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Comparison of Growth and Biomass of Red Alga Cultured on Rope and Net

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***Abstract*—**This research has been conducted to study the method of culture and comparing growth and biomass of *Gracilaria corticata* cultured on rope and net for 50 days through two treatments (first treatment: culture of alga on net and the second treatment: culture of alga on rope and each treatment was repeated by four cases). During culture period, the water of aquariums was replaced once every two days for 40-50%. Also, 0.3-0.5 grams of urea fertilizer was added to the culture environment for fertilization. Moreover, some of the environmental factors such as pH, salinity and temperature of the environment were measured on a daily basis. During the culture period, extent of longitudinal growth of the species of both treatments was equal. The said length was reached from 8-10 cm to 10.5-13 cm accordingly. The resulted weight in repetitions of the first treatment was higher than that of the second treatment in such a way as in the first treatment, its weight reached from 10 grams to 21.119 grams and in the second treatment, its weight reached from 10 grams to 17.663 grams. On a whole, it may be stated that that kind of alga being studied has a considerable growth with respect to its volume. The results have revealed that the percentage of daily growth and wet weight at the end of the first treatment was higher than that of the second treatment and it was registered as 0.934, 6.072 and 811.432 in the first treatment and 0.797, 4.990 and 758.071 in the second treatment respectively. This difference is significant ($P<0.05$). Growth and biomass of *G. corticata* through culture on net was more emphasizing on numerous branches due to wider bed. Moreover, higher level of the species in this method was exposed to sunlight and this increased biosynthesis and eventually increases of growth and biomass.

***Keywords*—**Red alga, growth, biomass, culture, net, rope.

I. Introduction

SEAWEEDS of the southern coasts of Iran in Macrophita group are divided into three major classes of green, brown and red alga [6]. From among the said seaweeds, red alga especially *Gracilaria corticata* are of great importance due to high density and frequency on the coasts of Persian Gulf and Oman Sea especially Bushehr Province, growth in high volume and significant and valuable materials such as Agar, Karaginan, Iodine, minerals and different kinds of vitamins and the ones [2], [6], [9], [10].

Nowadays, *G. corticata* is used as the main raw material for providing agar. Agar industry enjoys a noticeable capacity for growth. However, this industry faces shortage of raw materials and has been limited in this regard [3], [8], [12]. Furthermore, natural beds available across the world cannot have sufficient production. Due to demand for operating the natural populations, it is necessary to have fixed and reliable offer. This could be realized only through artificial culture [2], [10]. Nowadays, there are several methods used for culture of *G. corticata*. Culture of the aforesaid alga is mainly done in deep parts of water by installing growing organs on rope, net, frame, inside a basket, experimental tanks, farming pools and using Spore in consideration of ecological conditions of the region [2], [3], [7], [14].

Determination of the best culture approach is the first step taken for culture of and farming seaweeds. Since many parts of the southern coasts of Iran enjoy desirable ecological conditions for growth of multicellular alga [6], study of growth process of *G. corticata* is of great importance. Considering type of bed, seep of water flow and easiness and cost-effectiveness of the executive method, culture of alga on net, rope and other methods of culture must be studied [7] and the best culture method should be determined accordingly.

This research has been conducted to choose the best culture method for *G. corticata* in order to achieve more biomass and production emphasizing on comparing culture of the species on rope and net.

II. Materials and Methods

The research has been performed to study culture method and comparing growth and biomass in culture of *G. corticata* on rope and net. Reserving operations were performed in two treatments with 4 repetitions (three repetitions of feeding by the use of Urea and one treatment without feeding as control group) in summer for 50 days.

- Treatment 1: Culture of *G. corticata* on net
- Treatment 2: Culture of *G.corticata* on rope

The intended samples of the specieswere collected from the coasts of Bushehr County at time of complete reflow and were transferred to the place of culture. At the place, epiphytes and other unwanted alga and mud were separated from the samples and eventually, using a scale, groups of the samples for 10 grams were separated and installed on rope and net [4], [11].

