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The Potential of Increasing Pond Fish Production by Growing Dhaincha *(Sesbania rostrata)* in the Pond Bottom

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Abstract

An on-farm trial was carried out in 12 earthen ponds at the Montala Village, Muktagacha, Mymensingh for a period of 4 months (July-October 2003) to assess the potential of increasing pond fish production by growing dhaincha (*Sesbania rostrata*) in the pond bottom. The experiment consisted of four treatments each with three replications with an object of replacement for the use of fertilizers in fish production. In treatment-I (T_1) dhaincha without fertilizer, in treatment-II (T_2) dhaincha with 25% fertilizer, in treatment-III dhaincha with 50% fertilizer and in treatment-IV (T_4) dhaincha with 100% fertilizer were used. Dhaincha seed was sown at 100 g•40m^{-2} from bottom to dike. After 50 days of sowing dhaincha on the moist pond bottom, lime and fertilizer were used and fish fry were released after watering the ponds. The stocking density of rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus cirrhihosus*), silver carp (*Hypophthalmichthys molitrix*) and Thai sarputi (*Puntius gonionotus*) was 12,350 fish•ha^{-1} in all treatments. Fertilization was done at 100 g urea + 100 g TSP•40 m^{-2}, 50 g urea + 50 g TSP•40 m^{-2}, 25 g urea + 25 g TSP•40 m^{-2} in treatments T_4, T_3 and T_2, respectively and no fertilization in T_1. Some of the water quality parameters showed significant difference among different treatments, but most parameters were found within the suitable ranges for pond fish culture. Recorded periphyton groups were composed of Bacillariophyceae (9), Chlorophyceae (10), Euglenophyceae (2), Cyanophyceae (6), Crustacea (2) and Rotifera (3). Among these groups Cyanophyceae was the most abundant in number of which *Microcystis* was most abundant. The mean abundance of Cyanophyceae in treatments T_1, T_2, T_3

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and T_4 were 62,099±7,159 cells•cm^{-2}, 59,259±7,941 cells•cm^{-2}, 53,827±12,983 cells•cm^{-2} and 56,419±13,015 cells•cm^{-2}, respectively. The mean survival rate in treatments T_1, T_2, T_3 and T_4 were 82.14, 84.53, 82.83 and 83.23%, respectively. The highest growth rate of fish observed after one month of stocking and then growth rate was decreased gradually. Highest total net fish yield was recorded in T_2 (1,619 kg•ha^{-1}), where 25% fertilizer was used along with Dhaincha followed by T_1 (1,249 kg•ha^{-1}), T_3 (1,421 kg•ha^{-1}) and T_4 (1,268 kg•ha^{-1}). It can be concluded that use of dhaincha along with 25% fertilizer would be a better environment friendly management system for pond aquaculture than the only fertilizer dependent culture practice.

Introduction

Asian pond production systems are becoming increasingly reliant on external resources (feed, fertilizer) to supplement or stimulate autochthonous food production for pond fish and excluding poorer sectors of the community from participation (O'Riordan 1992; Beveridge and Phillips 1993; Beveridge et al. 1994; NACA 1995). Moreover, most production systems are inefficient, only about 30% of nutrient inputs being converted into harvestable products, the remainder being lost to the sediments, effluent water and the atmosphere (Beveridge et al. 1994; Olah et al. 1994).

Nitrogen is one of the most critical limiting factors for better production of natural foods in an aquatic habitat. Nitrogen is added primarily as urea, but organic materials such as plant residues and green manures are also effective sources of nitrogen in the water-body. Chemical fertilizers are too expensive and the poor farmers of Bangladesh cannot afford it. On the other hand, continuous use of synthetic nitrogenous fertilizer may cause environmental pollution.

