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Cost Containment Options for Tilapia Production in Central Luzon, Republic of the Philippines: Alternate Day Feeding Strategy

Tenth Work Plan, Product Diversification Research 2 (10PDVR2)
Final Report

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Abstract

The growout efficiency and economics of using alternate day feeding in the pond culture of Nile tilapia (*Oreochromis niloticus*) was evaluated in an on-farm trial. This feeding strategy was compared with daily feeding to determine the effects on growth rate, survival, yield, and net profit. At harvest, the mean weight of fish in the daily feeding was 167.3 ± 53 g while in alternate day feeding it was 137.8 ± 72 g. The mean survival rates were 55% and 63% for the daily and alternate day feeding groups, respectively. Fish yields were 222 kg from the daily fed group and 200 kg from the alternate day fed group. These apparent differences in mean weights, survival rates and fish yields from the two feeding schedules were not statistically significant. The quantity of feeds was 475 kg in the daily feeding schedule and only 208 kg in the alternate day feeding schedule. Feed conversion ratios (FCR) were 2.24 and 1.0, respectively. The amount of feeds and FCR were significantly different between the two feeding schedules. The cost-benefit analysis, taking into account gross sales and fingerling, feeds and fertilizer costs resulted in a negative net return for the daily feeding (-P2,240 ha^{-1}) while the alternate day feeding schedule gave a net return of P43,095 ha^{-1}. The study indicates that alternate day feeding strategy can provide another cost containment feeding option for tilapia farmers.

Introduction

The determination of feeding strategies based on mathematical and economic models can be rather complex (Cacho, 1993). It is not known whether the reduction of feed costs without a net reduction in crop yield is a result of more efficient feed consumption (i.e. lack of waste), better feed utilization (increased feed conversion ratio) or both. It has also been argued that optimal feeding levels should be below the level supporting maximal growth on the basis of water quality concerns—regularly feeding to the point of satiation increases the risk of waste, feed decomposition, and compromised fish health (Hatch and Kinnucan, 1993). The modeling of optimal feeding regimes is based on a mix of observations and assumptions. Most often, decisions about the amount to feed are left to chance, or the instincts of the farmer.

Feeding management strategies have been investigated for several species of fish (Singh and Srivastava, 1984; De Silva et al., 1986; Srikanth et al., 1989; Diana, 1997). De Silva (1985; 1989) had presented a number of mixed feeding schedules which involved feeding the fish alternately with high and low protein feeds. The results of a study on Nile tilapia reared on some of the mixed feeding schedules (i.e., high protein feed alternated with the low protein feed) indicated comparable growth performance to those reared in entirely high protein feed. A substantial cost saving on feeds was realized and the nitrogen loading of the system reduced in such feeding schedules (De Silva, 1985; De Silva et al., 1993).

A series of farm trials were concluded on costs and benefits of feeding strategies available to tilapia farmers (Brown et al., 2000; Bolivar et al., 2001; Bolivar et al., 2003). The experiments were designed to test the efficiency of production under conditions of variable feeding intensity. Earlier studies including those of Diana et al. (1996) have raised doubts about the efficacy of pushing the feeding schedule in order to maximize growth. Nevertheless, our studies have shown that it is possible to reduce feed costs without compromising fish production by means of efficient feeding strategies in semi-intensive tilapia culture.

The first study compared production of tilapia in fertilized ponds with the initiation of supplemental feeding at either 45 days or 75 days post-stocking. Seven commercial farms were involved in this study, in which ponds were assigned to each of the two treatments. Tilapia fingerlings (mean weight 0.11 g) were stocked at 4 m^{-2}, and a farm-made feed of rice bran and fish meal were used beginning on either day 45 or day 75 and continued through the 150-day grow-out cycle. Yields, daily weight gains, and survival rates were determined. Cost analyses of the two feeding strategies were carried out using a paired t-test. There were no significant differences observed on growth (mean final weight, mean daily weight gain) and survival (85–87%) for the two treatments. The extrapolated fish yields were 5,104 kg ha^{-1} after 45-day onset versus 4,926 kg

Table 1. Feeding guide used during the farm trial.