On a whole, the samples were placed on rope and net for culture in four repetitions with 127 grams per each treatment. Finally, a total amount of 508.574 grams of samples was studied for culture on the rope. The said amount equals to total weight of alga cultured on the net for 507.812 grams and shall equalize density (primary reservation of samples) in the treatments subject of study.

During culture period, water of the aquariums was replaced once every two days by 40-50%. Also, 0.3-0.5 grams of Urea was added to the environment.

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Moreover, some of the environmental factors such as pH, salinity and temperature were measured and recorded every day.

In order to designate the increase of wet weight of the alga culture on rope and net, biometrics operation was carried out using a digital scale with a preciseness of 0.001 grams per gram once every week. For calculation of ration of daily growth and net production, the following formulations were used:

$$R = \frac{\mathrm{Ln}W_t - \mathrm{Ln}W_0}{t} \times 100$$

$$W = \frac{W_t - W_0}{t}$$

W_t =Weight after t days; t = number of days of culture

R and W= percentage of daily growth (%day/m^{-2}) and net production (gr/m^{-2}/day).

Data was analyzed using Student-T Test in order to specify significance of difference among treatments and unilateral variance analysis test ANOVA and Duncan's Complementary Test was used to specify the significance of statistical difference among repetitions with a level of reliability given as 95%.

III. Results

A. Changes of Temperature, pH and Salinity in Samples Subject of Study

According to Table I, maximum and minimum values, temperature, salinity and pH during culture period in the respective treatments have been given. Comparing the changes in temperature, pH and salinity among the treatments subject of this study, it is revealed that change in environmental factors studied in culture environments for the treatments subject of this research have been equal.

TABLE I
MINIMUM AND MAXIMUM PH, TEMPERATURE AND SALINITY OF WATER OF AQUARIUMS

Treatment	Temperature (°c)		pH		Salinity (ppt)	
	min	max	min	max	min	Max
First treatment (Culture on net)	27	32	8.29	8.45	40	48
Second treatment (Culture on rope)	27	32	8.28	8.45	41	48

B. Changes in Daily Growth Percentage and Net Production in the Treatments

Tables II-IV indicate the results obtained from daily growth percentage (percentage per 0.5 m2 every day) and net production (gram per 0.5 m2 every day) for the treatments.

Thus, daily growth percentage and net production for predicted treatments have been calculated as 0.934 and 6.072 for the first and 0.797 and 4.990 for the second treatments respectively.

Relying on these results, it has been revealed that daily growth percentage and net production in the first treatment (culture on net) was higher than that of the second (culture on rope) and indicated higher level of growth accordingly.

TABLE II
AVERAGE OF DAILY GROWTH PERCENTAGE AND NET PRODUCTION IN THE RESPECTIVE REPETITIONS STUDIED IN TREATMENT ON NET

	R5 (Control)	R6	R7	R8	Total	Average
Daily growth percentage (% /0.5 m2/Day)	0.801	1.110	0.974	0.850	3.735	0.934
Net production (Gram /0.5 m2/Day)	1.257	1.890	1.589	1.338	6.072	1.518

TABLE III
AVERAGE OF DAILY GROWTH PERCENTAGE AND NET PRODUCTION IN THE RESPECTIVE REPETITIONS STUDIED IN TREATMENT ON ROPE

	R1	R2	R3	R4 (Control)	Total	Average
Daily growth percentage (% /0.5 m^2/Day)	0.875	0.794	0.809	0.713	3.190	0.797
Net production (Gram /0.5 m^2/Day)	1.395	1.243	1.265	1.087	4.990	1.247

Comparing net production and daily growth percentage among the repetitions studied in both treatments, it may be stated that since repetitions 4 and 5 have been regarded as control repetition and no feeding has been done, less daily growth and net production compared to other repetitions have been found in the said study.