There has been continuous effort to explore sources of organic based fertilizers. African dhaincha (*Sesbania rostrata*), a root and stem nodulating species, with vigorous growth and high biomass production created a new dimension in the science and art of green manuring (Dreyfus et al. 1985). It thrives well in moist and water-logged soils. It is able to nodulate along its stem as well as in roots. Its nodes can fix nitrogen and release it to the soil after incorporation (Dreyfus et al. 1985). The stem nodules are arranged in 4 to 5 vertical lines along the stem and also on lateral branches. At vegetative stage the stem and leaves are very soft and deep green in color. It can be propagated through seed and stem cutting (Hossain et al. 1990). Plants grown on the pond bottom both in the seasonal ponds or in the periphery of the perennial ponds during dry season from December to April may provide a good source of nutrients on submerge. The soft parts and leaves of the plants can be decomposed while the stick in the water column can act as substrate for periphyton and thus may increase the availability of food organisms.

Most omnivorous fish, like major carps of Indian and Chinese origin feed on larvae, benthic animals, epiphytic or periphytic algae, rather than on pure phytoplankton alone (Horn 1989). Such algae require substrates for attachment, which are virtually absent in fish ponds. If pond algae could be grown on dhaincha substrates, culturable fish species may be able to harvest them, resulting in a more efficient utilization of primary production. This system may help fish not to spend lot of energy for filtering a large volume of water for collecting feeds.

The project explores the possibilities of dhaincha-fish farming technology into low input aquaculture systems with the aim of reducing dependency on external resources (e.g. fertilizer) and increasing nutrient and energy utilization, thereby improving sustainability and the access of poorer sectors of community to aquaculture for income generation and nutritional security.

Materials and Methods

Preparation and management of ponds

Twelve earthen ponds situated at the Montala, Mymensingh district of Bangladesh were used for this experiment. The experiment was conducted from 2 July 2003 to 31 October 2003. The experiment consisted of four treatments and three replications. Treatment-1 comprised of 3 ponds each with area of 7 to 10 decimals (1 decimal = 40 m^2). Treatment-2 comprised of 3 ponds each with area of 7 to 10 decimals, treatment-3 comprised of 3 ponds each with area of 8 to 15 decimals and treatment-4 comprised of 3 ponds each with area of 8 to 22 decimals. The experiment designed in T_1-Dhaincha plus no fertilizer, T_2-Dhaincha plus 25% fertilizer, T_3–Dhaincha plus 50% fertilizer and T_4-Dhaincha plus 100% fertilizer.

In the month of May all selected ponds became dry with slightly moist bottom. Dhaincha seeds were then sown at 100gm•decimal^{-1} from bottom to dike. After 50 days lime was applied at 1kg•decimal^{-1} in all the treatments. Fertilization was done at 100g urea + 100g TSP•decimal^{-1} in treatment-4, 50g urea + 50g TSP•decimal^{-1} in treatment-3, 25g urea + 25g TSP•decimal^{-1} in treatment-2 and no fertilizer in treatment-1. All the treatment ponds were stocked with the same stocking density of 5, 9, 10, 13, 8 and 5•decimal^{-1} of silver carp, catla, silver barb (rajputi), rohu (rui), mrigal and common carp (carpio), respectively. Dhaincha was submerged with increasing of pond water that was used as green manure and the stems of unsubmerged dhaincha were used as substrates for the growth of periphyton. All ponds were also fertilized fortnightly with the mentioned doses. The farmers supplied rice bran as supplemental feed.

Measurement of water quality parameters

Water quality parameters in the ponds such as water temperature, Secchi depth, dissolved oxygen (DO), pH, PO_4-P, NO_3-N, NH_3-N and chlorophyll-a were measured fortnightly. Water temperature (°C) was measured with the help of a thermometer, dissolved oxygen (mg•L^{-1}) measured with the help of a portable DO meter (Model-Lutron DO-5509), pH of water was determined with the help of a portable pH meter (Corning pH meter 445 model), NO_3-N and PO_4-P of water were determined with the help of a portable Spectrophotometer, (HACH-DR/2010), chlorophyll-a was determined by using a spectrophotometer (Milton Roy Spectronic, Model 1001 plus) after filtering 100 ml of water sample through Whatman filter paper, Model-GF/C, circles 47 mm.