Age (wk)	Average Fish Weight (g)	Feeding Rate (%)	Type of Commercial Feeds			
			Fry Mash	*Starter*	*Grower*	*Finisher*
1	0.2–1.0	20	+			
2	1.1–2.9	15	+			
3	3.0–5.9	10	+			
4	6.0–9.9	7		+		
5	10.0–15.9	7		+		
6	16.0–22.9	7		+		
7	23.0–30.9	6		+		
8	31.0–39.9	6		+		
9	40.0–50.9	5		+		
10	51.0–65.9	5			+	
11	66.0–75.9	4			+	
12	76.0–90.9	4			+	
13	91.0–120.9	3			+	
14	121.0–150.9	3				+
15	151.0–160.9	3				+
16	161.0–200.9	3				+
17	201.0–250.9	2				+
18	≥ 251	2				+

Note: Assumed fish survival rates:
First month, 100%;
Second month, 90%;
Third month, 85%; and
Fourth month, 80%.

ha^{-1}after 75 day onset, but this difference was not statistically significant ($P > 0.05$). Earlier feeding strategy required 37% more prepared feed than the delayed feeding, sharply increasing production cost and reducing profit. The relatively better feed conversion ratio associated with delayed feeding may have resulted from reduced waste or compensatory growth, or both (Brown et al., 2000).

Our second study (Bolivar et al., 2001) compared growth, survival, and yield of tilapia fed daily at either 100% or 67% of experimentally-determined satiation. Analysis of growth performance demonstrated that the reduction of ration to 67% of satiation had no effect on growth or yield, and again the more moderate feeding strategy was more profitable. A third study combined feeding starting at day 75 and 100% or 67% satiation feeding. Result of this study again proved that feeding of fish at 67% satiation level reduced the production cost in tilapia culture as opposed to the 100% satiation feeding (Bolivar et al., 2003), although the overall profitability of the combined reduction of ration and delayed onset of feeding was compromised, in comparison with the individual feed reduction methods tested previously.

A fourth feeding strategy that was recently tested under the Aquaculture CRSP is provision of prepared feeds to tilapia on alternate days. Consonant with the overall objective of this project—to demonstrate efficient feeding strategies for tilapia production in semi-intensive culture—the present study was

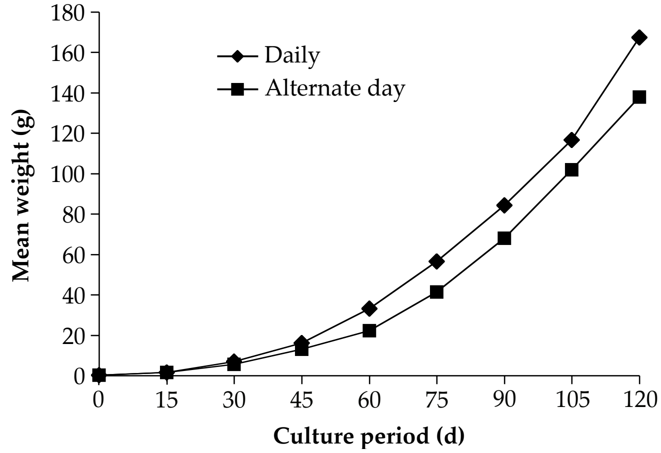

Figure 1. Growth trend of Nile tilapia in the daily and alternate-day feeding schedules.

conducted to determine the effect of alternate day feeding on grow-out efficiency and net profit.

