DEVELOPING NEW SYSTEMS FOR PERIPHYTON ENHANCEMENT IN FARMERS' PONDS

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Production System Design and Best Management Alternatives/Study/16BMA04UM

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Objectives

1. To identify other possible methods besides bamboo rafts to enhance periphyton growth in ponds while not interfering in harvest systems.
2. To field test the most promising of these methods for periphyton enhancement in ponds in additional on-farm trials.

Significance

The government of Nepal (GoN) has recognized that chronic malnutrition is a major problem in the country. The most common forms of malnutrition include undernutrition (insufficient energy) and deficiencies of vitamins and minerals, particularly vitamin A, iodine, and iron. About 41% of children less than 5 years of age are stunted (UNICEF, 2012a) and 48% are anemic (MoHP, 2006). With the nutrition problem, there is a need to develop environmentally sustainable and cost-effective food production systems that function year-round to provide adequate nutrients and improve household income for rural poor farmers. Our research activities in Nepal have targeted local women for improvements in household and larger scale fish pond production. In Nepal, men from poorer rural areas are often forced to seek employment outside the home (often even outside the country), and women are left to maintain the household and care for the family (Bhujel et al., 2008). As a result, most of the ponds developed for household aquaculture are managed by women.

Since 2008, the Institute of Agriculture and Animal Science (now the AFU) has promoted an innovative and environmentally sustainable fish production system of "Carp-SIS polyculture" to improve nutrition of poor women and children in Terai (Rai, 2012, 2013). The approach includes increased intake of small indigenous fish species (SIS) to improve health and nutrition of women and children. SIS are self-recruiting in aquaculture ponds, after initial stocking or colonization from natural waters, and can be harvested weekly and biweekly, favoring regular household consumption. A carp-SIS polyculture system also provides additional income through the sale of surplus fish. Addition of SIS to the carp polyculture system raised fish production above the national average, doubled consumption rate of household members, and provided Rs. 3,025 income per household in 270 days, which helped families become economically empowered (Rai, 2012).

We have done considerable research to help improve the carp polyculture system in Nepal by introducing new species (especially SIS, tilapia, and sahar) and by enhancing pond production by providing substrates for colonization of periphyton. As periphyton removes nutrients from the water and adds oxygen as it grows, it also cleans water being discharged from ponds and improves environmental performance. Since rohu, catla, and common carp are periphyton feeders (Rai and Yi, 2012), their growth and production are enhanced in ponds with added substrate for periphyton colonization compared to ponds without substrate

(Azim et al., 2002; Rai et al., 2008). We recently completed a series of trials in on-station and on-farm experiments (Rai et al., 2016). These experiments showed dramatic increases in net fish yield (27%) and profit (74%) in on-station experiments. For on-farm studies, total fish production and gross margin were 19.3% and 151% higher in the carp+SIS+substrate treatments with 50% feeding than in carp polyculture with 100% feeding. Reduced feeding that is possible when periphyton is enhanced is not only economically more viable, but also enhances environmental performance, as the water quality in ponds is generally higher and effluent released on draining for harvest is not as damaging. However, the on-farm work also identified some problems with our periphyton system. We used fixed rafts of bamboo covering about 1% of the pond area as a substrate for periphyton growth, but culturists believe these structures interfered with harvesting of fish, although on the positive side, they may also have provided hiding places for fish to avoid predation by birds, since survival of some carp species was higher in substrate ponds. Further outreach on this system, including meetings with farmers and testing of alternative periphyton enhancing substrates, is the main objective of this investigation. Some possible methods might include using portable and floating substrates or ones that could be lifted from the water or pond during management activities. Since these issues were identified by farmers, we intend to hold two workshops to meet with farmers and identify their best ideas to develop periphyton substrates that will minimize disturbance to their operations. We then plan to field test the various methods identified in farm ponds.

The economic value of periphyton enhancement includes the ability to grow fish faster under similar inputs, as well as the ability to reduce inputs of feed and achieve similar growth rates. However, our previous trials included both periphyton enhancement and feed input reduction together. We have not tested reduced feeding without periphyton enhancement, and thus the gain in profit by reduced feeding has been included in the benefit of periphyton enhancement in our studies to date. We need to also separate these two management activities so we can clearly understand the importance of reduced feeding compared to periphyton enhancement in polyculture systems.

The purpose of this study is to assess 2-3 alternative periphyton enhancement methods identified by farmers in farm ponds with polyculture of carps and SIS in two locations of Nepal.