Estimation of growth, survival and yield of fish

To estimate growth, five fish were sampled of each species fortnightly with the help of a cast net from each pond. Then the length (cm) and weight (g) of individual fish were recorded separately with the help of a measuring scale and an electronic balance. Fish survival for each treatment and replication was estimated on the basis of number of fish harvested at the end of the experiment. The gross and net yield of fish for each treatment were determined by multiplying the average gain in weight of fish both in gross and net by the total number of fish survived in each treatment at the end of the experiment. Yield per treatment were then converted to yield per ha.

Results

Water quality parameters

Physical parameters transparency and temperature and the chemical parameters pH, dissolved oxygen (DO), nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), phosphate-phosphorus (PO_4-P) and chlorophyll-a were measured at 15 day intervals during the experimental period. The overall mean values of each water quality parameter in four treatments are presented in table 1.

Table 1. Water quality parameters (Mean value ± SE) of the ponds under four treatments

Parameters	Treatments				Level of significance
	T_1	T_2	T_3	T_4	
Temperature (°C)	30.40±0.25	30.06±0.26	29.99±0.20	30.35±0.20	NS
Transparency (cm)	38.88±1.83	28.67±1.21	24.63±1.10	39.42±1.61	**
Dissolved oxygen (mg•L^{-1})	4.93±0.30	4.22±0.23	4.84±0.30	4.96±0.25	NS
PH	6.79±0.06	6.66±0.09	6.98±0.13	6.79±0.07	NS
Chlorophyll-a(µg•L^{-1})	162.70±19.8	176.09±17.1	281.45±32.4	166.73±20.4	*
No_3-N	0.15±0.04	0.78±0.27	0.06±0.02	0.11±0.03	*
NH_3-N	0.22±0.04	0.54±0.15	0.20±0.02	0.17±0.03	*
PO_4-P	0.17±0.04	0.34±0.09	0.26±0.09	0.18±0.04	NS

NS = Not significant; * = Significant; ** = Highly significant

Periphyton

During the study period 32 species of periphyton (27 phytoplankton and 5 zooplankton) belonging to 6 different groups of Bacillariophyceae (9), Cyanophyceae (6) Chlorophyceae (10), Euglenophyceae (2), crustacea (2) and Rotifera (3) were found in the four treatments. Among all these groups, Chlorophyceae, Bacillariophyceae and Cyanophyceae were the most abundant groups. Among the major groups, Cyanophyceae ranked first in respect of abundance. The mean abundance of Cyanophyceae in treatments 1, 2, 3 and 4 were 62,099±7,159; 59,259±7,941; 53,827±12,983 and 56,419±13,015, respectively. The mean abundance of periphyton under different treatments is shown in table 2.

Table 2. Abundance (Mean ± SD) of periphyton (x 10^3 cells•cm^{-2}) on the dhaincha trees

Periphyton groups	Treatments			
	T_1	T_2	T_3	T_4
Bacillariophyceae	13.33±6.0	21.36±9.12	13.21±5.29	15.56±8.73
Chlorophyceae	18.03±10192	22.22±7.62	19.01±9.01	17.16±12.29
Cyanophyceae	62.10±7.16	59.26±7.94	53.83±12.98	56.42±13.02
Euglenophyceae	6.79±3.66	9.88±2.14	8.64±1.14	4.44±1.97
Crustacea	2.35±0.95	2.47±0.94	2.22±0.74	0.99±0.94
Rotifera	5.06±0.85	4.44±1.97	4.20±1.35	6.05±2.55
Total	107.66±28.78	119.63±29.72	101.11±30.52	100.62±39.48

Growth and production of fish

Growth and production of fish in different treatments were different. Details of stocking, harvesting, survival and production of fish species are presented in table 3. On the basis of final growth attained by each species, it was observed that among all species of carps under four treatments, silver carp attained the highest average length (42 cm) and weight (670 g). The mean survival rate (%) in treatments 1, 2, 3 and 4 were 82.14, 84.53, 82.83 and 83.23 respectively. After four months of rearing the production ranged from 1459.58 to 1836.26 kg•ha^{-1} in the four treatments. The highest production was obtained in treatment-2 (Dhainche plus 25% fertilizer) while the lowest total production was obtained in treatment-1 (Dhaincha plus no fertilizer). Highest growth was observed after one month of stocking but growth rates decreased in subsequent months. The rotting of dhaincha in the first month, producing large quantities of green manure as well as fish food, may have been a factor.

