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Potentiality of Periphyton based Aquaculture Technology in Water Reed (*Schoenoplectus lactustris* Linn) - Fish Environment in Manipur, India

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A B S T R A C T

Periphyton is defined as the entire complex of sessile aquatic biota attached to the substratum including associated detritus and microorganisms. Kouna (*Schoenoplectus lacustris* Linn) otherwise known as water reed, plants grow widely in the marshy land, pond, canals, along the river and lake beaches. It is cylindrical in nature, attains a height of 2.5 m with numerous dark green, soft spongy, glabrous stems arising from an underground stalk with tough fibrous roots. The experiment was carried out in nine number earthen ponds size of 0.25 ha area in farmers field of Imphal East District, Manipur under Krishi Vigyan Kendra, Andro, Imphal East, Central Agricultural University, Manipur (India) during the year 2017. The experiment consists of three treatments: Control (C), control and substrate (CS), and control and substrate with supplementary feeding (CSF). The study observed that, there were no significant differences in water quality parameters between the different treatment ponds. The Survival (%) appeared to be independent of the treatments and varied between 65.33-91.98. ANOVA showed a significant ($p<0.05$) increase in growth in ponds provided with water reeds. The absolute growth for common carp was observed to be highest among all the treatments. The mean absolute growth of fish was significantly ($p<0.005$) higher in treatment having water reed as substrate than without substrate and highest in the treatment having substrate and feed. The total yield of fish was significantly ($p<0.005$) higher in substrate based treatment where highest yield was found in treatment with substrate and supplementary feed. This technology can be practiced in the region where the cost of feed is a big challenge for aquaculture development.

Keywords

Periphyton, Nutrient cycling and biological productivity

Introduction

Manipur is a small state located in the North Eastern part of India bordering Myanmar. It is situated between 23° 83´N and 25° 68´N latitude and between 93° 02´E and 94° 98´E longitude, at an altitude of 790 m above mean sea level. The state has a distinct zoo-geographical identity. The total area of the state is 22,327 km² with hilly areas covering about 92% of the landscape that enclose a central valley of about 1,800 km². Periphyton is defined as the entire complex of sessile aquatic biota attached to the substratum including associated detritus and microorganisms. Thus, the periphyton community comprises bacteria, fungi, protozoa, phytoplankton, zooplankton, benthic organisms and arange of other invertebrates and their larvae. Since periphyton can be easily grown on different substratum, any locally available material such as branches of different trees, higher aquatic plants, bamboo, PVC pipes etc can be used as substrate for the growth of periphyton. Ecologically, periphyton plays an important role in nutrient cycling and biological productivity in aquatic systems. Periphyton is preferable food for most of the herbivorous and omnivorous fish species (Azim *et al.,* 2002; Keshavanath *et al.,* 2002). Periphyton growth on substrates not only serves as the natural food and productivity in fish ponds, but also it improves water quality by utilizing nutrients from the medium (Umesh *et al.,* 1999; Ramesh *et al.,* 1999; Azim *et al.,* 2003; Mridula *et al.,* 2005). Periphyton based aquaculture lowers the production cost and it is a better fish culture practice for the poor farmers. Periphyton-based aquaculture can be practised wherever fish farming is possible (Azim *et al*., 2001). It is considered the best practice of fish farming since it requires only cheap and readily available inputs, yet highly efficient.

Comparative study on natural and artificial substrates for periphyton growth was conducted and found that more periphytic growth were found on the natural substrates and the taxa present in natural samples were nearly similar to the artificial substrates (Mohapatra *et al.,* 2016 and van Dam *et al.,* 2002). Higher survival of carps was recorded in periphyton based growth trials (Wahab *et al.,* 1999 a & b and Keshavanath *et al.,* 2001). A comparative study on rice straw mat and kanchi (bamboo sticks) as substrates for production of major carps in periphyton-based polyculture systems (Rai *et al.,* 2008), planktonic communities from four different substrates namely, paddy straw, sugarcane bagasse, plastic sheet and tile in fibre reinforced plastictanks (Bharti *et al.,* 2016), observation of periphytic growth and their planktonic communities in four types of plastic sheets, (Mohapatra *et al.,* 2016) was also reported. Provision of optimum density of the substrate, periphyton supported production technology can offer considerable potential for enhancing aquaculture production without any deleterious impact on pond ecosystem (Garg and Bhatnagar, 2016). Gogoi *et al.,* (2018) observed effective grazing on periphyton by cultured fish species in carp polyculture system.