Low net production and daily growth percentage in control repetition were found in both treatments. This process has not been beyond expectation due to importance of feeding and accessibility of nutrients for growth of alga.

TABLE IV
COMPARING THE AVERAGE OF DAILY GROWTH PERCENTAGE AND NET PRODUCTION

Treatment	Average of primary weight (gr)	Average of final weight (gr)	Daily growth percentage (% /0.5 m^2/Day)	Net production (gr /0.5 m^2/Day)
Culture on net	507.812	811.432	0.934	6.072
Culture on rope	508.071	758.071	0.797	4.990

Statistical comparison of daily growth percentage, net production and final wet weight of *G. corticata* among the treatments obtained based on Student-T Test, have been given in Table V.

Table V reveal that average of daily growth percentage, net production and final wet weight in the treatments subject of study show a significant difference ($P<0.05$).

TABLE V
SIGNIFICANCE OF NET PRODUCTION-DAILY GROWTH PERCENTAGE AND FINAL WET WEIGHT IN TREATMENTS

	Net Production	Average daily growth percentage	Final wet weight
T1-T2	S	S	S

S: Significant Difference NS: No Significant Difference

Moreover, in order to study the significance of difference among net production final wet weight and daily growth

percentage, Duncan's Complementary test was used in control repetition of both treatments. The results have been given in Tables VI and VII. The results reveal that in the first treatment, final wet weight, daily growth percentage and net production in the 5th repetition as control repetition has shown no significant difference with repetitions 2, 3 and 8. However, upon the 6th and 7th repetitions, it has shown a significant difference. Moreover, in the second treatment, final wet weight, daily growth percentage and net production were considered as control repetition in the 4th repletion and showed a significant difference with other repetitions (repetitions No 1, 2, 3, 5, 6, 7 and 8).

TABLE VI
DIFFERENCE IN NET PRODUCTION, DAILY GROWTH PERCENTAGE AND FINAL WET WEIGHT

	T1-5(Control repetition in culture on net)						
Treatment-Repetition	T 2-1	T 2-2	T 2-3	T 2-4	T 1-6	T 1-7	T 1-8
Net production	NS	NS	NS	S	S	S	NS
Daily growth percentage	NS	NS	NS	S	S	S	NS
Final wet weight	NS	NS	NS	S	S	S	NS

S: Significant Difference NS: No Significant Difference

TABLE VII
DIFFERENCE IN NET PRODUCTION, DAILY GROWTH AND FINAL WET WEIGHT

	T2-4(Control repetition in culture on rope)						
Treatment-Repetition	T 2-1	T 2-2	T 2-3	T 1-5	T 1-6	T 1-7	T 1-8
Net production	S	S	S	S	S	S	S
Daily growth percentage	S	S	S	S	S	S	S
Final wet weight	S	S	S	S	S	S	S

S: Significant Difference NS: No Significant Difference

C. Final Wet Weight in the Treatments

Higher final wet weight of the treatments subject of study has been given in Table VIII. In this study, study of final wet weight of the first treatment was higher than that of the second treatment. This equaled to 811.432 and 758.071 grams respectively.

TABLE VIII
FINAL WET WEIGHT OF *G. CORTICATA*

	T1				
Final wet weight	R1	R2	R3	R4 (Control)	Total
	196.823	189.799	190.163	181.286	758.071
	T2				
Final wet weight	R5 (Control)	R6	R7	R8	Total
	190.387	221.849	205.981	193.215	811.432

IV. DISCUSSION

The results of study of the environmental factors such as temperature, pH and salinity have shown that during culture period, temperature, pH and salinity were fluctuating from 27 to 32 degrees centigrade, 8.28 to 8.45 and 40 to 48 parts per thousand respectively. These values were at desirable level and had no undesirable effect on growth and net production of the species in the treatments subject of study.

