Periphyton Growth on Two Different Bamboo Substrate Models for Its Use in Aquaculture

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Abstract

Periphyton-based fish farming practices are considered low-cost technologies as they help in sustainable aquaculture production. The present study was designed to determine the efficiency of two different substrate models (viz. roof hut model and prism model) made from the bamboo sticks. The small-sized substrate models were constructed for invitro studies. The growth of periphyton was investigated on the 30th day of the experimental setup. This is the first time experimenting with bamboo substrate models. From the result it was found that the biomass of periphyton in terms of dry weight 0.03±0.01 g/cm² was observed on both substrate models. There is no biomass difference and taxonomic difference between these two models. It may be due to the material used for the construction of the model being the same i.e. bamboo sticks and cotton thread. The taxonomic identification of the periphyton community showed the different genera of class Chlorophyceae and Bacillariophyceae. These models are efficient for periphyton growth and they also increase the productivity of periphyton due to increased surface area of substrate models. These models can be used for low-cost aquaculture.

Keywords

Periphyton, substrate model, bamboo, aquaculture.

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Introduction

Periphyton is defined as "a complex of sessile organisms attached to submerged substrates such as stones and sticks and including algae, invertebrates, detritus and microorganisms" (Azim et. al. 2002). Periphyton is considered as an important nutritional component of fish. It grows on a variety of substrates in aquatic ecosystems and supports fish production. The periphyton-based aquaculture technology brings great advances in the development of aquaculture farming at low cost, without the need for supplementary feeding and reduced pollutants. In pursuit of low-cost aquaculture, a variety of substrate-based aquatic systems have been developed to grow finfish and shellfish to provide shelter and increase the production of Periphyton as food. **(Dutta et al. 2018)**

The addition of substrate is beneficial in aquaculture to increase energy and nutrients in the system. The periphyton grown on substrates are easily harvested by the herbivorous and omnivorous fishes. According to Azim et al. (2001) addition of hard substrates such as bamboo and other tree branches, which are generally absent in traditional fish ponds, is an essential component of the periphyton-based aquaculture to generate microbial and zooplanktonic biomass associated with alga growth. This abundant natural food source is directly exploited by many herbivorous and omnivorous fish species as a basic food source. **(Amisah et al. 2008)**

In recent years, periphyton-based fish farming has developed as an alternative for systems with low supplementary feed inputs. Higher fish yield from such systems is achieved through the nutritional contribution of periphyton growing on the substrates and also through better survival as the substrates act as shelters for fish. Active photosynthetic periphyton community increases pH and oxygen levels in water thereby improving water quality. Fish/prawn culture is enhanced by fertilization, substrate introduction or biofuels technology. **(Keshavanath et al. 2017)**

Periphyton production in ponds is enhanced through the provision of substrate, such as bamboo poles. Wahab et al. (1999) reported that yields of calabash, *Labeo cal*abash (Hamilton),were 80% higher in ponds using bamboo substrates as compared to the control ponds without substrate. This increase in fish production is thought to be due to providing substrate for the growth of periphyton on which the fish feed. **(Azim et al. 2001)**

In this study, to increase the growth of periphyton instead of using isolated substrates of bamboo the substrate models are constructed. The logic of the construction of models depends on a simple idea i.e., increased surface area gives increased periphyton growth and also provides shelter and breeding habitat for the fishes.

Materials and Methods

Collection of Periphytic Water Sample

The periphytic water sample was collected from the Kayadhu River system canal, Tq. Kalmnoori, Dist. Hingoli, Maharashtra, India in the month of March, 2023.

Physico-chemical Parameters of Initial Water and Aquarium Water

The physicochemical parameters of initial water and periphyton-grown water were tested, such as, temperature, pH, dissolved oxygen, chloride, phenolphthalein alkalinity and total alkalinity, free CO2, hardness and calcium hardness by following the standard procedure of water examination. (Trivedy et al. 1998 and Eaton, APHA 1995)

Construction of Substrate Model

For in vitro studies, the substrate models were constructed from the bamboo sticks with the help of cotton thread. It is the first time use of substrate models for the growth of periphyton. In this experiment two types of bamboo substrate models were constructed,

1. **Pentagonal Roof Hut Model**

In this model the bamboo sticks are arranged in a pentagonal shape one above the other in such a way that it forms a ladder-like structure from each side. Different sizes of bamboo sticks were used to construct this model. These bamboo sticks are tied by a cotton thread to fix the shape and at the top one common knot is made to support the model for easy handling.