Methods and Materials

Nine commercial tilapia farmers participated in this trial. At each participating farm site, two ponds of similar sizes were assigned one each of the two feeding schedules—daily feeding and alternate day feeding. The goal of this study was to test feeding strategies under authentic operating farm conditions. Inherent in meeting that goal is the somewhat less than complete control that one has over small variables, but on the positive side, this approach provides direct insight in the real-world applicability of certain techniques. It also has the advantage of built-in outreach activity, in the sense that voluntary participants tend to readily adopt methods that they see first-hand as potentially profitable.

The ponds were stocked with sex-reversed Nile tilapia (*Oreochromis niloticus*) of the GenoMar Supreme Tilapia or GST strain acquired from the GIFT Foundation International, Incorporated. This strain is genetically selected for faster growth. Fingerlings with mean weight of 0.19 ± 0.03 g were stocked in the ponds at 4 fish m^{-2}. All ponds were fertilized with inorganic fertilizers at the rate of 28 kg N and 5.6 kg P ha^{-1} wk^{-1}. Water depth of the ponds was maintained at 1 m. The fish were provided with commercial feeds following the two feeding schedules of daily and alternate day and using a feeding guide for the adjustment of the amount and type of feeds (Table 1). The rations used in the control group (fed daily) were intended to be representative of a feeding schedule used under typical commercial production conditions, as opposed to deliberate overfeeding.

Water quality was monitored once a month in all ponds. The water was analyzed for dissolved oxygen, pH, total alkalinity, total ammonia and soluble reactive phosphorus. Dissolved oxygen was measured using a DO meter while a pH meter was used to get the pH concentration of the water. Total alkalinity, total ammonia, and soluble reactive phosphorus were analyzed in the laboratory following standard methods (Aquaculture CRSP, 1992).

A sample of 50 fish was obtained from each pond every month

Table 2. Mean final body weight, specific growth, and survival rate of Nile tilapia fed daily (A) and on alternate days (B) in the different farms after 120 d.

Farmer Cooperators	Mean Final Weight (g)		Specific Growth (%)		Survival (%)	
	A	*B*	*A*	*B*	*A*	*B*
Limos	182.87	144.28	5.67	5.46	64	67
Sadural	83.82	92.02	5.15	5.24	82	96
De Guzman	127.13	68.83	5.59	5.09	42	63
Catalma	153.23	99.78	5.49	5.13	67	77
Danting	221.24	198.04	5.63	5.47	52	66
Saturno	178.20	144.72	5.67	5.47	38	31
Mendoza	129.84	75.42	5.40	4.96	42	100
Palada	263.73	296.69	5.95	6.02	21	25
Onia	166.12	120.38	5.63	5.33	48	47

Table 3. Total feed given, fish yield, and feed conversion ratio (FCR) of Nile tilapia fed daily (A) and on alternate days (B) in the different farms after 120 d of culture.

Farmer Cooperators	Total Feed Given (kg)		Total Fish Yield (kg)		FCR	
	A	*B*	*A*	*B*	*A*	*B*
Limos	451.50	214.20	262.50	237.10	1.72	0.90
Sadural	280.70	116.50	152.80	166.70	1.84	0.70
De Guzman	403.70	107.50	144.30	88.00	2.80	1.22
Catalma	240.30	101.60	147.90	108.10	1.62	0.94
Danting	334.50	130.60	147.10	181.80	2.27	0.72
Saturno	500.10	197.50	156.90	137.00	3.19	1.44
Mendoza	575.50	179.30	419.00	277.40	1.37	0.65
Palada	758.60	567.90	220.60	362.20	3.44	1.56
Onia	728.20	255.30	351.50	242.10	2.07	1.05

Table 4. Mean values across farms of the performance of Nile tilapia fed daily and on alternate days after 120 d culture period.

