Production of Periphyton to Enhance Yield in Polyculture Ponds with Carps and Small Indigenous Species

Sustainable Feed Technology and Nutrient Input Systems/Experiment/13SFT08UM

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ABSTRACT

The two best treatments obtained from our on-station trial were tested at farms in Chitwan and Nawalparasi districts. Carp polyculture with 100% feeding and carp+SIS+substrate with 50% feeding were introduced to 19 and 18 women farmers, respectively. Farmers stocked carp and small indigenous species (SIS), fed them with supplementary feed, and fixed bamboo substrate to ponds, as per the protocol of the on-station trial. Farmers were provided with a book to record fish that were consumed, sold, or died. Final harvest was conducted after eight months of culture by netting fish following partial water withdrawal from ponds. Total fish production and gross margin were 19.3% and 51.7% higher in carp+SIS+substrate with 50% feeding than in carp polyculture with 100% feeding. Apparent food conversion efficiency was higher in these ponds than during the on-station trial because ponds were randomly selected for monthly growth measurements and feed adjustment accordingly for all ponds at that farm. Training on carp+SIS+substrate technology was also provided to another 35 farmers through a workshop in Chitwan.

INTRODUCTION

Government of Nepal (GoN) has recognized that chronic malnutrition is a major problem in the country (UNICEF 2012). With the nutrition problem, there is a need to develop an environmentally sustainable and cost effective means of year-round food production that provides adequate nutrients and improves household income to rural poor farmers. Since 2008, the Institute of Agriculture and Animal Science (IAAS) has been promoting an innovative and environmentally sustainable household fish production system "Carp-SIS polyculture" to improve nutrition of poor women and children in Terai (Rai et al. 2012). The approach includes increased intake of nutrient-rich Small Indigenous Fish Species (SIS) to improve health and nutrition of women and children. Vitamin A, calcium, zinc and iron are found to be much higher in the eyes, head, organs and viscera of SIS (Roos et al. 2006). Since SIS are eaten whole, there is no loss of nutrients from cleaning or as plate waste. Moreover, SIS are self-recruiting and therefore, can be harvested weekly and biweekly, favoring household consumption. Carp-SIS polyculture also provides additional income through the sale of surplus fish. Studies revealed that the farming system raised the fish production above that of the national average, doubled consumption rate of owners, and farmers earned Rs 3,025 per household in 270 days which helped them to be empowered economically (Rai et al. 2012).

In commercial fish farming, feed alone accounts for about 60% of total input cost (Bhujel 2009), which is expensive to small-scale farmers, and so it is essential to provide an alternate to reduce feed cost. Adding substrates such as bamboo to carp ponds can increase carp production by facilitating growth of periphyton which serves as food. Since rohu *(Labeo rohita)*, catla (*Catla catla*), and common carp *(Cyprinus carpio)* 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 substrates (Azim et al. 2002, Rai et al. 2008). Azim et al. (2004) showed a 70% increase in Rohu production in ponds for periphyton, compared

to control ponds, a 59% increase in net yield for polyculture carp ponds with feed and periphyton enhancement, and a 28% increase in yield for periphyton enhancement only, compared to ponds with fertilizer only. Since, the combination of species and type of feed influence the yield and income in such a system, it is necessary to test the full combination of feed inputs, periphyton enhancement, and production to truly understand the best system to use for commercial production (Diana 2012).

We conducted trials on-station at AFU to determine the best combination of carps, SIS, and periphyton enhancement choices to maximize net fish yield and profit in ponds. The purpose of this experiment was to use the best treatments found on station and to extend the trial to farmers who would follow some of our protocols but produce fish in their usual manner. Therefore, we assessed the effect of periphyton enhancement on Carp-SIS polyculture with reduced and without feeding systems in Chitwan and Nawalparasi, Nepal.

OBJECTIVES

- To verify findings of the on-station trial through an on-farm trial; and
- To provide training on carp+SIS+substrate technology to nonadopters through workshops.

