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# FEASIBILITY OF SEAWEED CULTURE IN INANI AND BAKKHALI COAST OF COX'S BAZAR, BANGLADESH

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**ABSTRACT:** The study was analyzed physico-chemical parameters of seaweed culture sites and culture feasibility for a seaweed (*Hypnea* sp.) in Bakkhali and Inani of Cox's Bazar coast, Bangladesh. The results obtained by the water salinity, temperature, transparency, pH and DO are very much suitable for seaweed cultivation. The water and soil nutrients of Saint Martin and Bakkhali were also comparable, indicated the suitability of seaweed culture. Seaweed *Hypnea* sp. was cultured in Bakkhali and Inani along with Saint Martin using 4m x 4m coir rope net attached to bamboo pole for a period of two months in winter. Maximum daily growth rate of 3.21±0.01%/day at 60$^{th}$ day from Saint Martin and minimum daily growth rate of 0.41±0.11%/day at 15$^{th}$ day from Inani was observed. Significantly higher biomass of seaweeds (11.05±0.10 kg fresh wt./m$^2$) yielded in Saint Martin than Bakkhali ($p<0.001$) and Inani ($p<0.001$). Bakkhali and Inani could be suitable areas of seaweed culture added a new dimension to mariculture prospect of Bangladesh.

**KEYWORDS:** Seaweeds, *Hypnea* sp., Cox's Bazar.

## INTRODUCTION

Macroscopic marine algae, commonly known as 'seaweeds', has morphological characteristic to attach and colonize over the hard substratum of shallow water zone of the coast which is suitable for their enormous growth. Seaweeds regarded as a high profile commercial marine biota for its variety of uses, like raw materials of bio-chemicals (agar, agarose, algin, carrageenan), dyes, food, feed, enzymes and drugs (Athithan, 2014). In Bangladesh, the natural abundance of seaweeds is reported from the south-eastern part of the country and Saint Martin Island have enormous natural growth of seaweeds. About 200 species belonging to 77 genera of seaweeds have been recorded in the coastal and estuarine areas of Bangladesh, whereas 1500 metric ton of red seaweed biomass is available around St. Martin's Island (Aziz, 2015). Natural status quo and survey showed that *Hypnea* sp. is a fast growing species, found abundantly in St. martin, Cox's Bazar coast (Zafar, 2007). Moreover, *Hypnea* sp. is an important economic algae which is used for food among people and also as a raw material for industrial uses in many Asian countries (F. Liu, 2001). Due to its tolerance over a wide range of water temperatures, salinities and light intensities (Dawes *et al.*, 1976), *Hypnea* sp. cultivation have been initiated in several countries (Humm and Kreuze, 1975; Mshigeni, 1976; Rao and Subbaramaiah, 1980; Guist *et al.*, 1982; Liu, 2001).

Seaweed as a low level, absorb nutrients from the surrounding waters through thallus to live and grow well. For this process, seaweed needs suitable physical and chemical water quality factors related to current, temperature, salinity, nitrate and phosphate level as well as exposure to sunlight for growth (Trono, 1993). Therefore, study of suitable sites for seaweed cultivation is crucial and necessary. Identification of suitable species and development of commercial culture techniques of seaweed might benefit Bangladesh with its new vision of “Blue Economy”. Hence, the aim of this study was to identifying potential seaweed farming areas based on environmental parameters and seaweed growth in Cox’s Bazar coast.

