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Short Communication

Indigenous techno-vention to promote periphyton-based aquaculture

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Abstract: Considering the increasing demand for aquaculture production, semi-intensive and intensive cultures have already been established, but with enhanced cost of supplementary and complete feed and associated incidence of water quality deterioration due to accumulated nutrient loss, an alternative approach of periphyton-based aquaculture has been initiated. Periphyton-based aquaculture is a low-cost culture technique with less feed input and has been reported to support the high production of most cultured fish species. Apart from this, an improved level of water quality in periphyton-based aquaculture has also been reported. Even considering these advantages, periphyton-based aquaculture has not been implemented on a huge scale due to one major disadvantage: the stationary nature of the substrate on which the biofilm grows. For this reason, partial harvesting of the stock or regular management practices of the cultured pond is impossible as these require complete removal of the substrates. To solve this problem, a model with indigenous technical intervention has been proposed where any substrate, bio-degradable or non-biodegradable so far, used for periphyton-based aquaculture can be used. Though this model is handy using bamboo poles and split bamboos; other components like crushed sugarcane bagasse, paddy straw, and PVC pipes can also be incorporated into it.

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Introduction

With the increasing demand for aquaculture food for human consumption, there is a need for the expansion and intensification of aquaculture production in the next five decades (Henriksson et al., 2018). Considering this, semi-intensive and intensive aquaculture has already been developed. In a semi-intensive culture, supplementary feeding is essential to enhance production (De Silva and Anderson, 1995). Supplementary feeding accounts for about 50-70% of production cost, depending on the intensity of feeding (Munguti et al., 2021), and more often, it becomes beyond the capacity of the poor farmers. Above all, it has been reported that only about 30% of the nutrient input is converted to fish biomass, the rest being lost to effluent water and sediment (Gross et al., 2000; Krishnani et al., 2019), leads to eutrophication and deterioration of water quality. To reduce the cost of supplementary feed and maintain the water quality parameters of the culture pond, an alternative approach has been taken in the form of periphyton-based culture.

Periphyton is a complex community of microorganisms consisting of bacteria, fungi, microalgae, epiphytes, and detritus (Liu et al., 2018; Mai et al., 2020). In aquaculture with a broader sense, periphyton has been considered as the entire complex of sessile aquatic biota attached to the submerged substratum. It includes associated detritus and microorganisms, i.e., the periphyton community consists of bacteria, fungi, protozoa, phyto- and zoo-plankton, benthic organisms, and a wide variety of invertebrates and their larval stages (Azim et al., 2005).

Periphyton in Aquaculture

The number of advantages of periphyton-based aquaculture have been reported by researchers which are as follows:

(1) Enhanced production has been observed in periphyton based monoculture and polyculture of

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freshwater prawn (*Macrobrachium rosenbergii*), black tiger shrimp (*Penaeus monodon*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), catla (*Catla catla*), mrigala (*Cirrhinus mrigala*), calbasu (*Labeo calbasu*), fringed lip Peninsular carp (*Labeo fimbriatus*), mahseer (*Tor khudree*), catfish, tilapia, pearlspot (*Etroplus suratensis*) and varieties of small indigenous species (Hem and Avit, 1994; Umesh et al., 1999; Ramesh et al., 1999; Wahab et al., 1999a, b; Tidwell et al., 2000; Azim et al. 2001a, b, 2002b, c, 2004a, b; Dharmaraj et al., 2002; Keshavanath et al., 2002; Mridula et al., 2003, 2005; Garg et al., 2007; Sahu et al., 2007; Uddin et al., 2007; Amisah et al., 2008; Rai et al., 2008; Shyne Anand et al., 2014; Bharti et al., 2016; Shilta et al., 2016; Jha et al., 2018; Muthoka et al., 2021). Two major factors contributing to the enhanced production are (i) a reduction in metabolic cost with the availability of additional shelter provided by the periphyton substrates and challenization of the energy in fish biomass and (ii) enhanced primary and benthic productivity on the substrates that lead to enhanced fish biomass by providing enhanced available food (Miller and Falace, 2000). Further, Dempster et al. (1993, 1995) have suggested that it is easier for the fishes to scrap or feed on larger food particles like algal detritus developed on substrates rather than filtering the phytoplankton from the water column; thus, periphyton provides additional complements of nutrients to the fishes that ultimately promotes the growth and production. The microbial population associated with periphyton also enhances fish survival by supplying antibiotic substances, vitamins, and probiotics (Azim et al., 2005). The suitability of periphyton-based culture for rearing fry to fingerling has also been reported (Keshavanath et al., 2002; Gangadhar et al., 2015). (2) Improved level of water quality has also been reported in periphyton-based aquaculture (Umesh et al., 1999; Ramesh et al., 1999; Azim et al., 2002a; Mridula et al., 2003; Li et al., 2019) as periphyton has the unique ability to remove nutrient from the water column (incorporate it into their biomass), trap particulate matter (thus reduce turbidity) and enhance nitrification (Keshvanath et al., 2001; Abakari et al., 2020; Mai et al., 2020).