Considering the effect of pH on *G. corticata* and its changes on growth of the species, it should be said that since the values of 6-9 were given as suitable pH on culture of *G. corticata* and its optimum has been reported within the range of 8.2 -8.7, and that all repetitions subject of study were replaced for water once every two days during the culture period, this causes slight amount of carbon is injected to the environment and following formation of CO_2 solved in water as used by alga, increased pH is removed. Thus, the measured values of pH during culture have not shown high fluctuations and in the treatments subject of study its minimum and maximum values were given as 8.28 and 8.45 respectively.

Consequently, since temperature and salinity were constant for the treatments used in this study and comparing the said conditions to the required optimum values by *G. corticata* [3], [14], it may pointed out that these two factors have no significant effect on growth of the species during culture period and have not influenced its growth either. Considering recorded values of pH, although urea fertilizer used during the culture period was effective on the values of pH to some extent, these values have not been effective since water was regularly replaced. Fluctuation area of pH could not be effective on the growth of this species so that the fluctuation area of pH calculated in fed repetitions equaled to control treatments and no significant changes were observed in the said repetitions either. Thus, one may come up with this conclusion that the only factor that is effective on culture of *G. corticata* under artificial farming conditions in an open environment for its growth is the culture method used for its farming.

In this research, during culture of *G. corticata* in the control samples where no feeding was conducted, lower growth is observed compared with the fed samples using urea. The cause is attributed to urea, which is a nutrient for supply of the required nitrogen [12].

Moreover, in the samples not fed, more evident change is observed and during culture period, the color of the control sample alga was changed to dark brown.

This may be because of lack of or insufficient amount of nitrogen in the environment and eventually inside the reservation alga. Instead, in the samples fed using urea, due to appropriateness of consumed nitrogen, not only color of thallus has not been changed but also due to nitrogen reservation in form of metabolites such as pigments and protein, color of thallus in the said samples was brick red.

The results of this research have revealed that increase of SG increase of cultured *G. corticata* on net compared to culture on rope is more appropriate. During the culture period, longitudinal growth of *G. corticata* was equal in both treatments and it reached from 8-10 to 10.5-13 cm. It may be said that salinity during summer was more due to huge quantity of evaporation. Thus, the said plant had slight longitudinal growth during summer season. This characteristic goes the same with other sea plants that reduce their body size due to high quantity of salt in seawater and shrunk to avoid absorbing additional salt. Moreover, the obtained weight in

treatment on net was higher than of treatment on rope so that in the first treatment, its weight reached from 10 to 20.119 grams. Comparing the second treatment, it showed equal longitudinal growth. However, increase of its SG was lower reaching from 10 to 17.663 grams.

The results reveal that *G. corticata* has a noticeable SG. However, its longitudinal growth is less [1], [3], [10].

The results have revealed that daily growth percentage and net production for treatments subject of study was different. Thus, treatment on net has shown the highest daily growth percentage and net production. This value in daily growth percentage and net production was given as 0.934, 6.072, 0.797 and 4.990 in the first and second treatments respectively. This reveals a significant statistical difference.

Moreover, the results have revealed the function of *G. corticata* through culture on net is higher than culture on rope [2], [5]-[7], [10], [13].

Concerning the fact that *G. corticata* enjoys a noticeable SG, this may be due to stands and thalluses are placed on bed for lining. Since any of thallus in the species is used as leaning and creating new branches on its connection area to bed, it can be said that culture method on net causes development of numerous branches and increase of growth and biomass since alga enjoys wider bed area.

It should be noted that culture method on net promotes photosynthesis and eventually higher production and growth in this method since wider surface area of *G. corticata* is exposed to sunlight [7] while using culture method on rope, due to location of alga on the rope, less surface area of the species is exposed to sunlight and less photosynthesis occurs and eventually, net production is less.

Since culture area is less using culture method of *G. corticata* on rope, in sea natural environment, upon biomass of the transplants cultured on rope, unicellular alga cause completion in absorbing light and nutrient elements. Due to growth of the unicellular alga on photosynthesis surface of *G. corticata* on ropes, making material and production decrease by using this method of culture compared to culture on net.

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