting row (B3)			
West to east seasonal change (A1) (April-May)		1.65		1.60		1.62			
		1.65		1.62		1.68			
		1.67		1.57		1.60			
		1.67		1.60		1.71			
		1.75		1.65		1.79			
Total		8.38		8.04		8.40			
Average	A1B1	1.68	A1B2	1.61	A1B3	1.68	A1	4.96	1.65
East season (A2) (June-July)		1.85		1.82		1.90			
		1.82		1.82		1.88			
		1.88		1.82		1.82			
		1.96		1.78		1.90			
		1.90		1.79		1.93			
Total		9.41		9.03		9.44			
Average	A2B1	1.88	A2B2	1.81	A2B3	1.89	A2	5.57	1.86
East to east seasonal change (A3) (August-September)		1.99		1.90		1.99			
		1.96		1.85		1.99			
		1.93		1.82		1.93			
		1.92		1.76		1.96			
		1.96		1.79		1.96			
Total		9.76		9.13		9.83			
Average	A3B1	1.95	A3B2	1.83	A3B3	1.97	A3	5.74	1.91
West season (A4) (October-November)		2.24		2.14		2.21			
		2.20		2.13		2.20			
		2.18		2.10		2.18			
		2.18		2.13		2.20			
		2.21		2.10		2.23			
Total		11.02		10.60		11.02			
Average	A4B1	2.20	A4B2	2.12	A4B3	2.20	A4	6.53	2.18
Total		7.71		7.36		7.74			
Average	B1	1.93	B2	1.84	B3	1.93			

Table 6. Average daily growth rate of seaweed for 50 days based on treatment and planting systems, Bangkep Regency, 2002 (kg/raft/50 days)

Planting season	Long line			Usual planting row			Three-furrow planting row		
	Initial weight (g)	Final weight (g)	Growth rate (%)	Initial weight (g)	Final weight (g)	Growth rate (%)	Initial weight (g)	Final weight (g)	Growth rate (%)
April-May (WE)	90.0	601	3.9	78	574	4.1	80	600	4.1
June-July (E)	88.3	672	4.1	75	645	4.4	77	674	4.4
August-September (EW)	90.1	697	4.2	80	652	4.3	78	702	4.5
October-November (W)	90.0	787	4.4	75	757	4.7	77	787	4.8

Table 7. Economic analysis on seaweed cultivation per raft for the October-November planting season in Bangkep Regency, 2002.

Description	Usual planting row		Three-furrow planting row		Long line	
	Total/ estimation	Value (Rp)	Total/ estimation	Value (Rp)	Total/ estimation	Value (Rp)
Fix cost						
Materials						
- Bamboo @ Rp 5.000	8 stalks	40,000	8 stalks	40,000	4 stalks	20,000
- Timber @ Rp 5.000	4 stalks	20,000	4 stalks	20,000	4 stalks	20,000
- Nylon rope of 6 mm @ Rp 18.000	6 kg	108,000	5 kg	90,000	5 kg	90,000
- Nylon rope of 12 mm @ Rp 18.000	3 kg	54,000	3 kg	54,000	3 kg	54,000
- Plastic rope @ Rp 7.500	2 kg	15,000	1.5 kg	11,250	1kg	7,500
- Cork @ Rp 10.000	-	-	-	-	3 sheets	30,000
Material reduction/PS						
- Bamboo	6 PS	5,833	6 PS	5,833	6 PS	3,333
- Timber	6 PS	12,500	6 PS	12,500	6 PS	3,333
- Nylon rope of 6 mm	12 PS	12,000	12 PS	10,500	12 PS	7,500
- Nylon rope of 12 mm	24 PS	2,250	24 PS	2,250	24 PS	2,250
- Plastic rope	3 PS	5,000	3 PS	3,750	3 PS	2,500
- Cork	-	-	-	-	6 PS	5,000
Total material reduction	-	37,583	-	34,833	-	23,916
Variable cost						
Seaweed seed Rp1.000/kg	25 kg	25,000	189 kg	189,000	95 kg	95,000
Labor						
- Raft making and rope installation @ Rp 8.000	2 DLC	16,000	2 DLC	16,000	2 HOK	16,000
- Seaweed tying and planting	2 DLC	16,000	2 DLC	16,000	2 HOK	16,000
- Maintenance @ Rp 8.000	2 DLC	16,000	2 DLC	16,000	2 HOK	16,000
- Harvesting @ Rp 8.000	2 DLC	16,000	2 DLC	16,000	2 HOK	16,000
Total		316,000		253,000		159,000
Grand total		353,583		287,833		182,916
Dried seaweed production						
- Usual row, 1 unit @ 52.99 kg	265 kg	927,500				
- Three furrow, 1 unit @ 55.09 kg			275 kg	962,500		
- Long line, 1 unit @ 55.09 kg					165 kg	577,500
Net income		573,917		674,667		394,584
R/C		1.6		2.3		2.2

The price of dried seaweed was Rp3,500/kg.

three furrow planting row system. The daily growth rate is considered to be profitable if it is above 3% (Pusat Penelitian dan Pengembangan Perikanan 1999). The average daily growth rate of seaweed for each treatment can be seen in Table 6.

Analysis on Seawed Farming

Analysis on seawed farming aimed to find out the extents of profit obtained and capital invested in a business. The analysis on seaweed cultivation is presented in Table 7. From the calculation, the highest net income was obtained from the three-furrow system with the R/C of 2.3 followed by that of long line with the R/C of 2.2 and usual planting system with the R/C of 1.6. However, all planting systems provided for the seaweed cultivation were feasible to be developed seen from the R/C bigger than 1.0

CONCLUSION

The three furrow and long line systems provided the highest productions and productivities in seaweed cultivation compared to those of usual planting row system. The best planting time is the October-November planting period, followed by the August-September, the June-July and the April-May planting periods. All planting systems are feasible to be developed, but the best is the three furrow planting row system.

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