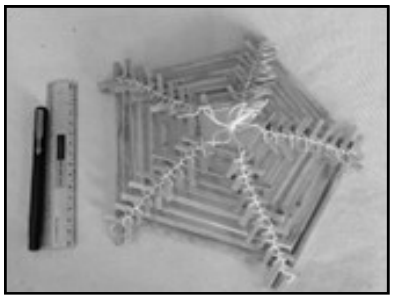


Fig 1: Pentagonal Roof Hut Model

2. **Prism Model**

The model consists of three rectangular sides and two triangular sides; hence, it is named a prism model. The triangular sides are open. The two rectangular sides have horizontally arranged sticks fixed to the two vertical sticks and the one rectangular side at the bottom has intersecting sticks which make small squares. The whole structure is fixed by the cotton thread.

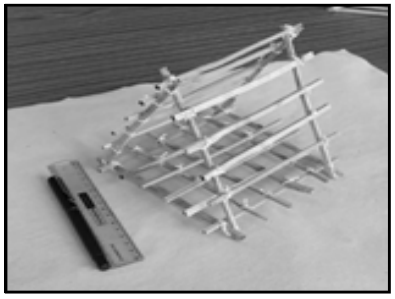


Fig 1: Prism Model

Experimental Set-Up for Growth of Periphyton

The experimental setup consists of a small trough size (38x23 cm at the base and 40x25.5 cm at the top side) having a 1 cm soil layer at the bottom. The soil is provided with fertilizers such as cow dung (8g), NPK (1.6g) and Urea (1.6g). The basic periphytic culture water and fresh water in 1: 9 ratios were added in a trough. The stone weights are attached to the constructed substrate models. These models were submerged in the water. The oxygen is provided by aquarium air pumps and light is provided by tungsten bulbs for photosynthetic activity. The experimental substrate models were kept in the trough for 30 days (Shaikh & Chavan 2015).

Fixation and Identification of Periphyton

The substrate models were removed from the water of the periphyton culture system. The periphyton grown on the surface were collected by using a soft brush and rinsed with distilled water. The periphytic sample was preserved in 4% formalin. Temporary mounts of periphyton were prepared in glycerin and xylene. Periphytic samples were identified by using keys from freshwater biology by Edmonson (1959).

Biomass Estimation of Periphyton

The biomass of periphyton was estimated in terms of dry weight. For this the sample was collected from the substrate models by scrapping area about 1 cm^2 and collected in Whatman filter paper. Dry these samples in incubator at 37 °C for 24 hrs. The weight of filter paper was measured before and after the collection of periphyton. The dry weight of the periphyton was calculated by using the formula

$$TDP = WF_2 - WF_1$$

where,

TDP = Total dry weight of periphyton

WF_1 = Weight of filter paper before collection of periphyton

WF_2 = Weight of filter paper after incubation

Results

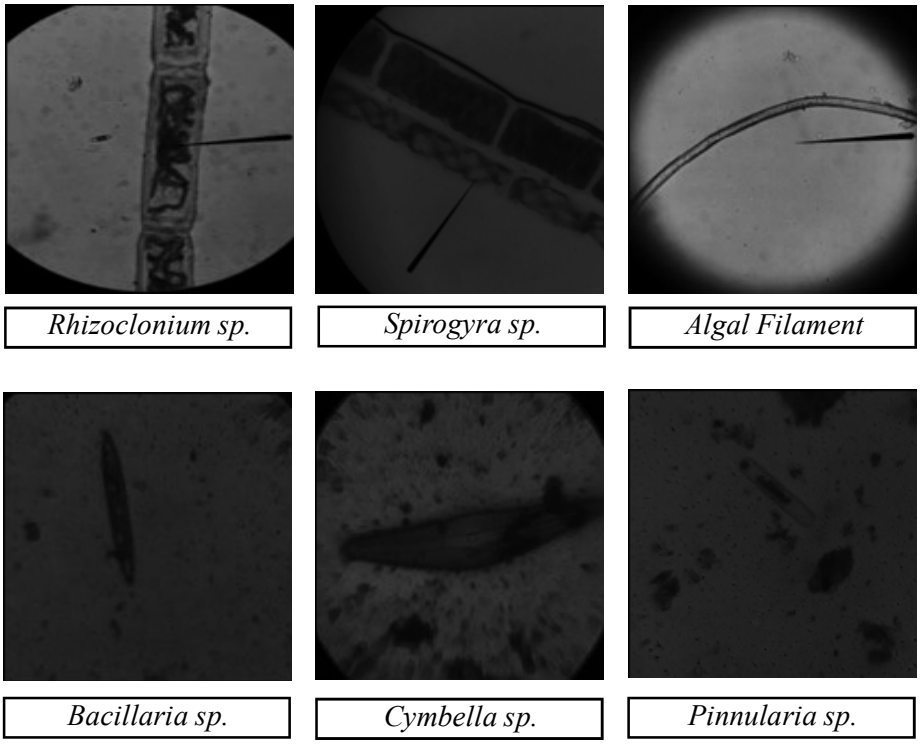
Table 1: Physico-chemical Parameters of Water