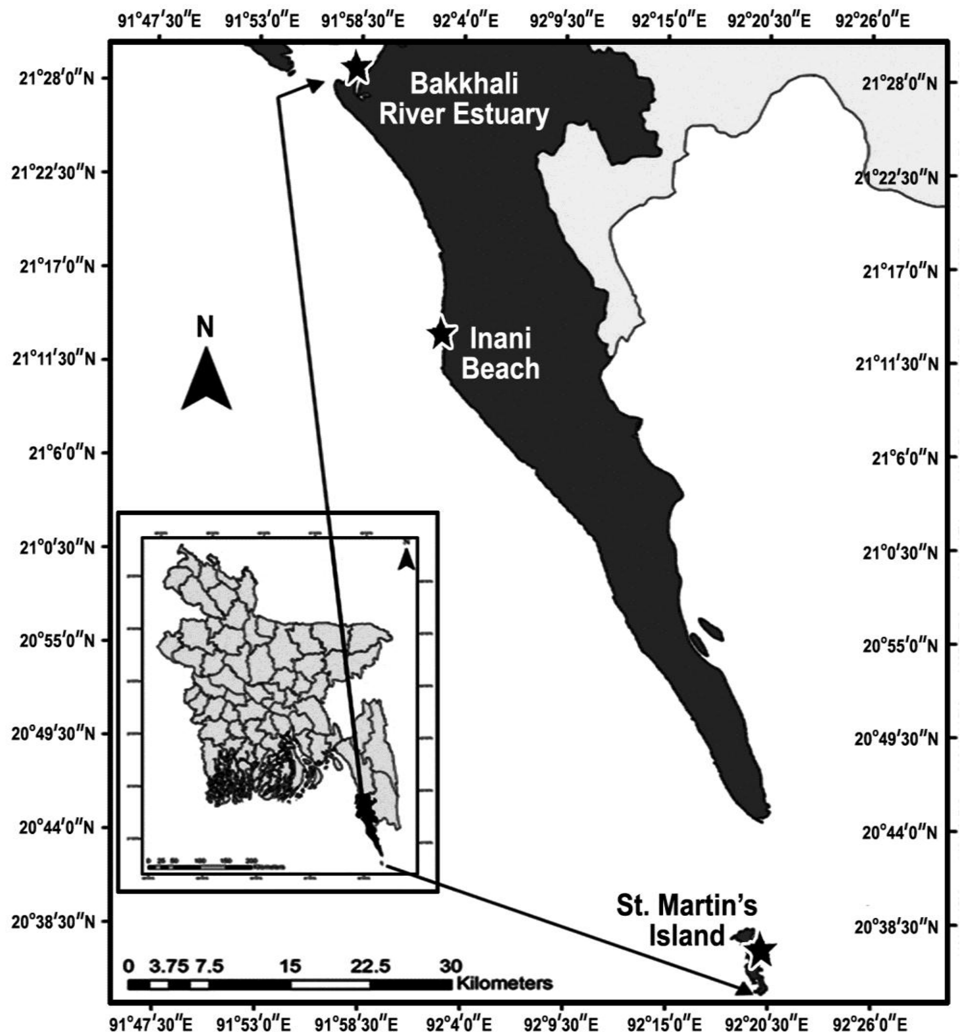


Fig. 1. Seaweed culture sites at Saint Martin, Inani and Bakkhali of Cox’s Bazar.

## MATERIALS AND METHOD

Seaweed culture suitability study on Cox's Bazar coastal waters devoted to the allotment of site suitability for cultivation of naturally abundant seaweed *Hypnea* sp. through the analysis of physical and chemical environmental conditions and growth.

**Study area:** Study was conducted from November 2015 to February 2016 in the Cox's Bazar coast, south-east Bangladesh. Three experimental sites were selected on sheltered intertidal zones of Saint Martin Island (N20°37.043, E092°19.715), Bakkhali river estuary (N21°28.500, E091°57.941) and Inani (N21°13.941, E092°02.596) of Cox's Bazar district (Fig. 1) along the north eastern coast of the Bay of Bengal. The site of St. Martin Island is sandy and rocky bottom, protected by the coral reef with slanting; wave action is weak, which supported favorable environment for several seaweed species (Hossain *et al.*, 2007). Bakkhali river estuary sites is sandy to muddy bottom with luxuriant growth of seaweeds (Hena *et al.,* 2013). Inani beach site has sandy bottom with boulders, pebbles, broken shells and naturally grown seaweeds observed in this area (Umamaheswara, 1974).

**Seaweed culture method:** For seaweed culture, a square net frame of 4 m x 4 m size fabricated with coir rope (obtained from coconut husk) was chosen as a support since it has loose braids to hold the seaweed seedlings. Coir rope with 16 mm diameter was used and the mesh size of the coir rope nets on the culture frame was maintained as 20 cm.

