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Growth performance of *Catenella nipae* on bamboo poles in the inter-tidal mangrove swamps of Chittagong coast

Abstract

Macro-benthic algae *Catenella nipae* was cultured from November '06 to August '07 at the Salimpur planted mangrove area of Chittagong Coast. Growth of the cultured *C. nipae* on bamboo poles was measured during the investigation period. Average growth of *C. nipae* on bamboo poles was recorded 0.19cm/day. Physico-chemical parameters of water and soil were recorded during culture period in the tidal swamp of Salimpur mangrove area. Water temperature ranges from 24.0 to 31.5˚C, salinity from 6.0 to 21.0‰, dissolved oxygen (DO) from 3.8 to 5.8ml/l, water pH from 7.2 to 8.4, total dissolved solids (TDS) from 410 to 598mg/l, , total suspended solids (TSS) from 50 to 118mg/l, Total alkalinity from 95 to118 ppm, NO_2-N from 0.18 to 0.47mg/l, NO_3-N from 0.56 to 0.69mg/l, PO_4-P from 0.90 to1.10 mg/l, HCO_3 from 69.88 to 93.80mg/l, were recorded during culture period. Soil organic carbon, organic matter, soil PO_4-P, soil pH were ranges from 2.22-2.37%, 4.22-4.51%, 1.10-1.39mg/100g and 5.9-6.7, respectively in the culture area. Growth of *C. nipae* showed a significant positive relation with water and soil parameters such as dissolved oxygen (DF=17, P=0.006, t=3), NO_3-N concentration (DF=17, P=0.055, t=2) and a negative correlation with HCO_3 concentration (DF=17, P=0.004, t=3). Physico-chemical parameters of both water and soil revealed that the coastal area of Salimpur could be a significant place for commercial culture of seaweeds *C. nipae* in Bangladesh.

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Mohammad Rokan Uddin
Institute of Marine Sciences and Fisheries, University of Chittagong, Bangladesh

Correspondence: Mohammad Rokan Uddin, Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong-4331, Bangladesh, Tel +880-1819097919, Email rokancu@gmail.com

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Introduction

Seaweeds are sedentary organisms, growing on the rocky or hard substratum of intertidal water of World Ocean.[1] They belong to the group of plants known as algae containing some of the most primitive members of the plant kingdom.[2] Okazaki[3] stated, "Seaweeds as the name implies covers the macroscopic plant life of the sea except for the flowering plants". It has immense importance both for human and faunal communities. Prehistorically, people have been consuming seaweed either raw or cooked condition. Novaczek[4] reported that seaweeds have large amount of protein, amino acids, lipids, vitamins and minerals, polysaccharides and dietary fibers. Some compounds of seaweeds control high blood pressure, level of cholesterol, and prevent strokes. These can also be used as remedy for rheumatism, diarrhea, and for controlling the growth of tumors.

The culture of seaweed for human consumption is a relatively new enterprise. The concept of seaweed and its cultivation is limited to the scientific community, people hardly known about its importance and culture technique in developing countries. The status of seaweed cultivation in Bangladesh is still at the nascent stage.

The study is first experiment of *Catenella nipae* culture on bamboo poles in the intertidal waters of Salimpur coast in Bangladesh where plenty of *C. nipae* grows naturally remains unutilized for long time. In addition, now-a-days utilization of algae as human food has been increasing in many countries like China, Japan, Philippines and Myanmar.[5] Whereas the mass people of Bangladesh do not know that the algae can be used as human food.