Parameters	Feeding Schedules	
	Daily	*Alternate Day*
Initial Mean Weight (g)	0.19 ± 0.03	0.19 ± 0.03
Final Mean Weight (g)	167.35 ± 53	137.79 ± 72
Mean Daily Weight Gain (g d^{-1})	1.39 ± 0.44	1.15 ± 0.60
Total Weight Gain (g)	167.16 ± 53	137.60 ± 72
Specific Growth (%)	5.58 ± 0.22	5.35 ± 0.31
Fish Yield (kg)	222 ± 102	200 ± 88
Extrapolated Fish Yield (kg ha^{-1})	2,994 ± 808	2,807 ± 857
Survival (%)	55.34 ± 20	63.42 ± 26
Feed Conversion Efficiency	2.24 ± 0.73	1.00 ± 0.34
Quantity of Feeds (kg)	475 ± 185	208 ± 145

to monitor weight gain. After 120 days, the fish were harvested by seining and then complete draining of the ponds. The total number of fish was counted, and bulk weighed. Final mean weight, daily weight gain, gross yields, and survival rates were calculated. The total amount of feed given in each treatment was also estimated at the end of the study. The data were analyzed statistically using T-tests, with significance set at $P < 0.05$.

RESULTS

Table 2 presents final mean body weight of the fish, specific growth and survival rates from the different participating farms. While growth performance differed between farms, as some farms appeared to have better fish growth than the others, the mean growth performance of fish in the daily and alternate day feeding did not show any significant differences. The growth response of the fish over 120 days is shown in Figure 1. Although a trend favoring faster growth rate in the daily-fed group was observed, the apparent difference was not statistically significant. Similarly, the specific growth rates were comparable in the two feeding schedules and in some farms, even higher in the alternate day-fed group.

The survival rates obtained were 55.35% and 63.42% for the daily and alternate day feeding, respectively. Higher survival values were reported for the experimental groups (fed on alternate days) than the controls on seven of the nine participating

Table 5. Cost and return of tilapia production per hectare using daily and alternate-day feeding strategies (PHP 53.4 = US$1).

Item	Feeding Schedule	
	Daily	*Alternate Day*
GROSS RETURN (PHP ha^{-1})	136,534	120,920
COST (PHP ha^{-1})		
Tilapia Fingerlings	19,599	21,163
Fertilizers	8,454	8,465
Feeds	110,722	48,197
NET RETURN (PHP ha^{-1})	–2,241	43,095

farms. However, this apparent difference in survival rate for the two feeding schedules was not statistically significant. We saw no evidence to suggest that the moderate survival rates observed in this experiment were treatment-related, or a result of nutritional deficiency, since there were no significant differences between treatments and since the fish fed on alternate days had, if anything, a trend favoring improved survival.

The amount of feeds given averaged 475 kg in the daily fed-group as opposed to 208 kg in the alternate day-fed group. The amount of feeds was significantly higher in the daily feeding schedule. Feed conversion ratio (FCR) also greatly differed between the two feeding strategies. A significantly better FCR was obtained on fish fed on the alternate day (Tables 3 and 4).

The cost-benefit analysis, taking into account gross sales and cost of fingerlings, feeds, and fertilizer resulted to a negative net return for the daily feeding (-P2,240 ha^{-1}) while the alternate day feeding schedule gave a net return of P43,094 ha^{-1} (Table 5).

DISCUSSION

The general problem associated with tilapia culture is on how to reduce the cost of production, particularly feed costs. While feeding with supplemental or complete feeds had greatly improved tilapia yields, it can entail up to 60–70% of the total production cost. Therefore, it has become imperative that cost containment options, especially on reducing feed costs, are developed and tested to further improve the economic productivity of the farmers.

