

A COMPARISON OF MONOCULTURE AND POLYCULTURE OF TILAPIA WITH CARPS FOR POND PRODUCTION SYSTEMS IN NEPAL

ASIA PROJECT: NEPAL

US Project PI: James Diana, University of Michigan

HC Project PI: Madhav Shrestha, Agriculture and Forestry University

Production System Design and Best Management Alternatives/Experiment/16BMA03UM

Collaborating Institutions and Lead Investigators

University of Michigan (USA)

Agriculture and Forestry University (Nepal)

James Diana

Narayan Pandit

RN Mishra

SK Wagle

Madhav Shrestha

Objectives

1. To compare monoculture and polyculture of Nile tilapia with carps on-station and on-farm for optimal production.
2. To evaluate the value of each management manipulation by comparing enterprise budgets for each treatment and pond system.

Significance

Total fish production in Nepal was 54,357 metric tons in 2012, with about 60% originating from aquaculture. Pond culture is the most popular method of aquaculture, but annual pond yield averages only 3.83 t/ha (DoFD, 2012). Carps are popular warmwater fish for culture in Nepal, contributing more than 95% of aquaculture production in the country. Tilapia is a globally prominent species for all types of management intensities. Nile tilapia (*Oreochromis niloticus*) was introduced into Nepal in 1985 (Pantha, 1993), but it remained under government control for more than 10 years (Shrestha and Bhujel, 1999). Since 1996, experiments conducted at Institute of Agriculture and Animal Sciences (IAAS) included polyculture of tilapia and common carp (*Cyprinus carpio*; Shrestha and Bhujel, 1999), mixed-size culture of tilapia (Mandal and Shrestha, 2001), polyculture of grass carp (*Ctenopharyngodon idella*) and tilapia (Pandit et al., 2004), and recently additional polyculture experiments on-station and on-farm (Bhandari et al., 2016). Recruitment control remains a problem, as mixed-sex tilapia is most commonly used for culture. Snakehead (*Channa striata*; Yi et al., 2004) and sahar (*Tor putitora*; Shrestha, 1997) have been evaluated for their ability to control tilapia reproduction by predation on tilapia fry. Tilapia and sahar co-culture was attempted to control excessive recruitment of tilapia and provide an additional species to increase productivity of high-valued indigenous fish (Shrestha et al., 2011). Experiments indicated that sahar can sometimes control tilapia fry production, but often result in overpopulation of tilapia even when sahar are present (Paudel et al., 2007; Rai et al., 2007; Yadav et al., 2007; Shrestha et al., 2011). Growth of sahar was higher in tropical and subtropical ponds than in cages reared in Pokhara lakes, as well as suspended cages in ponds (Bista et al., 2001, 2007; Shrestha et al., 2005, 2007). Sahar has been overfished in rivers and lakes, which has resulted in declining populations (Rajbanshi, 2001; Joshi et al., 2002; Rai et al., 2007).

Semi-intensive carp polyculture is an established system in the tropical and subtropical regions of Nepal, using fertilized ponds with supplemental feed. The carp species include silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*), common carp, grass carp, rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*). All 6 species are recommended in certain ratios with a combined density of 10,000 fish/ha, but fingerlings of all species are rarely available when needed for stocking. The typical number of species cultured ranges from four to six. The addition of other proven species (such as tilapia and sahar)

with increased stocking density into the existing carp production system could increase productivity up to 57% and net returns by 61% (Shrestha et al., 2012) with no added inputs. Since tilapia consume plankton, they will also improve water quality in ponds and in effluents at harvest. Such improvements in water quality, larger economic gain, and production of fish with no further inputs all enhance the sustainability of an aquaculture system environmentally and economically.

We recently completed an experiment incorporating tilapia into carp polyculture. The results showed significant increases in yield (29%) and profit margin (81%) when tilapia and sahar were added to carp polyculture. Overall production was still relatively low, about four tons per ha annually. This overall production is lower than monosex tilapia culture in ponds in Thailand, where we have achieved yields of about 5 tons per ha with only fertilizer inputs and up to 20 tons per ha in fed ponds (Diana, 2012). Monoculture of tilapia could possibly outperform polyculture with carps in Nepal, as well, either in terms of total production or in economic returns. It is not possible to directly transfer results on monoculture of tilapia from Thailand to Nepal, given the generally cooler and more seasonal climate in Nepal. Therefore, the purpose of this experiment is to examine monoculture of tilapia along with inclusion of tilapia in polyculture as techniques to best incorporate tilapia into the aquaculture industry in Nepal. Additionally, sahar are an endangered species (IUCN, 2016), so any success in rearing them will either relieve pressure on wild populations as a food source or will be used to supplement wild populations by stocking, again worthy goals to improve sustainability of aquaculture in Nepal.