Discussion

The term water quality in its broadest sense includes all physical, chemical and biological characteristics of water. In fish culture, water quality is usually defined as the suitability of water for the survival and growth of fish. It is therefore, important that the aquatic environment should be used in a sustainable way and that the aquatic resource base should not be damaged or destroyed. The water quality parameters meas

Table 3. Growth, survival and production of fish in different treatments

Species	Mean stocking weight (g±SD)	Mean harvesting weight (g±SD)	Survival (%)	Yield ($kg \cdot ha^{-1} \cdot 4\ month^{-1}$)	
				Species wise	Total
Treatment 1:					
Common carp	30.86±5.84	193.15±95.05	84.62	205.43	
Catla	5.94±3.40	62.86±19.85	82.40	116.68	1459.58
Mrigal	13.41±2.22	109.33±40.98	80.19	175.46	
Sar Puti	24.14±7.19	86.70±35.89	76.06	165.12	
Rui	19.50±6.77	114.81±70.72	81.90	306.37	
Silver carp	43.10±6.02	445.08±135.4	87.69	490.52	
Treatment 2:					
Common carp	30.86±5.84	186.41±80.94	89.55	208.82	
Catla	5.94±3.40	149.26±34.59	81.82	275.84	1836.26
Mrigal	13.41±2.22	182.17±37.39	83.18	302.73	
Sar Puti	24.14±7.19	127.26±23.12	77.24	245.88	
Rui	19.50±6.77	135.18±24.29	85.06	373.49	
Silver carp	43.10±6.02	380.25±53.48	90.30	429.50	
Treatment 3:					
Common carp	30.86±5.84	202.91±87.79	89.60	228.48	
Catla	5.94±3.40	81.52±34.37	80.06	148.20	1634.85
Mrigal	13.41±2.22	164.19±98.60	80.0	262.40	
Sar Puti	24.14±7.19	96.03±26.15	74.13	177.91	
Rui	19.50±6.77	150.04±96.47	84.15	410.96	
Silver carp	43.10±6.02	363.69±118.09	89.02	406.90	
Treatment 4:					
Common carp	30.86±5.84	196.89±81.69	87.11	214.56	
Catla	5.94±3.40	68.25±21.52	77.94	119.70	1482.20
Mrigal	13.41±2.22	120.63±46.08	81.94	197.6	
Sar Puti	24.14±7.19	96.12±21.54	75.0	180.38	
Rui	19.50±6.77	116.0±55.58	85.12	320.91	
Silver carp	43.10±6.02	389.02±97.38	92.27	449.05	

ured in all the ponds throughout the experimental period were found to be within the acceptable range of fish culture. Temperature, DO, pH and PO_4-P did not show any significant differences among the treatments. Dissolved oxygen and pH were found lower than the values recorded 6-6.5 mg•L^{-1} and 7.0-9.0, respectively by Kunda et al. (2008). It may be due to decomposition of submerged dhaincha leaf and bark. Transparency, chlorophyll-a, NO_3-N and NH_3-N showed significant differences among the treatments. Kunda et al. (2008) also reported the similar type of values in their study. Transparency varied significantly among the treatments due to surface runoff as the surface topography was not the same in all the pond dykes.

A serious problem arising from intensive aquaculture is pollution through nutrient loading during successive culture periods. Nowadays, with a gradual increase in aquaculture, specially intensive and semi-intensive aquaculture, farmers are utilizing high doses of fertilizers and in many cases with fish feed in the confined waters of ponds and lakes year after year to increase fish production. As a result most of the fish ponds become nitrified and fish farmers are experiencing many new unexpected problems such as, environmental degradation with noxious algal blooms, ammonia toxicity, different fish diseases or other problems that ultimately hamper or reduce the production.