Materials and methods

The investigation was carried out from November 2006 to August 2007 at Salimpur mangrove area. Bamboo poles were used for culture of *Catenella nipae.* A total area of 5mx5m was selected. To culture *C. nipae* on bamboo poles, at first bamboo poles were collected and cut into 0.5m size length each. Within the culture area bamboo poles were installed maintaining 0.5m distance between two consecutive poles. Then body segments of *C. nipae* from the nature were collected and were attached in the bamboo poles with the help of thread. Routine checked of the culture system was done. After each three months interval culture experimental algal species was collected carefully with the help of a sharp knife and taken in to plastic bag. Water and soil sample were collected from the intertidal mangrove areas of Salimpur coast during study period and analyzed using standard methods APHA.[6]

Results

Measurement of growth

The average daily growth was observed as 0.19+ 0.11cm during the culture period. Maximum daily average growth was 0.29cm in August 2007 and minimum value was recorded 0.11cm on July 2007 (Table 1). There is no major trend of fluctuation for the growth of *C. nipae* in the culture period. Growth of *Catenella nipae* shows a positive correlation with DO (DF=17, P=0.006, t=3) and NO_3-N (DF=17, P=0.055, t=2) concentration. A negative correlation was found between growth of *Catenella nipae* & HCO_3 concentration (DF=17, P=0.004, t=3).

Abundance of pneumatophores and natural biomass

In the present study the in parallel with culture performance growth of *C. nipae* was measured in the natural environment. The average number of pneumataphores found as 79.1+7.73 and average natural biomass content was found 159.10+41.14 g/m^2 (Table 2) whereas the maximum values in per pneumatophore was recorded on November (2.90) and minimum value was on March (1.52). A Significant relationship was found between number of Pneumatophores and biomass of *Catenella nipae* of the Salimpur mangrove area (t=3, P=0.0106, DF=29) and it was observed that biomss is proportionally related with the availability of water.

Table 1 Growth of the colony of *Catenella nipae* after attachment

Bamboo No.	Initial length (cm)	Measurement on Feb, 2007			Measurement on May, 2007			Measurement on August, 2007		
		Length (cm)	Growth (cm)	Daily Growth (cm)	Length (cm)	Growth (cm)	Daily Growth (cm)	Length (cm)	Growth (cm)	Daily Growth (cm)
1	2.5	5.08	2.58	0.08	8.47	3.39	0.11	22.86	14.39	0.46
2	4.96	10.16	5.2	0.17	12.7	2.54	0.08	21.59	8.89	0.29
3	3.01	6.35	3.34	0.11	11.85	5.5	0.18	22.86	11.01	0.36
4	5.07	11.43	6.36	0.21	12.7	1.27	0.04	20.32	7.62	0.25
5	2.54	5.08	2.54	0.08	11.01	5.93	0.2	19.05	8.04	0.26
6	10.98	20.32	9.34	0.3	22.31	1.99	0.07	25.32	3.01	0.1
Mean				0.16			0.11			0.29
Total Mean	0.19cm									

Table 2 Abundance of Pneumatophores along with natural biomass (g/m^2) of *Catenella nipae* in the vicinity of culture area

Month	Sample	Quadrate 1	Quadrate 2	Quadrate 3	Mean
November	Pneumatophores	75	82	98	85
	Biomass (g)	250	240	250	246.67
December	Pneumatophores	80	78	75	78
	Biomass (g)	160	150	140	150
January	Pneumatophores	80	76	84	80
	Biomass (g)	195	210	185	196.66
February	Pneumatophores	76	81	72	77
	Biomass (g)	120	150	160	143.33
March	Pneumatophores	73	60	70	68
	Biomass (g)	115	100	95	103.33
April	Pneumatophores	84	80	75	80
	Biomass (g)	150	140	155	148.33
May	Pneumatophores	81	90	75	82
	Biomass (g)	150	180	195	175
June	Pneumatophores	72	83	95	84
	Biomass (g)	120	135	150	135
July	Pneumatophores	75	80	70	75
	Biomass (g)	110	118	125	117.67
August	Pneumatophores	92	85	76	85
	Biomass (g)	150	180	195	175

Harvesting

After the culture period of three months, *Catenella nipae* colony weight on average was found as 176+4.97g on the bamboo poles.