The addition of new species to the carp polyculture system and testing of new species under new conditions fit the national aquaculture plans elaborated by government agencies, as well as the *Feed the Future* (FtF) plans for aquaculture improvement. The first FtF research goal is to advance the productivity frontier by both increasing productivity beyond current levels through technology development and extending technology so local production can reach the level of research farms. This proposal will focus on this goal. Secondly, the national plans for aquaculture and fisheries have goals to improve culture of indigenous fishes and raise yield of ponds from farms to the level of research stations (GoN 2000, NARC 2010). Again, this project is in complete alignment with these goals.

This study is intended to expand the technology developed through AquaFish research on carps, tilapia, and sahar production to farmers in order to demonstrate alternative fish production models. In particular, we will conduct a new on-farm experiment on monoculture and polyculture systems, using carp with the addition of tilapia and sahar, to determine the most practical system for farm adoption.

Quantified Anticipated Benefits

The results of this study will provide two additional species in the aquaculture system of Nepal, which should increase production and income. It will add high-valued fish to the culture system and supplement income. As carp polyculture is established, the increasing species will be easier to adopt by fish farmers. While adoption of monoculture may be more difficult, indications of higher production efficiency and profit will be the first steps in developing that system. Polyculture will also help in production of sahar, which could be stocked in natural waters to reverse population declines. It will benefit fish culture in southern Asia and other countries where carp culture is popular. The immediate impact will be measured by the increased production and economic returns in on-station and on-farm trials for the different polyculture systems. We expect to improve yield and economic returns for aquaculture systems by at least 30% over traditional carp culture and train at least 5 farmers in the new production system. We will document these benefits through on-station trials and subsequent surveys of farmers who attend our training sessions.

Research Design and Activity Plan

Location

Aquaculture Farm, AFU, Rampur, and private farm ponds in fish production pockets of the Chitwan district.

Methods

Null hypothesis: Monoculture of monosex tilapia produces significantly higher yields and profits than polyculture under current conditions.

- 1.1 Test species: carps (common, silver, bighead, grass, rohu, mrigal and catla), Nile tilapia, and sahar
- 1.2 Stocking:
carps (5-10 g) at 10,000/ha
Nile tilapia (5-10 g) at 3,000/ha in polyculture, 10,000 or 20,000/ha in monoculture
sahar (5-10 g) at 1,000/ha
- 1.3 Nutrient input: daily feeding with locally made feed (20% CP) composed of 1:1 mustard oil cake (28% CP) and rice bran (12% CP) at 2% of total biomass per day. Ponds fertilized biweekly at 0.4 g N and 0.1 g P m⁻²day⁻¹ with di-ammonium phosphate (DAP) (18% N and 46% P₂O₅), **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 m² pond.
- 1.4 Water management: maintain at 1 m deep.
2. Treatments:
 - 2.1 Existing carp polyculture (10,000/ha) + mixed-sex tilapia (3,000/ha) + sahar (1,000/ha)
 - 2.2 Existing carp polyculture and monosex tilapia at 3,000/ha.
 - 2.3 Monosex tilapia at 10,000/ha with fertilization only
 - 2.4 Monosex tilapia at 20,000/ha with fertilization and feeding
3. Each treatment will be tested in triplicate ponds at the Aquaculture Farm, AFU, Rampur. Additionally, each treatment will be tested in private farm ponds in Chitwan with at least three replications of each treatment.
4. Sampling Schedule: Water quality will be measured monthly in the on-station work and at initiation and harvest times in each on-farm pond using CRSP protocols. Fish growth and yield will be measured monthly from stocking to harvest in on-station trials but only at stocking and harvest in on-farm trials. Partial enterprise budgets will be estimated for overall production results of each treatment in both pond systems.
5. Statistical Design and Statistical Analysis:
The trial will be conducted in a completely randomized design, and data will be analyzed using one-way ANOVA within each research site. Evaluation of differences in values for a given treatment type between on-farm and on-station trials will be done by t-test.

Trainings and Deliverables

Training: 30+ farmers will learn new culture systems in on-farm trials
Workshop to train on-farm plus other farmers in system technology
At least 5 graduate and undergraduate students will receive research training by working on the trials

Deliverables: Testing results of 2 new polycultures and 1 monoculture system
Improve yield and economic return by 30% for farmers, documented by the outcome of our on-station and on-farm trials.
One fact sheet on use of tilapia in aquaculture in Nepal
One final report and hopefully one research publication to be completed after the grant period.

Research Project Investigations: Production System Design and Best Management Alternatives

Extend results to 30+ farmers through the demonstration project and a workshop.
Train at least 5 graduate and undergraduate students on aquaculture research.
Final extension to other farmers through a fact sheet.

Schedule

Stocking of on-station and on-farm ponds in April 2017. Harvest of ponds in November 2017. Final report no later than February 2018. Workshop in December 2017.