**Seaweed species:** Young, growing fragments of *Hypnea* sp. collected from the study areas were used as initial seedlings. Seedlings were grown by inserting the young fragments of *Hypnea* sp. with an average of 4±0.5 kg fresh weight and 5 cm length in the twists of the coir ropes. Culture net were anchored by bamboo poles and kept afloat at the surface level with plastics floats. The frame was tied loosely to the poles and fixed in a submerged so as to facilitate its going up and down vertically according to the tide. Seaweeds were partially harvested at 15 days interval when they reached an average of 30±5 cm length. Partial harvest was done by clipping the alga hanging on the rope leaving the base on the rope to grow further. Initially 1±0.01 Kg fresh weight/$m^2$ and 5 cm length were used for each seedling density.

Daily growth rate (DGR) %/day was calculated every 15 days of culture following the formula of Hung *et al.* (2009).

$$DGR = [(W_t / W_o)^{1/t} - 1] \times 100 \text{ \%/day}$$

Where: $W_0$ is the initial fresh weight, $W_t$ is the final fresh weight, and t is days of culture

Seaweed biomass expressed as fresh weight of seaweed per unit culture area (Kg/$m^2$) and computed with the following modified formula of Doty (1986):

$Y = (W_t - W_o) / A$ Where: $Y$ = biomass production;

$W_t$ = fresh weight at day $t$; $W_o$ = initial fresh weight; $A$ = area of 4 $m^2$ net.

**Water parameters:** Water temperature, salinity, transparency, pH and dissolved oxygen (DO) were recorded every 15 days at the cultivation sites. Temperature using a standard thermometer and salinity with a hand Refractometer (Atago, Japan), water transparency measured by Secchi disk (30 cm in diameter) and water pH with a pH meter (S327535, HANNA Instruments) were recorded. Dissolved oxygen was measured immediately using the Winklers (1888) method.

**Collection and analysis of soil:** Soil samples were collected using a mud corer, placed in plastic bags and labeled. After collection, samples were brought back to the laboratory within 24 h for analysis. In the laboratory, the samples were dried at 100$^{o}$C for 24 h and powdered, sieved through a 0.5 mm stainless steel sieve and kept in a desiccator until further analysis. All determinations were in triplicate and the mean value was used to obtain representation of each parameter.

**Statistical analysis:** Statistical analysis performed by using Predictive Analysis Software (PASW) and Microsoft Office Excel. One-way ANOVA, post-hoc tukey honest significant difference (HSD) test used to find out the significant difference on partial harvesting, daily growth rate and water quality parameter. Paired sample t-test used to find out the significant difference on total biomass production of seaweeds.

## RESULTS AND DISCUSSION

**Table 1. Seaweed culture suitability criteria.**

| | Criteria* | | |
|---|---|---|---|
| **Parameters** | **Unsuitable** | **Suitable** | **Strongly suitable** |
| Depth (m) | <2 or >15 | 1-2 | 2-15 |
| Wave (cm) | 0.10->0.40 | 0.10-<0.20 | 0.20-0.30 |
| Water Transparency (cm) | <30 | 30-100 | >100 |
| Salinity (ppt) | <24 or >37 | 24-37 | 28-34 |
| Water Temperature ($^{o}$C) | <20 or >30 | 20-24 | 24-28 |
| pH | <6.5 or >8.5 | 6.5-<7.5 | 7.5-8.5 |
| DO (mg/L) | <4 or >7 | 6.1-7 | 4-6 |
| Alkalinity (ppm) | <45 or >130 | 80-120 | 100-130 |

* (Zafar M., 2005, Zafar M., 2007).

**Seaweed bed ecological study:** The water quality parameters consider to be suitable for seaweed culture are highlighted in the Table 1. These parameters are very important hints for the seaweed culture. The requirement for a good water depth should be at least one meter at the lowest spring tide.