Quantified Anticipated Benefits

We anticipate that our workshops will identify new methods for periphyton to be enhanced in ponds, and about 40 farmers will adopt these systems after testing in on-farm trials. We will also hold a workshop for government personnel and farmers to extend the results of these experiments to these user groups.

Extension of periphyton enhancement to 20 farms through on-farm trials. Education of another 40 women will be done with a workshop to non-adopting farmers and 20 extension personnel during a workshop for government personnel, extending the results of our periphyton work. At least 5 graduate or undergraduate students will be involved in some aspect of this research, also enhancing their educational and research experience.

Research Design and Activity Plan

This experiment will evaluate increased yield of carps and SIS as a result of enhancing periphyton production, and will also determine improvements in water quality as a result of periphyton treatments.

Location

On-farm verification of the best system will be tested in farmers' ponds in two districts; at Majhui, Chitwan and Kawasoti, Nawalparasi.

Methods

Null hypothesis: There are no differences in growth, production, gross profit margin, and partial harvest among different polyculture systems (control, different periphyton substrates.

1. Workshops: Two workshops will be held: one in Majhui and one in Kawasoti. At the workshops, farmers from the region that have been involved in previous periphyton studies will be asked to propose better alternatives for periphyton substrates in ponds. These alternatives must be environmentally responsible, including the materials used for colonization. The best alternatives will then be determined by voting of all attendees for all alternative designs suggested. Probably 2-3 alternatives will be selected for future testing, but the number are currently uncertain.
2. Experiment:

2.1 Culture period: 6 months for on-farm trials, SIS monitored for 12 months.

2.2 Test species: carps (common, silver, bighead/catla, grass, rohu, mrigal) and SIS (dedhuwa and pothi)

2.3 Stocking and Treatments

Stocking size: carps (5-10 g), SIS (2-5 g)

2-3 periphyton enhancements will be tested in multiple ponds

Additionally, a control with reduced feeding and no periphyton enhancement will be tested.

Besides the substrate systems tested, the inputs will be:

(1) Carp polyculture (15,000/ha) + SIS (50,000/ha) with 50% feeding (control)

(2) Control + substrate (covering 2% of pond surface area) with 50% feeding. There will be multiple versions of these treatments, including various substrate enhancements identified in the workshops.

Overall production levels, fish size, and SIS yield will be evaluated for each farm by record keeping during harvest. Growth and production will only be assessed over the whole grow out season. Weight will be measured on 20 individuals of each species at stocking and harvest. Total harvest biomass will be measured for each species.

2.4 Nutrient input: feeding (for reduced rations) will be done 6 days per week with dough of rice bran and mustard oil cake at 1.5% BW for most carps and grass to grass carp at 50% BW. Carp and SIS will be fed with freshly made dough of mustard oil cake and rice bran (1:1). Grass carp will be fed daily with locally available grass at 50% body weight. Fertilization will be done biweekly at 0.4 g N and 0.1 g P $m^{-2}day^{-1}$ with di-ammonium phosphate (DAP) (18% N and 46% P_2O_5), urea (46% N) and farm yard manure (FYM)**.** DAP and urea input at 700 and 940 g, respectively, and FYM at 60 kg for a 200 m^2 pond.

2.5 Water management: maintain at 1 m deep.

2.6 Water quality will be measured at stocking, mid-point, and harvest by project personnel. Parameters will include Dissolved Oxygen, SDD, and temperature will be measured as close to dawn as possible on each date. Periphyton colonizing substrates will be identified to species by microscopy and quantified for relative abundance at the beginning, middle, and end of the experiment in each pond.

2.7 Farm visits will be made to each location at stocking, mid-point, and harvest to evaluate record keeping as well as to make measurements of fish and water quality variables.

2.8 Statistical design and statistical analysis:

Statistical design: Completely randomized design (CRD)

Statistical analysis: Multiple ANOVA

Trainings and Deliverables

Training: Twenty farmers will learn periphyton enhancement techniques through on-farm trials.
Forty women will learn about this technology through a workshop.
Twenty extension personnel will also be trained on the technology through a workshop.
At least five graduate or undergraduate students will be trained on research methods by involvement in these trials.

Deliverables: Two workshops to determine alternative periphyton technologies.
One workshop on periphyton technology results.

One fact sheet describing this technology.
One final report and hopefully one research publication after the end of this grant period.

Schedule

Periphyton workshops: 1 October 2016 through 1 January 2017. On-farm trials: 1 May 2017 through 1 December 2017. Final report will be completed no later than 28 February 2018.