Several studies have also reported that production of rohu in periphyton based pond systems is significantly higher (18–200 percent) in comparison to control ponds (Wahab *et al.,* 1999a; Umesh *et al.,* 1999; Ramesh *et al.,* 1999) reported that fish production levels of 5000 kg/ha can be achieved without supplementary feeding by providing substrata for periphyton that is equivalent to the pond surface area and fertilizing with cow manure at 4,500 kg/ha, urea at 150 kg/ha and Triple Super Phosphate at 150 kg/ha. Further, Azim *et al.,* (2004) observed that by adding periphyton substrata equivalent to 50 percent, 75 percent and 100 percent of the pond surface area increased fish production by 114 percent, 168 percent and 209 percent, respectively, compared to the control. Wahab *et al.,* (1999a) and Milstein *et al.,* (2003) revealed that the use of periphyton based systems, using suitable material such as bamboo poles, and stocking the pond with a bottom feeding species in conjunction with filter feeders hold significant advantages for farmers in resource poor areas or countries. Variation of periphyton quantity and quality depends on a range of factors such as submersion time, substrate type (Ramesh *et al.,* 1999; Keshavanath *et al.,* 2001; Azim *et al.,* 2002), and light intensity and quality. The latter is strongly influenced by the depth of the substrates (Asaeda and Son 2000).

In this study, a system of periphyton based aquaculture was considered as an alternative to fish production in conventional substrate free pond and other integrated farming system by introducing water reed integrated with fish for doubling farmers income.

Water reed (*Schoenoplectus lacustris)* and its uses

Kouna (*Schoenoplectus lacustris* Linn) otherwise known as water reed, matting rush or club rush is an aquatic terete herb belong to the family Cyperaceae, is locally known as "Kouna" in Manipur. The plants grow widely in the marshy land, pond, canals, along the river and lake beaches. It is cylindrical in nature, attains a height of 2.5 m with numerous dark green, soft spongy, glabrous stems arising from an underground stalk with tough fibrous roots. From time immemorial, these stalks, locally called Kouna, after drying have been used in making mats/mattresses by the people living mostly in the valley areas of Manipur state. Handicrafts of Manipur have a unique place among the various craft of the country and have aesthetic and artistic value. These plant have huge potential for large scale plantation, production and marketing for making cushions, mats, laundry baskets, hand bags for ladies, pen stand, flowers pots, wall hangings, hats, stools, chappals, shoe making, chair etc. of various sizes and designs, they are eco friendly and hand woven which is much durable and washable. All Kouna items are unique handicrafts of Manipur. The products of Kouna are in great demand not only in local markets but also in international markets as well.

The craft has been taken up as a gainful economic activity by artisans/entrepreneurs in the state for its high market demands. This aquatic plant is generally cultivated in the wetland of Manipur valley and is a good source of income. Cultivation and promotion of water reed not only boost the economy and enhance employment but will also help in the conservation of wetland.

Role of fish on water reed and *Vice Versa*

The culture of fish in water reed fields generally benefits water reed plants; as a result of better aeration of water, greater tilling due to the movement of fish and searching of fish feed by the bottom dweller fishes. The excreta of fish increase the fertility of soil. Fish also feed on harmful pest weeds and insect larva, which are harmful of water reed plants.

Periphytons are the tiny organisms that live on the surfaces of objects under water. When various plankton, microbes, invertebrates and other organisms are colonized that make up periphyton which act as a good fish feed. Fish can graze on these concentrated forms of food more efficiently than they are able to filter planktonic algae. In this system, water reed plant act as a substrate to enhance food availability *via* periphyton development and to increase the production of fish. The water reed once planted will grow for 20-30 years provided proper management year-round.

Materials and Methods

Site Selection

Selection of a suitable site is the most critical step in the development of a successful water reed cum fish farming venture, as this can have a significant impact on the profitability of the business. Hence prior to establishment, a careful analysis of the site is done to ensure satisfactory supply of the required water for farming. Since no site will have all the desired characteristics, a number of judgments is made for every site like can water reed and fish be farmed profitably and the type of appropriate management and system which should be taken up at the location. Unproductive paddy fields, low lying areas, wetland with good source of water and spacious benches/plots is brought under this system.

Pond/Plot Design

While designing the pond/plot layout due emphasis was given in the economics of construction, operation and maintenance. The pond was constructed for holding sufficient water of not more than 3ft water depth and also in such a way that the fishes could be harvested easily from such farming system. The bundhs height should be determined in accordance to the depth of water level. A peripheral trench of 20 ft width was constructed in one side of the pond to retain water and for easy harvesting of the fishes with at least 5ft of water depth. For getting additional income from horticultural crops the pond dyke /bundh were made to 6 ft width.

Pond preparation

The pond bottom was applied with quicklime at the rate of 75 kg/0.25 hectare. Then the pond bottom was ploughed twice followed by cross harrowing before filling of water during which Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) were applied @ 33kg, 63kg and 13kg/0.25 hectare respectively in the last ploughing. After 3 days, water is filled in the plot maintaining a water level upto 15cm followed by puddling and levelling. Then the soil is allowed to settle for at least 3 days before transplantation of the reeds.