Water parameters of seaweed culture beds in Saint Martin and Bakkhali area were recorded on monthly basis and are presented in Table 2. Saint Martin represented highest salinity, transparency, pH and lowest temperature. All the sites found suitable for seaweeds cultivation.

**Table 2. Month wise water quality parameters (mean±Sd) of seaweed culture sites, Cox's Bazar.**

| Parameters | Sites | Months | | | |
|---|---|---|---|---|---|
| | | **Nov.** | **Dec.** | **Jan.** | **Feb.** |
| Salinity (ppt) | St. Martin | 31±0.4 | 32±0.6 | 32±0.3 | 32±0.2 |
| | Bakkhali | 27±0.1 | 29±0.4 | 29±0.1 | 28±0.5 |
| | Inani | 29±0.5 | 30±0.3 | 29±0.8 | 29±0.2 |
| Temperature ($^{o}$C) | St. Martin | 23±0.2 | 23±0.3 | 24±0.1 | 25±0.2 |
| | Bakkhali | 25±0.4 | 25±0.1 | 26±0.4 | 28±0.2 |
| | Inani | 25±0.1 | 24±0.3 | 23±0.2 | 25±0.5 |
| Transparency (cm) | St. Martin | 74.3±0.1 | 78.2±1.1 | 76.5±1.4 | 76.0±0.8 |
| | Bakkhali | 65.1±1.3 | 65.5±0.4 | 64.8±1.2 | 64.5±0.6 |
| | Inani | 71.2±0.3 | 74.3±1.5 | 73.5±0.7 | 72.1±0.6 |
| pH | St. Martin | 8.5±0.2 | 8.5±0.4 | 8.0±0.1 | 8.5±0.3 |
| | Bakkhali | 7.4±0.1 | 7.5±0.3 | 7.5±0.2 | 7.5±0.1 |
| | Inani | 7.6±0.3 | 8.0±0.2 | 7.8±0.4 | 7.7±0.1 |
| DO (mg/L) | St. Martin | 6.9±0.2 | 7.1±0.2 | 7.2±0.1 | 6.9±0.3 |
| | Bakkhali | 5.8±0.1 | 6.1±0.3 | 6.8±0.4 | 6.2±0.2 |
| | Inani | 6.1±0.3 | 7.2±0.2 | 7.0±0.5 | 6.6±0.1 |

Mean water temperature in St. Martin's found significantly ($p<0.005$) higher than Bakkhali but there was no significant variation recorded with temperature from Inani. Mean salinity recorded from St. Martin revealed significantly ($p<0.005$) higher than Bakkhali and Inani ($p<0.005$), but there was no significant variation existed between Bakkhali and Inani.

Comparative nutrient parameters of water and soil in the seaweed beds of St. Martin, Bakkhali estuary and Inani are presented in the Table 3. From the table it was revealed that nitrate, nitrite and calcium of water were similar in three study sites. Whereas, water sulphate and soil calcium were in higher values in Bakkhali site.

**Table 3. Comparison of water and soil nutrients (mean±Sd) of seaweed bed in Saint Martin, Bakkhali and Inani of Cox's Bazar.**

| | Saint Martin | Bakkhali | Inani |
|---|---|---|---|
| ***Water parameters*** | | | |
| Nitrate ($NO_3$) (mg/L) | 0.731±0.2 | 0.673±0.1 | 0.514±0.1 |
| Nitrite ($NO_2$) (mg/L) | ND | 0.452±0.04 | 0.229±0.01 |
| Sulphate (S) (mg/L) | 10,775.25±125.3 | 16,236.28±102.2 | 12,326.33±41.6 |
| Calcium (Ca) (ppm) | 439.30±7.1 | 411.23±4.3 | 419.53±11.6 |
| ***Soil parameters*** | | | |
| Soil calcium (Ca) (ppm) | 18,387.32±103.5 | 26,560.52±209.8 | 15,240.67±189.3 |