A total of 32 genera of periphyton community belonging to 6 different groups (Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, crustacea and rotifera) were identified on the natural substrate dhaincha, from which 27 genera were phytoplankton and 5 genera were zooplankton. Most dominant genera were *microcystis, Oscillatoria, Euglena, Gonatozygon* and *Navicula*. The mean abundance of periphyton in the four treatments was very high which indicated that dhaincha was a good substrate for periphyton growth. Eminson and Phillips (1978) stated that the hard substrates, such as bamboo poles were the most suitable substrates for periphyton growth. The taxonomic composition of the periphyton showed a rapid development of a relatively stable community with a little difference between the substrate types. A total of 56 genera of algal periphyton and 35 genera of phytoplankton were identified by Wahab and Azim (2001). The most important of all the stems/sticks of Dhaincha may be used as substrates of sessile algae, zooplankton, benthic larvae and bacteria, as well as a platform for deposition of organic detritus. These rich foods may provide a new food web to the cultured fish species. This concept is similar to the periphyton-based fish culture which has recently been gaining popularity (Uddin 2007).

Regular fertilization in fishponds accumulates nutrients in pond mud. Nutrient budget in intensive and semi-intensive fish culture ponds reveals that a large quantity of these elements is not utilized by fish and often accumulated in the pond (Boyd 1990). About 75% of the nitrogen and 80% of the phosphorus supplied in feed were not utilized by fish and most of them accumulate in the sediments (Avnimelech and Lacher 1979). Leguminous green plants (Dhaincha) grown in the pond bottoms, can utilize the entrapped nutrients from the bottom sediments as well as can fix atmospheric nitrogen by the *Rhizobium* bacteria living in the leaves or shoot nodules, the rough symbiosis. These green plants can also remove the phosphetic and other nutrients and can be made available to the water column increasing natural pond productively and fish production. The production of the Indian major carps and Chinese carp species (silver carp, rohu, mrigal, catla, puti and carp) in treatment-2 was higher than in treatments 1, 3 and 4. The aim of this experiment was to reduce the application of chemical fertilizer over dhaincha in the fishpond. The study shows that the total production of fish was higher in treatment-2 (Dhaincha plus 25% fertilizer) than in treatment-1 (Dhaincha plus no fertilizer), treatment 3 (Dhaincha plus 50% fertilizer) and treatment-4 (Dhaincha-plus 100% fertilizer). Survival rate was also high (84.53%) among the treatments. It can be said that dhaincha may be the replacement/alternative for chemical fertilizer.

Since there are no reports whatsoever on the possibility of using dhaincha for enhancing pond fish production and there is an obvious potential of making pond mud nutrients and aerial nitrogen available to the water column, there is tremendous scope for its use in the fish ponds. Most omnivorous fishes, like major carps of Indian and Chinese origin feed on larger benthic, epiphytic or periphytic algae, rather than on pure phytoplankton (Horn 1989). Such algae require substrates for attachment which are virtually absent in fish ponds. These algae grow on dhaincha substrates and fish species harvest them, resulting in a more efficient utilization of primary production. It also absorbs large amounts of nutrients and removal might constitute an effective means of stripping nutrients from effluents or natural waters.

Conclusion

Nowadays, environmental pollution is a major issue all over the world. In aquaculture fertilization is mostly dependent on inorganic fertilizers and continuous use of these chemical fertilizers may cause environmental pollution. So, for a sustainable environment friendly aquaculture, we need to reduce the use of chemical fertilizers. Dhaincha can fix nitrogen effectively into its nodes which may be a source of nitrogen for pond and after decomposition of its leaf and bark it may be used as organic fertilizer. Moreover, dhaincha stem may be used as substrate of periphyton which is a very good natural food for fish. According to the result of the present study it can be concluded that the use of dhaincha along with 25% fertilizer would be a better environment friendly management system for pond aquaculture.

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