Water and soil parameters

The average water temperature was recorded as 29.05+2.45˚C whereas highest value (31.5˚C) was recorded on June 2007 and the lowest 24˚C in February 2007, average salinity was 14.30+5.35‰, highest salinity was recorded 21‰ on March 2007 and lowest 6‰ on August 2007, average D.O was (4.95+0.62ml/l) where highest 5.80ml/l on July and lowest value 3.80ml/l on December 2007, average pH was (7.78+0.37) where maximum was 8.4 on February 2007 and minimum was 7.2 on August 2007, average TDS was (541.10±59.35mg/l) where highest value 598.00mg/l was recorded on July 2007 and the lowest value 410.00 mg/l on February 2007, average TSS was (76.30±22.01mg/l) where the highest value 118.00 mg/l was recorded on Augus 2007 and the lowest value 50.00mg/l on April 2007, average alkalinity was (107.40+6.92ppm) where maximum 118.00 ppm was on February 2007 and the lowest value 95 ppm on August 2007, average NO_2-N as 0.34+0.09mg/l where highest NO_2-N value was found 0.47mg/l on June 2007 and lowest value 0.18mg/l was recorded on February 2007 average NO_3-N was 0.65+0.05mg/l where highest NO_3-N value was f.ound 0.69mg/l on May 2007 and lowest value 0.56 mg/l was recorded on January 2007, average PO_4-P was recorded as 0.99+0.06 mg/l where , highest PO_4-P value was found 1.10mg/l on January 2007 and lowest value 0.90mg/l was recorded on June 2007, average HCO_3 was observed as 81.33+4.50mg/l where highest HCO_3 value was found 93.80mg/l on June 2007 and lowest value 69.88mg/l was recorded on February 2007and average BOD was recorded 1.86+0.17ml/l where highest value was 2.16ml/l on November 2006 and lowest value 1.56ml/l on June 2007 respectively in the study area (Table 3).

The average soil organic matter was recorded as 4.39+0.10%, the highest value was 4.51% was recorded on January 2007 and the lowest value 4.22% in July 2007. The mean organic carbon was recorded as 2.31+0.05%, the highest value was 2.37% was recorded on November 2006 and January 2007 respectively and the lowest value 2.22% on July 2007. Average PO_4-P was observed as 1.28+0.10mg/100g. Highest PO_4-P value was found 1.39 mg/100g on August 2007 and lowest value 1.10 mg/100g was recorded on March 2007. The average soil pH was 6.30+0.28. Maximum soil pH 6.7 on January 2007 and minimum value was recorded 5.9 on August 2007. The soil texture of the study area was sandy clay loam. Sand ranges from 67.00% to 72.68%, Clay ranges from 23.69% to 29.60%, Silt ranges from 2.50% to 5.11% during the whole study period (Table 4) (Table 5).

Table 3 Physico-chemical parameters of tidal water in the culture site of *C. nipae* (November 06 to August 07)

Month	Water Temp. ˚C	Salinity ppt	D.O ml/l	Water pH	T.D.S mg/l	T.S.S mg/l	T.A	NO2-N mg/l	NO3-N mg/l	P04-p mg/l	HCO3	BOD ml/l
							ppm				mg/l	
November	26	10	4.5	7.5	585	78	115	0.38	0.69	1.01	70.8	2.16
December	28	18	3.8	7.7	547	65	110	0.36	0.66	1.09	75.33	2.05
January	30	20	4.2	7.9	498	69	102	0.25	0.56	1.1	73.25	2
February	24	16	5.3	8.4	410	58	118	0.18	0.65	0.99	69.88	1.98
March	31	21	5.8	8.2	467	57	113	0.22	0.61	0.96	71.8	1.92
April	30	20	5.2	7.9	563	50	111	0.37	0.58	0.97	85.05	1.88
May	30	15	4.8	8.1	578	67	107	0.35	0.69	0.99	92.98	1.78
June	31.5	10	4.9	7.4	593	89	103	0.47	0.68	0.9	93.8	1.56
July	30.27	7	5.8	7.5	598	112	100	0.42	0.69	0.93	91.87	1.63
August	29.75	6	5.2	7.2	572	118	95	0.4	0.69	0.95	88.56	1.67

DO, dissolved oxygen; TDS, total dissolved solid; TSS, total suspended solid; TA, total alkalinity; BOD, biological oxygen demand; COD, chemical oxygen demand