Transplantation

Water reed planting material of size 1.5-2.0ft in length is transplanted @ 4200 nos. per 0.25 hectare in line maintaining a distance of 2ft between plant to plant and row to row. After 20 days of transplantation (after the reed established) the water level increases to 1ftand to a desired level of 3ft after 45 days which is suitable for growth and development of water reed plant. If the water level increase more than 3ft, the plant become thicker and the luster quality of the plant decreases, which is not suitable for making good quality products.

Stocking of fish

The ponds were manured with Cow dung (@ 2500 kg/0.25 ha) and Mustard Oil Cake (MOC) (@ 75 kg/ 0.25 ha) after 20 days of water reed transplantation. Stocking of fish was initiated 45 days after transplantation of water reed plants. Pond were stocked with fingerling of Rohu (*Labeo rohita*), Common Carp (*Cyprinus carpio*), Mrigal (*Cirrhinus mrigala*) and Tilapia (*Oreochromis niloticus*) with an average weight of 80±2.5 gm (rohu, common carp, mrigal) and 30±1.3 gm (tilapia) respectively with a stocking density of 1500 fingerlings/0.25 ha. The fish stocking ratio were 50 (rohu): 20 (mrigal): 20 (common carp): 10 (tilapia)

Weeding

Weeding is done properly and regularly as it is necessary for healthy growth of the water reed plant.

Experimental set up

The experiment was carried out in nine number earthen ponds size of 0.25 ha area in farmers field of Imphal East District, Manipur under Krishi Vigyan Kendra, Andro, Imphal East, Central Agricultural University, Manipur (India) during the year 2017-18. The experiment consists of three treatments: Control (C), control and substrate (CS), and control and substrate with supplementary feeding (CSF). The pond management practice in control pond was carried out in same manner with that of other treatment ponds. Subsequent fertilisation was done fortnightly using Cow manure (104 kg) and MOC (3 kg) in all the ponds. Supplemental feeding at the rate of 3% per pond biomass per day was applied in pond P4 and P5 using a mixture of Rice Bran (RB) and MOC at a ratio of 1:1. Feeding started on the second day after stocking and was administered twice daily between 09:00 and 16:00 hrs. Water depths were monitored throughout the study period, and evaporation losses were compensated through regular filling. Physicochemical characteristics including temperature, pH, Dissolve oxygen, transparency, total alkalinity, nitrate-nitrogen, and ammonium-nitrogen levels were monitored. At the end of the experiment data were collected on: Gross production; *i.e.*, (i) Total bulk weight and number by species harvested per pond (ii) Mean weight of species by pond (iii) Survival percentage (mortality) by species per pond and comparative net return of different treatment pond were calculated.

Statistical analyses

Statistical analysis was worked out by using SPSS version 16.0 for Windows. One-Way ANOVA was used to analyze the variance to determine the relation between the absolute growth, yield and benefit cost ratio (α=0.05).

Results and Discussion

Water quality data variation over the study period is presented (Table 1). Water quality parameters were within acceptable ranges for fish culture. There were no significant differences in water quality parameters between the different treatment ponds. The mean temperature, pH and dissolved oxygen of the water for all treatments throughout the culture period were 27.81°C, 7.41 and 6.04 mg/l for control, 27.52°C, 7.52 and 6.12 mg/l for control substrate and 27.49°C, 7.56 and 6.26 for control substrate feed respectively.

The fish growth, survival and production for different treatment is presented in Table 2. Survival (%) appeared to be independent of the treatments and varied between 65.33-91.98. In control (C) the survival for rohu, mrigal, common carp and tilapia were 89.27, 88.29, 87.98 and 65.33 percent respectively.

The survival for rohu (91.17%) was highest in control substrate (CS) treatment followed by mrigal (87.42%), common carp (87.15%) and tilapia (66.00%). It was also observed that, in case of control substrate feed (CSF) treatment the survival for rohu, mrigal, common carp and tilapia were 91.98, 89.00, 87.22 and 68.06 percent respectively. ANOVA showed a significant ($p<0.05$) increase in growth in ponds provided with water reeds.

Treatments having substrate have better growth performance compare to treatment without substrate. The absolute growth in control for rohu, mrigal, common carp and tilapia were 320.95g, 298.90g, 786.45g and 351.35 g respectively. In case of control substrate treatment highest absolute growth was for common carp (708.05g) followed by tilapia (358.71g), rohu (355.25g) and mrigal (345.45g). The absolute growth (g) for rohu, mrigal, common carp and tilapia in control substrate feed treatment were 458.11, 409.15, 867.30 and 454.25 respectively. The absolute growth for common carp was observed to be highest among all the treatments. The total yield of the fish was highest in treatment having feed and substrate in contrast to other treatment.