The concept of periphyton-based aquaculture is not that new as traditionally it was there in the form of "acadjas" in Cote d'Ivoire (Welcomme, 1972), "samarahs" in Cambodia (Shankar et al., 1998) and "katha" fisheries of Bangladesh (Wahab and Kibria, 1994); the only modifications in it have been researched recently by analyzing the impact of different types of substrates on periphyton production, the composition of micro-organisms in biofilm and growth of cultured species.

Periphyton can be grown on any easily available substratum, be it biodegradable or non-biodegradable; though better growth has been reported on biodegradable substrate (van Dam et al., 2002; Dutta et al., 2013; Mohapatra et al., 2016) due to the occurrence of nutrient leaching at the substrate-water interface which promotes enhanced growth of periphyton (Shyne Anand et al., 2014). So far bamboo side shoots and poles, jute sticks, crushed sugarcane bagasse, paddy straw, coconut coir, coconut shell, palm leaves, PVC tubes, FRP sheets, ceramic tiles have been used for periphyton culture (Shankar et al., 1998; Ramesh et al., 1999; Azim et al.; 2001a; Keshavanath et al., 2001, 2012; Mridula et al., 2003, 2005; Gangadhar and Keshavanath, 2008, 2012; Rai et al., 2008; Dutta et al., 2013; Mohapatra et al., 2016; Mansour et al., 2017; Santhiya et al., 2017; Ruby et al., 2018; Kaviyarasan and Athithan, 2019). Among these substrates, the best result has been reported using bamboo poles and shoots (Hem and Avit, 1994; Azim et al., 2001a, b, 2002a, c; Keshavanath et al., 2001; Amisah et al., 2008; Kaviyarasan and Athithan, 2019; Vijay Amirtharaj et al., 2022).

An indigenous technical intervention for periphyton-based aquaculture

Even with so many advantages, periphyton-based aquaculture shares one major disadvantage: the stationary nature of the substrates on which the biofilm grows. For this reason, during the period of running culture, it is quite impractical to harvest part of the stock or imply regular maintenance activities, as all the substrates should be removed for these.