Table 4 The physico-chemical parameters of soil in the culture site of *C. nipae* (November 06 to August 07)

Month	% of Organic carbon	% of Organic Matter	PO4-P mg/100g	Soil pH	Soil Texture			Classification of Soil
					% of Sand	% of Clay	% of Silt	
November	2.37	4.5	1.16	6.1	67.58	27.85	4.57	
December	2.35	4.48	1.27	6	68	29.12	2.88	
January	2.37	4.51	1.38	6.7	67.95	28.86	3.19	
February	2.34	4.46	1.26	6.5	67	29.6	3.4	
March	2.31	4.4	1.1	6.6	69.55	26.9	3.55	
April	2.27	4.33	1.15	6.5	70	24.88	5.11	
May	2.24	4.26	1.33	6.5	72.68	23.69	3.63	Sandy Clay loam
June	2.26	4.3	1.36	6.2	71.9	25.6	2.5	
July	2.22	4.22	1.35	6	70.55	26.53	2.92	
August	2.34	4.45	1.39	5.9	69.88	26.95	3.17	

Table 5 Correlation Matrix between the Biomass of *Cattenella nipae* with different water parameters

	Biomass (g)	D,O (ml/L)	NO_2-N (ml/L)	NO_3-N (ml/L)	PO_4-P (ml/L)	HCO_3 (ml/L)	BOD (ml/L)
Biomass (g)	1						
D,O (ml/L)	-1	1					
NO2-N (ml/L)	1.00E-01	-9.00E-02	1				
NO3-N (ml/L)	1.00E-01	8.00E-02	1	1			
PO4-P (ml/L)	5.00E-01	-1	-4.00E-01	-4.00E-01	1		
HCO3 (ml/L)	-3.00E-01	3.00E-01	1	4.00E-01	-1	1	
BOD (ml/L)	1	-5.00E-01	-1	-4.00E-01	1	-1	1

Discussion

Growth performance of *C. nipae*

In the present study the daily growth was observed 0.19cm/day on the bamboo poles in an average which suggest a suitable rate for culture of this alga in this area. And growth of the cultured algae showed a significant positive relation with dissolved oxygen (DF=17, P=0.006, t=3) (Figure 1), NO_3-N concentration (DF=17, P=0.055, t=2) (Figure 2), and a negative correlation with HCO_3 concentration (DF=17, P=0.004, t=3) (Figure 3).

Soe-Htun et al.[7] reported luxuriant growth of *Catenella* on the bamboo stakes in an experimental culture in Myanmar. These were harvested using a spoon. The yield of *Catenella* was about 40-50g (wet-wt.) per bamboo stake (Figure 4).

There are the components in sea water in concentrations of mg-atoms/m^3 that are of fundamental importance to the growth of marine algae, the base of the food chain in the sea. These components are soluble inorganic phosphate (0.1-3.5mg-atoms/m^3), nitrate (0.1-43mg-atoms/m^3), nitrite (0.1-3.5mg-atoms/m^3), ammonium (0.35-3.5mg-atoms/m^3), and hydrated silicate ions (0.1-170mg-atoms/m^3). These marine fertilizers are consumed only in the upper layers of the ocean where light conditions permit photosynthesis and are often limiting to growth.[8]

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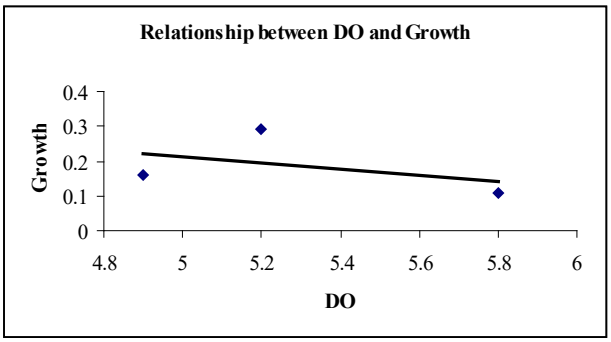

Figure 1 Scatter diagram showing relation between DO and growth.