Table.1 Mean water quality parameters measured in various treatment ponds.

Parameters	Treatments		
	Control (C)	**Control Substrate (CS)**	**Control Substrate Feed (CSF)**
Temperature (°C)	27.81	27.52	27.49
pH	7.41	7.52	7.56
DO (mg/l)	6.04	6.12	6.26
Transparency (cm)	51.30	53.59	55.13
Total alkalinity (mg/l)	153.69	150.24	152.55
Nitrate (mg/l)	1.61	1.86	2.01
Ammonia (mg/l)	0.23	0.27	0.31

Table.2 Fish growth, survival and production in control (C), Control Substrate (CS) and Control Substrate Feed (CSF)

Sl. No.	**Treatment**	**Stocking density per 0.25 ha**	**Survival (%)**	**Absolute growth (g)**	**Total yield (Kg/0.25ha)**	**BC ratio**	
						1st year	**2nd year**
1.	**Control(C)**						
	Rohu	750	89.27±0.40^{a}	320.95±0.55^{aa}	Fish: 640.00±1.08^{a}	1.65±0.003^{a}	3.38±0.000^{a}
	Mrigal	300	88.29±0.67^{b}	298.90±0.60^{ba}			
	Common carp	300	87.98±0.27^{c}	786.45±0.73^{ca}	Reed: 0		
	Tilapia	150	65.33±0.94^{d}	351.35±0.70^{da}			
2.	**Control substrate (CS)**						
	Rohu	750	91.17±0.69^{a}	355.25±0.33^{ab}	Fish: 653.25±0.62^{b}	2.60±0.001^{b}	5.55±0.001^{b}
	Mrigal	300	87.42±0.49^{b}	345.45±0.32^{bb}			
	Common carp	300	87.15±0.48^{c}	708.05±0.04^{cb}	Reed: 6751.00±1.73^{a}		
	Tilapia	150	66.00±0.58^{d}	358.71±0.35^{db}			
3.	**Control substrate feed (CSF)**						
	Rohu	750	91.98±0.10^{a}	458.11±0.57^{ac}	Fish: 800.50±0.64^{c}	2.38±0.009^{c}	4.16±0.000^{c}
	Mrigal	300	89.00±0.57^{b}	409.15±0.37^{bc}			
	Common carp	300	87.22±0.44^{c}	867.30±1.12^{cc}	Reed: 7742.00±1.15^{b}		
	Tilapia	150	68.06±0.61^{d}	454.25±0.59^{dc}			

Different subscripts indicate significant differences (p<0.05).

The total yield of reed for CS and CSF treatment were 6751kg and 7742 kg respectively. Water reed plants used as substrate was found to be very economical and profitable for periphyton based aquaculture system. Among the three treatments the cost benefit ratio was highest in treatment having control and substrate in both first year and second year.

The present study shows that survivals (%) of fish were not significantly different irrespectively of treatment since there is no relationship between the survival of fish and growth of periphyton in pond. Plantation of water reeds as a substrate in pond affected the growth and production of *Labeo rohita*, *Cirrhinus mrigal*, *Cyprinus carpio* and Tilapia. The mean absolute growth of fish were significantly (p<0.005) higher in treatment having water reed as substrate than without substrate and highest in the treatment having substrate and feed. Similar observations were also reported by (Garg & Bhatnagar, 2016) in ponds where bamboo poles were used as substrate in culturing Nile tilapia. It may be due to the availability of higher number of periphyton in the pond as periphyton act as both feed for fish and also as water quality enhancer. Periphyton can also act as an antibiotic against a variety of fouling bacteria or as a probiotic (Azad *et al*., 1999). The total yield of fish was significantly ($p<0.005$) higher in substrate based treatment where highest yield was found in treatment with substrate and supplementary feed. Better yield of carp was demonstrated by adding substrate and reducing feed input in pond by Jha *et al*., (2018). However, the benefit cost ratio (B:C) was highest in treatment with substrate without supplementary feed because feed constitute 45-50% of total variable cost for culture of fish. The overall results showed that the benefit cost ratio can be improved by reducing the feed cost and increasing the yield. Till date, no attempts were made to study periphyton based aquaculture using water reed as a substrate.

Periphyton based Aquaculture Technology in Water reed

Plantation of water reeds for periphyton production had a positive effect on growth and yield of fish. This technology can be practiced in the region where the cost of feed is a big challenge for aquaculture development. The B:C was better in treatment without supplementary feed since the cost of feed was not included. This method of fish farming is suitable to rural farmers as it is cost effective, simple and doubling of income from both water reed and fish.

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