**Seaweed culture trials**

**Daily Growth Rate (DGR) of seaweed culture:** Maximum daily growth rate of seaweed *Hypnea* sp. found 3.21±0.01%/day at 60$^{th}$ day and minimum daily growth rate (2.24±0.05) %/day was observed at 30$^{th}$ day in Saint Martin. In this sampling site, DGR of 15$^{th}$ day was significantly ($p<0.001$) higher than 30$^{th}$ and significantly ($p<0.001$) lower than DGR of 60$^{th}$ day, but there is no significant ($p>0.05$) difference with DGR of 45$^{th}$ day (Fig. 2). In Bakkhali, the DGR value peaked at 2.97±0.04%/day at 60$^{th}$ day and the lowest was 1.71 ±0.10%/day at 15$^{th}$ day. In this site, DGR value of 60$^{th}$ day revealed significantly ($p<0.001$) higher than DGR of 15$^{th}$, 30$^{th}$ and 45$^{th}$ day of selected seaweed but DGR of 15$^{th}$ day had no any significant variation with DGR of 30$^{th}$ day. In Inani site, the DGR was maximum (2.65±0.02 %/day) at 60$^{th}$ day and minimum (0.41±0.11 %/day) was observed at 15$^{th}$ day of harvest. The DGR of *Hypnea* sp. in this site attributed as sequential significant changes ($p<0.001$) from 60$^{th}$ day to 15$^{th}$ day, where the value at 60$^{th}$ day value was significantly higher than rest of all. DGR rate of selected seaweeds species in every individual day found significantly different from each other of total three selected locations. That means, the DGR of 60$^{th}$ day from three sampling sites resembled highly significant ($p<0.001$) consecutive difference from Saint Martin's to Inani and they descending as, Saint Martin> Bakkhali> Inani. Same changing trend also found for DGR of 45$^{th}$, 30$^{th}$, 15$^{th}$ day (Fig. 2).

**Total seaweed biomass:**

Harvest at the end of 60-day duration of culture period in three sites resulted in the absolute maximum biomass (11.05±0.10 kg fresh wt./$m^2$) yielded in Saint Martin and the lowest biomass (7.82±0.04 kg fresh wt./$m^2$) in Inani (Fig. 3). Total biomass of seaweed production in St. Martin was significantly higher than the biomass in Inani ($p<0.001$) and Bakkhali ($p<0.002$). Total biomass of Bakkhali was also significantly ($p<0.001$) higher than the total biomass of Inani ($p<0.001$). So, total seaweed biomass production was descending sequentially as Saint Martin>Bakkhali> Inani.