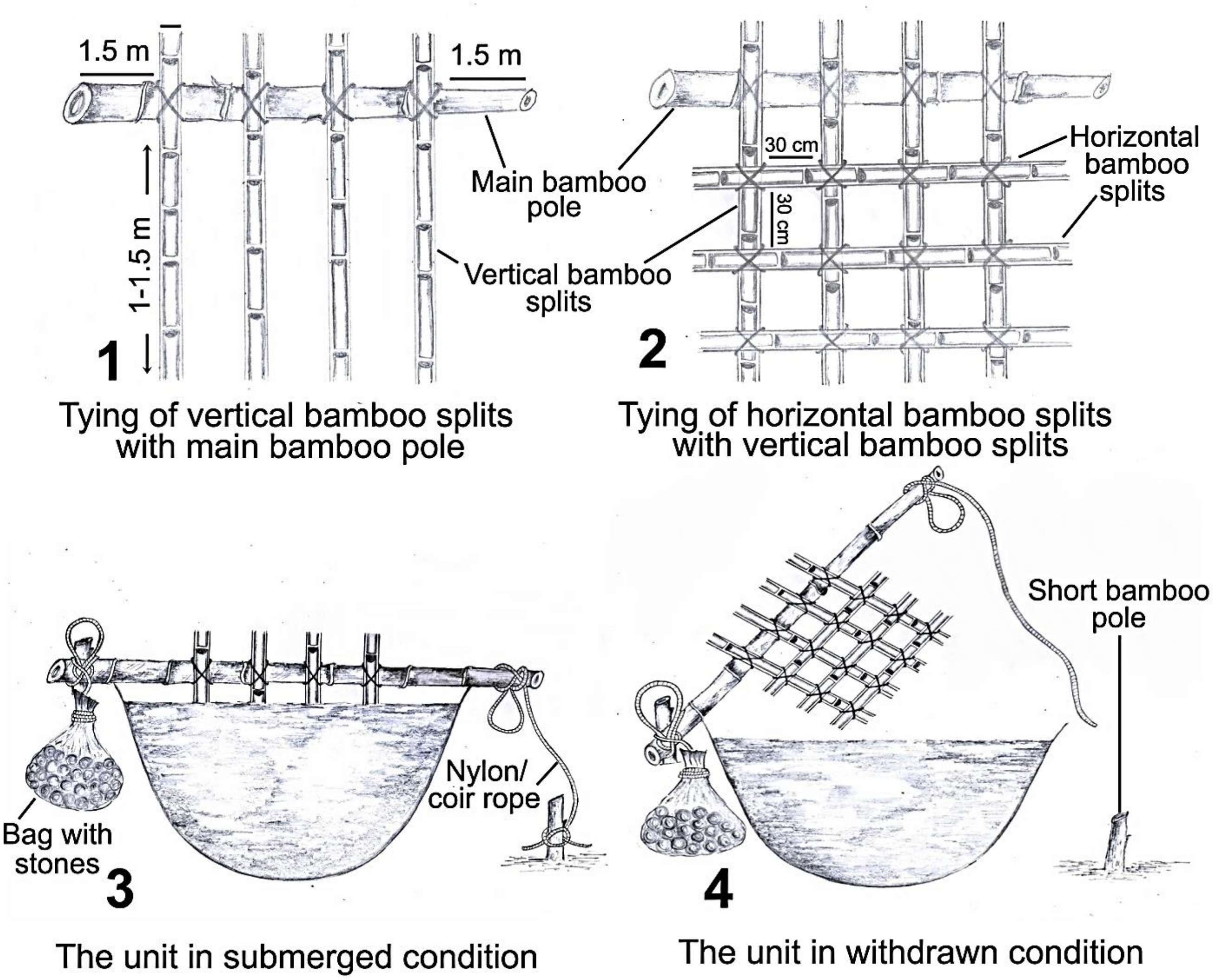

Figure 1. Demonstration of the preparation of a unit (1-2) and the way of utilization (3-4) of the same for periphyton-based aquaculture.

Considering this problem, we are interested in discussing an indigenous technical intervention that can be implemented to solve this issue. Any substrate, bio-degradable or non-biodegradable so far experimented for periphyton-based culture, can be incorporated into this model. However, using bamboo poles and split bamboo will be handy to continue concerning the management and long-term maintenance.

In this model (Fig. 1), each bamboo pole with tied bamboo splits will form a unit, and many such units will be used as substrates for developing periphyton. At first, as per the diameter of the culture pond, the required length of bamboo poles (for each unit) and the number of units required to cover the pre-decided area of the pond should be determined. At first, leaving at least 1.5 meters in length from both ends of the bamboo pole, bamboo splits should be tied vertically with it. Two bamboo splits of 1.5-meter height and mean diameter of 5-5.5 cm should be tied on two sides of the bamboo pole using coconut coir/nylon rope, and following this method, more such bamboo splits should be arranged along the length of the bamboo pole. At least a 30 cm gap should be left between two sets of bamboo splits. Next, bamboo splits should be tied horizontally with respect to the main bamboo pole with the already tied vertical bamboo splits using coconut coir/nylon rope, and a gap of at least 30 cm should also be maintained between the two rows. In this fashion, three rows of bamboo splits can be tied with the vertical bamboo splits. This will form one complete unit. The required numbers of such units should then be prepared to cover the pre-decided area of the culture pond. The height of the vertical split bamboo can be changed per the culture pond's depth.

Next, arrangements should be made for easy withdrawal and immersion of the units in the culture pond. For this, each unit should bear a weight (in the form of a jute/nylon bag packed with stones/bricks of required weight and the mouth of the bag should be tied with coconut coir/nylon rope and tied to the end of the bamboo pole) in the straight side and a nylon/coconut coir rope in the bent side to tie with a short bamboo pole on the other side of the pond to keep the unit in immersed condition in requirement.

So, this model with the Indigenous technological intervention will be helpful for the farmers to continue the periphyton-based aquaculture with phase harvesting or regular pond management practices. The units will be kept in immersed condition for the development of bio-film on the split bamboo, and as required, those can be withdrawn above the water level just by unfastening the ropes of the bend side of the unit. Though this model is suitable for using split bamboo as a substrate, other components like crushed sugarcane bagasse, paddy straw, and PVC pipes can also be incorporated into it.

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