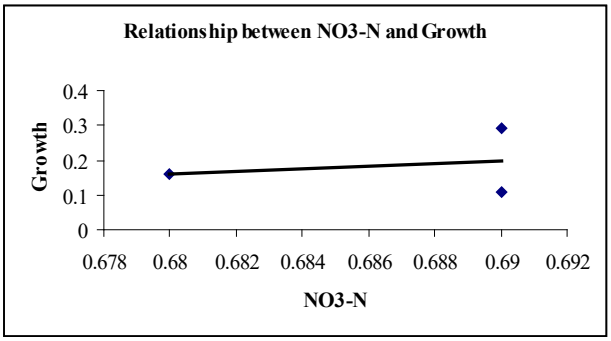

Figure 2 Scatter diagram showing relation between NO_3-N and growth.

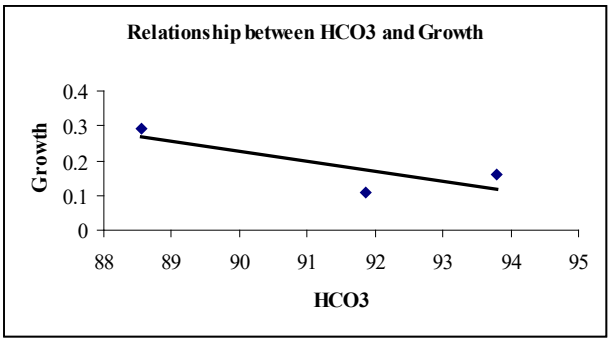

Figure 3 Scatter diagram showing relation between HCO_3 and growth.

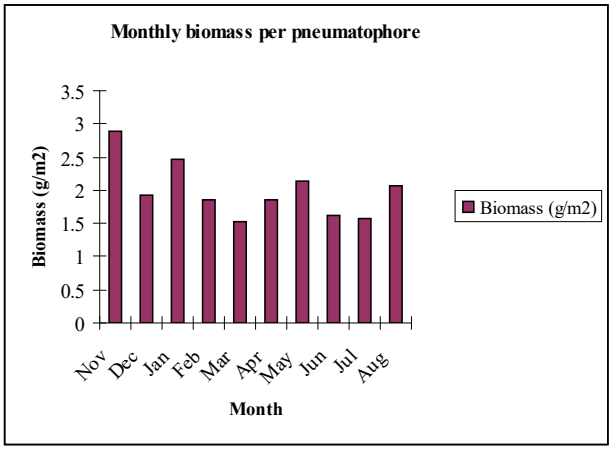

Figure 4 Graphical presentation of monthly biomass content in each pneumatophore.

Physico-chemical parameter

The growth of seaweeds is governed by various factors like temperature, salinity, pH, dissolved oxygen, water transparency; nutrients Lunning.[9] His studies found that for the growth of tropical seaweeds the optimum water temperature ranges between 15-30˚C. The findings of the present investigation is exclusively agreed with the above mentioned report.

Meade[10] recommended standard water quality for aquaculture as water pH 6.5-8, DO 5mg/l, and alkalinity 10-400ppm. The mean D.O value was found (4.95+0.62)ml/l in the present investigation which is quite satisfactory for normal growth and functioning of aquatic organisms. While the standard values of D.O of the coastal water of Bangladesh is 6ml/l.[11] So the present findings are exclusively agreed with the above information.

The environmental quality standard value of pH of coastal water of Bangladesh is 6-9. Zafar[12] found, the water temperature, salinity, pH, DO ranged from (30-33˚C), (6-16ppt), (6.9-7), (2.95-5.77ml/l) at the Fauzdarhat planted mangrove area. The present study also showed a similar trend of results.

Hossain[13] recorded water temperature, salinity, water pH, DO ranged from (20-29˚C), (6.5-16ppt), (6.8-7.4), (3.77-5.50ml/l) at the Fauzdarhat mangrove area. In the present investigation recorded water temperature, salinity, DO, water and soil pH were more or less similar to the above mentioned report.