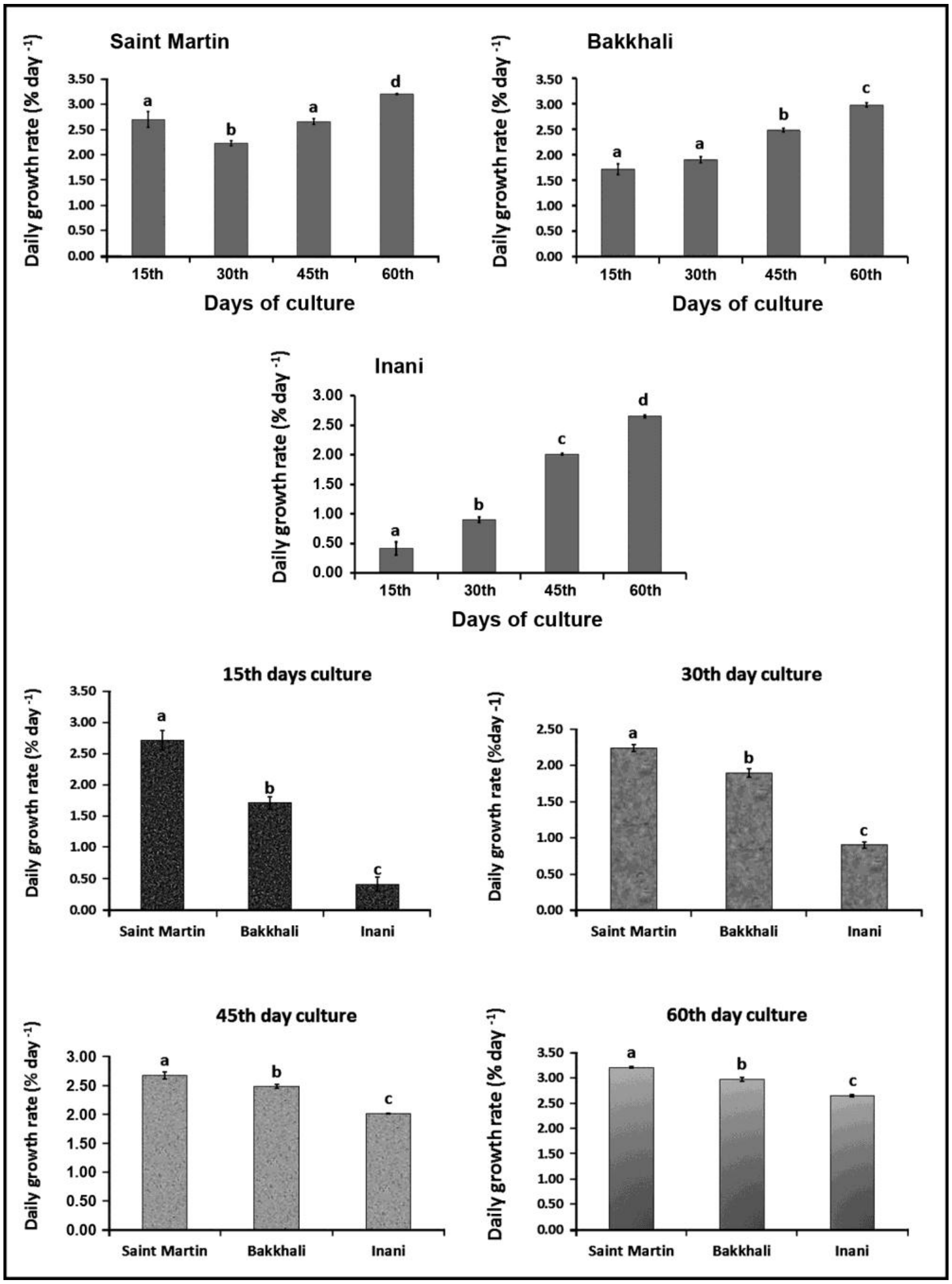


Fig. 2. Bar diagram shows the daily growth rate %/day of *Hypnea* sp. on different cultural site and culture periods. Bars with different letters were significantly ($p<0.001$) different from each other (1-way post-Hoc Tukey HSD test).

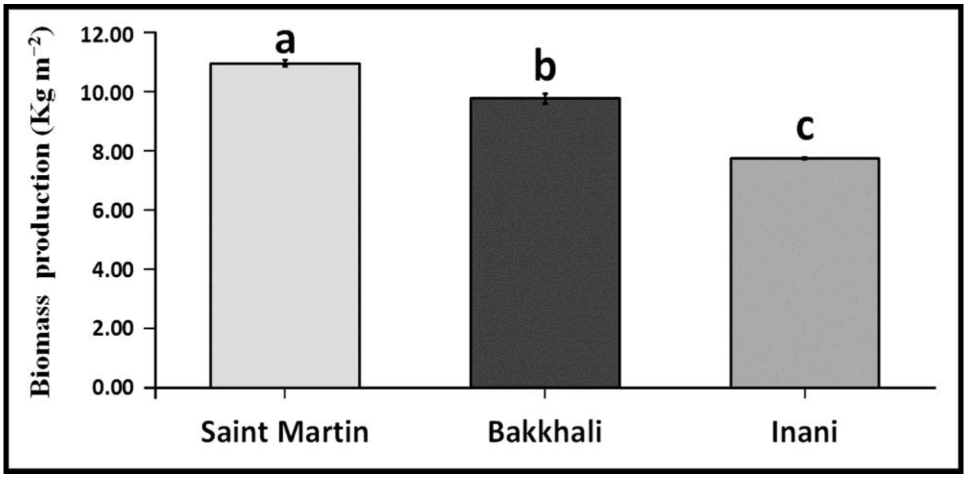


Fig. 3. Bar diagram shows the biomass production (Kg/m$^2$) of *Hypnea* sp. on 60 days of culture period in three sites. Bars with different letter are significantly different from each other (Paired sample t-test).