Sr. No.	Parameters	Initial	Model 1	Model 2	Standard
1	Temperature ˚C	28	28	28	25-32
2	pH	8	8	8	7-9
3	DO (mg/l)	8.51	17.83	15.40	5-15
4	Free CO2 (mg/l)	39.6	83.6	88	1-10
5	Chloride (mg/l)	46.9	65.18	54.94	1-100
6	PA (mg/l)	40	100	80	50-300
7	TA (mg/l)	140	140	150	50-300
8	Ca^{+2} hardness (mg/l)	61.72	92.18	85.77	5-100

All water quality parameters were within the limits suitable for periphyton growth. Variations of some parameters in vitro conditions occur due to the change in habitat. The DO of initial water and periphytic culture system water differ due to the air pumps. The free CO_2 increased in the invitro system due to fertilizers. Chloride content, total alkalinity and phenolphthalein alkalinity increased in the invitro condition. The calcium hardness increased in the invitro condition but it is normal range of periphyton growth.

Identification of Periphyton

The sample of periphyton grown on substrate models consists of different genera of class Chlorophyceae such as *Rhizoclonium, and Spirogyra* and some algal filaments and it also shows different genera of bacillariophyceae such as *Bacillaria, Cymbella* and *Pinnularia*.



Estimation of Biomass

After 30 days of experimental setup up the periphyton growth on substrate models was measured in terms of dry weight (g/cm^2). The growth obtained on the pentagonal roof hut model and prism model are 0.03 (g/cm^2) and 0.03 (g/cm^2) respectively.

Discussion

Generally, water quality remained within the normal range during the Invitro experiment. The growth of periphyton on two different bamboo substrate models shows similar results. The biomass of periphyton measured from both substrate models was 0.03 ± 0.01 g/cm^2. According to Rai et al. (2008) plankton density did not differ among all substrate added treatments. The substrates (rice straw and kanchi) added to the pond significantly increases fish production and did not negatively affect water quality; therefore, the treatments with substrates were better than the treatment without a substrate (control). Keshavanath et al. (2017) conducted two experiments using plant substrates viz. bamboo, Bombay and Leucaena without and with fish to evaluate their suitability for periphyton development, and their influence on water quality and growth performance of Karachi (*Semaprochilodus insignis*). The best growth of periphyton was observed on bamboo, followed by ambay and Leucaena. Bamboo-grown periphyton had the highest chlorophyll-a and protein content. All the water quality parameters monitored were within the suitable limits for aquaculture. The effect of periphyton, grown on bamboo substrate, on the growth and yield of two Indian major carps, Labeo rohita and Labeo genius, were studied by Azim et al. (2001). A large number of plankton were colonized on bamboo substrates. Rohu grew faster, in the ponds with bamboo substrates compared with the ponds without substrate. From these research reviews we can conclude that the bamboo substrate has a positive effect on the carp culture. According to Wahab et al. (1999) a large number of periphyton have colonized on the bamboo substrates. The survival rate of rohu in the treatment was higher than in the control. This may be due to the periphyton growing on bamboo substrates influencing the better survival of stocked fish by protecting fish-eating birds. In this finding the two different models are constructed from bamboo sticks for the first time to evaluate the growth of periphyton for invitro studies. So, these models would be more efficient for stocking fish than the isolated substrate. These models also increase the productivity with increased surface area of the substrate model. A similar type of research was conducted by the Garcia et al. (2016), they evaluated the potential of periphyton-based cage culture of Nile tilapia with or without bamboo substrates for periphyton growth. They installed bamboo modules made from bamboo rods cut into halves lengthwise. Each module consists of seven vertical bamboos (1 m) attached at their edges to two horizontal bamboos (2 m) and secured with a diagonal bamboo. Galvanized wire was used to tie the bamboo rods. The presence of bamboo substrates improved the fish weight gain but reduced the carrying capacity of the cage at the highest density.

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