MATERIALS AND METHODS

On-farm trial. The two best treatments — carp polyculture with 100% feeding and carp+SIS+substrate with 50% feeding — were selected based on fish production and profit from our on-station trial and tested in the field trial. A total of 37 women farmers participated in the on-farm trial: 15 in Majhui, Chitwan (one farmer dropped out in the middle of the project period), and 22 (14 in Seri village and eight in Nandapur village) in Nawalparasi district. Among them, 18 farmers (eight in Chitwan and 10 in Nawalparasi) participated in carp+SIS+substrate polyculture with 50% feeding. Similarly, 19 farmers (7 in Chitwan and 12 in Nawalparasi) participated in carp polyculture with full feeding. Average pond size was 259 m^2 (145–500 m^2) in Chitwan and 413 m^2 (163–552 m^2) in Nawalparasi. All farmers stocked fingerlings of rohu (25%), silver carp (*Hypophthalmichthys molitrix*) (20%), bighead carp (*Aristichthys nobilis*) (5%), mrigal (*Cirrhinus cirrhosis*) (15%), common carp (15%) and grass carp (*Ctenopharyngodon idella)* (20%) at a rate of 1500 fish per hectare and stocking was completed on 8 April 2015. Dedhuwa *(Esomus danricus)* and pothi *(Puntius sophore)* (SIS) were introduced by allowing them to enter the pond from a feeder canal. Those farmers who did not have canal supply collected SIS from nearby canals and stocked some to the pond. Farmers fixed the split bamboo substrates in ponds late in the last week of June (later than originally planned due to the earthquake disruption in Nepal). Substrate preparation was conducted as per protocol of the on-station trial. Sabita, a research student involved in the on-station trial, demonstrated how to construct substrate on both sites. Farmers fed fish with dough of rice bran and mustard oil cake (1:1) in the morning. The feeding rate was 3% fish biomass in ponds without substrates, and feed was reduced to half that level in substrate ponds. Feed quantity was adjusted monthly based on fish sampling conducted in randomly selected ponds. Grass carp were fed on grass, banana leaves, and vegetables. A book was given to each farmer to record the number and weight of fish that were consumed, sold, or died.

Final harvest began on 9 December and ended 19 December 2015. Harvest was conducted without draining ponds, by carefully netting a minimum of three times in each pond; all fish were then weighed. Ponds were not drained because fuel to operate pumps was scarce due to a blockade at the borders of Nepal. Since farmers wished to keep fish for their biggest festival "Maghi" that fell on January 15, netted fish were counted, weighed, and returned to the pond. During Maghi, major sales of fish occur because fish is an important food item in this celebration. Some farmers also may save fish in ponds for year-round consumption and to fetch higher prices later when there is less fish in the village. Gross income from fish sales was calculated from total production, assuming all carp were sold. Selling price of carp was Rs. 250/kg in Chitwan and Rs.270/kg in Nawalparasi, and that of SIS was Rs. 200. Gross margin was

calculated using gross income values for profits and determining the cost of inputs for each farming treatment. This was calibrated to a 100 m^2 pond size and assumed that all SIS were not sold but eaten in the household.

Workshop. A one-day training on periphyton-enhanced carp-SIS polyculture system was provided to 35 (seven men and 28 women) farmers from Chitwan district on 30 November 2015. Experts were from the Agriculture and Forestry University (Dr. Dilip K. Jha, Professor), Directorate of Fisheries Development (Bhagwat Prasad, Senior Fisheries Development Officer), the National Training Centre (Rajan Pd. Poudel, Master Trainer), and an NGO (Sovan Mahato, President and Ms. Usha Chaudhary, staff of Rural Integrated Development Society). The training venue was Kathar, Chitwan. The training was coordinated by Dr. Rai.

RESULTS

Production was higher in farm ponds with SIS treatments and half feeding than in carp ponds that were fully fed (Table 1). Overall production was 25.4% higher in the SIS treatments, and gross income was 51.7% higher (Table 2). Increases in income were the result of both higher overall production and lower costs due to reduced feed costs for the SIS ponds, with gross margin increasing 103% in ponds of the SIS treatment (Table 3).

Table 1. Fish (carp and SIS) production in two treatments in Chitwan and Nawalparasi districts.

Variable	Chitwan		Nawalparasi	
	Carp	Carp+SIS+substrate	Carp	Carp+SIS+substrate
carp production (kg/100 m^2)	26.8	35.3	33.1	37.6
SIS production (kg/100 m^2)	0.10	1.06	0.13	0.48
Total production (kg/100 m^2)	26.9	36.4	33.2	38.1
Extrapolated NFY (t/ha/yr)	4.1	5.5	5.0	5.8
AFCR	4.6	2.3	4.0	1.9

Table 2. Fish production, consumption, sale, and gross income per pond by farmers in Chitwan and Nawalparasi districts.

District	Treatment		Carp sold (kg/pond)	Carp consumed (kg/pond)	SIS consumed (kg/pond)	Total production * (kg/pond)	Gross income from fish sale (Rs./pond)
Chitwan (n=15)	carp polyculture (n=7)	Avg.	10.0	15.0	0.3	75.0	18,761
		Max	60.0	35.0	2.0	150.0	37,530
		Min	0.0	6.0	0.0	24.0	5,974
	carp+SIS+substrate (n=8)	Avg	31.0	23.5	2.6	109.6	27,411
		Max	170.0	45.0	5.0	302.4	75,598
		Min.	0.0	8.0	2.0	30.0	7,510
Nawalparasi (n=22)	carp polyculture (n=12)	Avg.	44.4	15.7	0.5	128.8	34,766
		Max.	260.0	55.0	5.0	261.4	70,575
		Min.	0.0	0.0	0.0	41.0	11062
	carp+SIS+substrate (n=10)	Avg.	25.8	8.7	2.2	164.0	44290
		Max.	155.0	20.0	10.0	275.8	74454
		Min.	0.0	0.0	0.0	107.5	23055

*Includes carp left in the pond and not consumed or sold at harvest.