Talukder[14] recorded water temperature ranged between 11.65-31.40˚C, water pH 6.27- 7.75, dissolved oxygen 2.34-5.71ml/l, salinity ranges from 6.51-16.30 ppt, total suspended solids ranges between 112.03mg/l to 343.34mg/l, total dissolved solids 377.16mg/l to 573.32mg/l, PO_4-P ranges from 1.01-4.68ml/l, NO_3-N varied from 1.15-3.34ml/l, BOD 2.95-6.63ml/l, soil pH 5.30-7.70 in a study on macrobenthic algae of the Fauzdarhat coast, chittagong. The findings of the present investigation are apparently similar to the above mentioned report.

Chowdhury[15] reported the micronutrients of the coastal water of Cox's Bazar and recorded maximum (NO_2-N=1.520µ-g at/l, PO_4-P=1.804µ-g at/l and SiO_3-Si=46.62µ-g at/l) during July to August and minimum (NO_2-N=0.084µ-g at/l, PO_4-P=0.224µ-g at/l and SiO_3-Si=3.28µ-g at/l) during November to December respectively. Noori (1999) reported the micronutrients concentration of the coastal water of southeast coast of Bangladesh and recorded maximum (NO_2-N=1.198µ-g at/l, PO_4-P=2.330µ-g at/l and SiO_3-Si=63.31µ-g at/l) during May to August and minimum (NO_2-N=0.020µ-g at/l, PO_4-P=0.075µ-g at/l and SiO_3-Si=0.673µ-g at/l) during September to December respectively. The findings of the present investigation are apparently similar to the above mentioned report.

Grant[16] recoded the inter-tidal soil pH ranged from 7.6 to 8.1 from the inter-tidal sand flat of North Inlet, South Carolina, U.S.A. Islam[17] recorded pH values ranged from 6.35 to 6.85 in bottom sediment collected from lower Meghna river estury during premonsoon. Present findings are more or less similar to these above mentioned report.

Within the marine sediments there is generally a decrease in organic content with depth in the deposit. Correns,[18] Revelle and Shepard[19] have all reported this characteristics distribution. Connell,[20] obtained a linear relationship between organic matter and calcium carbonate and concluded that calcareous material contained about 0.2% organic matter and having no calcareous material contained a constant proportion of organic matter. Kondalarao and Murty[21] reported that organic matter of intertidal zone of the Kinda bay,

east coast of India was 0.70% to 2.17% which is closely similar to the present observation where organic matter varied from 4.22% to 4.51%.

Vizakat et al.[22] expressed that the texture of sediment as silty clay'sand silts; silty sand of the subtidal soft sediment of the west coast of India. Alam[23] recorded the seasonal variation of sediment percentage in the Halishahar coast; Chittagong and he found maximum sand percentage in monsoon and minimum in winter, which is similar to the present investigation.

Growth of *Catenella nipae* shows positive relation with physico-chemical parameter of water viz. with T.S.S (r=0.43355), NO_3-N(r=0.0.2485), NO_2-N(r=0.963417), PO_4-P(r=0.0.612974), BOD (r=0.0.579897) and negative relation with DO (r=-0.44623), Temperature (r=-0.51815), HCO3 (r=-0.79903), pH (r=-0.99814), T.D.S (r=-0.99593), Total alkalinity (r=-0.79447) in the present investigation. Soil parameter viz. organic matter (r=0.997018), organic carbon (r=0.998137), PO_4-P (r=0.999554) shows positive relation and soil pH (-0.55191) shows negative relation with growth.

Conclusion

If the proper steps are taken for seaweed culture and management, it may open a new avenue for the local farmers, creating an alternative livelihood option. Thus, phyco-aqua industry will come as an indicative tool for national economic emancipation, poverty alleviation, mitigating unemployment problems and finally maintaining socio-economic condition of the coastal poor communities of Bangladesh. No systematic study on this economic seaweed has done in Bangladesh before. Therefore, the present study can be the path-finder on the detailed study of specific seaweed for the enrichment of the study of phycology in Bangladesh.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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