Alternate day feeding may already be practiced by farmers unintentionally such as on occasions when there are delays in the availability of feeds on the farm, or when other tasks draw farmers away from their tilapia ponds. Sometimes the feeding interval goes up to several days before fish are fed with commercial feeds. Recently, during personal interviews, some farmers, expressed interest in the use of feeding on alternate days, but also expressed hesitance about the possible consequences because of the lack of an appropriate study on this feeding practice. In this design of alternate day feeding schedule, a cost savings of more than 50% was realized. The remarkable savings of half of the feed bill was not accompanied by any statistically significant reduction in pond production. This study did not provide a means of determining the specific cause of the similar growth rates and production values of the control and experimental fish, and we still suspect that reduced feeding leads to less waste and perhaps more efficient nutrient absorption. It is also likely that the reduction of feed waste could lead to indirect effects on growth rate, either by altering water quality or microbial effects, although we do not have data to either support or refute this hypothesis. It has been our observation that outbreaks of pathogenic bacteria tend to be associated with heavy feeding in intensive tilapia culture, and organic loading of the system may be a contributing factor.

CONCLUSIONS

This study demonstrates that the alternate day feeding strategy can provide another cost containment feeding option for tilapia farmers. Cutting the cost of feed in half without significantly diminishing production has obvious and profound potential for application. Some might argue that rearing fish in a perpetually unsatiated state is inhumane, or that keeping animals in a hungry state is abusive. Our data suggest otherwise, that the fish fed on alternate days were robust and healthy, and that neither growth nor survival was in any way compromised. Obviously, farmers have no use for a feeding paradigm that borders on starvation, or under which conditions fish are in any way weakened or immunocompromised. We do not recommend denial of rations to the degree that fish become distressed, and our data show clearly enough that our feed reduction strategies did not have this effect. Certainly the Nile tilapia evolved with lower feed requirements than even the most minimalistic of farm scale production feeding paradigms that we have tested.

Our investigations to date have provided three clear options for reducing feed bills without negatively impacting production. Delaying the onset of feeding in fertilized ponds (Brown et al., 2000), feeding daily but at a reduced rate (Bolivar et al., 2001), or feeding on alternate days (present study) can be practiced without diminishing the harvest. Experimentation to date does suggest that there are limits to the degree that feeding can be reduced without compromising crop value, as combining the first two feed-reduction strategies proved less profitable than either strategy alone (Bolivar et al., 2003).

ANTICIPATED BENEFITS

The tilapia is a well established crop with growing importance worldwide, particularly in Southeast Asia, and the generation of new strategies for tilapia culture could have an economic impact throughout the region. Because farmers have experienced this cost-savings first hand in the course of this study, we believe the dissemination of this information and its implementation on the farm is already underway. Based on our most recent experience, we anticipate that these studies on feeding strategies will provide insight into the suitability of a variety of cost-cutting options available to farmers—not so much in the form of a dogmatic paradigm to be followed, but a series of choices and expected benefits available for their use as they see fit, and depending on the circumstances on their farms.
It has been our experience that farmers require flexibility in their decisionmaking, and that they prefer not to be given a set of strict imperatives when it comes to cultivation protocols. Many consider farming to be a mix of art and science, and the ideal advice from the research community does not always come in the form of a single "Best Management Practice," but rather a set of options that they can invoke at their own discretion. Our studies to date have provided a series of methods for reducing feeding costs and thereby increasing profits.

The use of reduced feeding approaches also has general benefits that come from the reduced consumption of materials that can be used for other purposes, and the potentially reduced risk of environmental contamination that can result from inefficient farming methods. Among the environmental implications, it should be considered that uneaten food is cycled through the microbial food web, and under some circumstances the consequences of microbial and algal blooms may be harmful. The discharge of water laden with nutrients and microorganisms from culture ponds can have highly undesirable effects on natural ecosystems as well, especially when pathogenic bacteria are part of the microbial population. The consumption of fishmeal for the production of fish by farmers is considered to be an ecologically unsound practice by many environmentalists, and an inefficient use of the protein contained in fisheries bycatch. Our demonstration that the consumption of protein in tilapia farming can be cut by up to half without disrupting fish production seems compatible with these arguments. Applied on a wider scale, it would appear that feed reduction strategies could extract more food for human consumption from available sources of fish and fisheries bycatch.

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