Table 3. Gross margin (Rs/100 m^2 pond) for the two treatments in Chitwan and Nawalparasi districts.

Variables	Chitwan		Nawalparasi	
	Carp	Carp+SIS+substrate	Carp	Carp+SIS+substrate
Variable cost				
Carp seed	600	600	600	600
Feed	3,744	24,88	3,980	2,184
Total variable cost	4,344	3,088	4,580	2,784
Return				
Carp	6,703	8,853	8,817	10,190
SIS	19	211	27	96
Gross return	6,722	9,064	8,844	10,286
Gross margin	**2,378**	**5,976**	**4,264**	**7,502**
Gross margin (Rs/ha/yr)	361,654	908,850	648,483	1,140,929

DISCUSSION

Fish production was determined based on harvest weight listed by farmers in their record book. Harvest was conducted in shallow ponds without complete draining, so we may not have been successful in removing 100% of the fish. In Chitwan, four ponds had deep water, and some fish may have escaped during netting. Although farmers were clearly instructed not to add water for a month prior to harvesting, four farmers in Chitwan (one SIS, three carp-only treatments) did not drawdown ponds due to water insecurity in the region. In Nawalparasi, the water level was fairly low for effective netting because 90% farmers used well water as the source, and they followed instructions since the water supply was under their control. In Chitwan, almost all farmers used canal water to fill the pond because they did not have wells. The harvesting process may therefore have affected overall fish (carp and SIS) production.

Carp, SIS, and total fish production was also higher in carp+SIS+substrate ponds than carp polyculture in both project sites, indicating increased carp production due to periphyton enhancement. Carp, SIS, and total fish production was 18.0%, 85.4%, and 19.3% higher in carp+SIS+substrate ponds than in carp ponds. Contribution of SIS to total production was small and ranged 1.3-2.6% by weight in carp+SIS+substrate ponds and 0.3-0.4% in carp ponds. SIS production was very low in Nawalparasi because farmers used well water and had no source for SIS colonization. SIS was also harvested in carp-only ponds, as they could enter over time from canal water. AFCR was higher in farm ponds than in the on-station trial, which can be attributed to random selection of ponds for monthly sampling of fish and using it as a basis for calculation of feed ration to all ponds. Sampling in every pond would likely have resulted in more precise measures of fish size and correction of feeding rate. Since farmers did not fertilize the pond, excess feed probably served as fertilizer.

Fish sale and consumption was calculated based on the record books. Despite instruction and format provided for recording sale and consumption by both number and weight, most farmers recorded only by weight, so survival could not be estimated. Carp was the major fish consumed by farmers. Farmers did not sell SIS; it was all consumed at home. Around 84% of farmers (16 carp farmers and 15 carp+SIS+substrate farmers) consumed fish at home, and 41% of farmers (seven carp farmers and eight carp+SIS+substrate farmers) sold carp. Farmers generally sold carp directly to neighbors in the village. Selling price was Rs. 20 higher in Nawalparasi (Rs 270/kg) than in Chitwan (Rs 250/kg), which is reflected in both income and profit. Both return and profit was better in the carp+SIS+substrate treatment due to higher carp yield and reduced feed cost. Gross income was 25.4% higher, and gross margin was 51.7% higher from carp+SIS+substrate ponds than from carp ponds. All farmers returned a profit except one in Chitwan, who lost Rs 1,674 due to poaching of her fish. The gross margin analysis did not take cost of electricity to run pumps into account because it was difficult to separate electricity consumed by

pumps from that of regular household consumption. Similarly, the cost of SIS and bamboo was also not taken into account because SIS were collected free from canal water (labor cost only), and bamboo was freely available in the village. These variable costs would reduce profit but probably only to a small degree.

CONCLUSION

The on-farm trial confirmed that carp+SIS+substrate with 50% feeding gave better yield and profit compared to carp polyculture with 100% feeding.

ANTICIPATED BENEFITS

Using carp, SIS, and periphyton enhancement with reduced feeding produced a 19.3% increase in fish production in farm ponds and a 51.7% increase in gross margin. This technology of polyculture of carp and SIS in a periphyton-enhanced system was shared with 37 women farmers through on-farm training, and 35 (seven men and 28 women) farmers through a workshop.

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