As with other mariculture systems, selection of a suitable site is critically important for a new seaweed farming. The success of seaweed farming does not only depend on farming techniques, but also to a large extent on the ecological suitability of the site. Based on the water quality and seaweed *Hypnea* sp. culture results; this was means that besides Saint Martin, two other sites were suitable for the cultivation of seaweed. In accordance with site fertility concept, seaweed growth rate vastly governed by a complex biogeochemical process of irradiance, temperature, nutrients and circulation of water (Santelices, 1999). Some of these factors may interact for regulating the growth of target species and the major decline of one factor could be compensated by another factor (Thirumaran and Anantharaman, 2009).

Water salinity is a potential factor to grow seaweeds, as it is the key determinate of osmotic balance. Nutrient accumulation from water, severely stimulated by the osmotic balance that governed by water salinity, although, range of optimum salinity differed from species to species. Wang *et al.* (1993) observed that photosynthesis rate of *Gracilaria verrucosa* decreased when it moved from high to low salinity. Zafar (2007) observed lower growth of *Hypnea* sp. from Saint Martin's, when salinity drops below 24 ppt but better growth reported when salinity increased (>30 ppt). During the present study, recorded salinity ranged from 27-32 ppt along three sites and salinity did not depleted below 31 ppt in Saint Martin. So, stable and moderate salinity was the key factor of highest biomass yield in Saint Martin. Moreover, water salinity had a strong positive correlation with pH, DO and transparency which means salinity played a vital and effective role to these water quality parameters.

Temperature is a promising environmental factor that controls the growth rate of seaweeds, although this effect can be varied from species to species. Guist *et al.* (1982) found that the biomass of *H. musciformis* increased by 20% when the water temperature remained within 18-24 ºC. *Hypnea* sp. is autotrophic and can't live avoiding photosynthesis in any condition, as the physiological processes had a close and strong affinity to the trend of temperature change. Ding *et al.* (2013) revealed high growth rate of *Hypnea* sp. at the temperature ranges from 15-25 ºC. In present study, temperature ranged from 23 to 28 ºC, was very suitable to culture the *Hypnea* sp. and this optimum temperature prominently accelerated the normal growth of *Hypnea* sp. in three cultural sites. Among the three culture sites, Saint Martin showed stable and significant higher temperature within optimum level that may be another effective cause of higher biomass yield of cultured *Hypnea* sp. in this site. Water temperature had a significant positive correlation with water pH, DO and water transparency, which means that these parameters were highly governed by temperature and the optimum temperature intended to keep the optimum value of correlated parameters.

Daily growth rate of seaweed *Hypnea* sp. found higher in Saint Martin compared to Bakkhali and Inani. Growth rate increased gradually from first phase (15 days) of sampling to last phase of sampling period (60 days) in every cultural site. Mean DGR remained significantly high in Saint Martin than rest of two culture sites. Zafar (2007) adopted two types of culture system (net and suspended rope methods) in 60 days culture period where he found growth rate of 1.06 cm/day and 0.95 cm/day for *Hypnea* sp. in Saint Martin Island which is similar to present result. The observed biomass yield of *Hypnea* sp. found significantly higher in Saint Martin rather than Bakkhali and Inani, where Bakkhali ranked 2$^{nd}$ and Inani ranked 3$^{rd}$. Generally, Bakkhali and Inani allocated in upstream, where, magnitude of water quality parameters did not remain stable like Saint Martin and did not have vast substratum facilities to form an enormous colony of seaweeds.

Taking all those factors into account, present study recommended that cultivation of *Hypnea* sp. on coir rope is viable and fisher folk can take up such activities as an income generating activity and same time it reduces the fishing pressure in our coast. However, piloting in the potential farming areas, mass cultivation technology and suitable season are needed before seaweed farming to large scale. Present study revealed that seaweed could be cultured in our coast particularly in Bakkhali river estuary and Inani beach in winter season.

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