A Comparative Study on Different Feeding Machines to Growth, Water Quality and Economic Performance in Nile Tilapia (*Oreochromis niloticus*) Commercial Farming

Jaruwan Songphatkaew[1], Amararatne Yakupitiyage[2], Monthon Ganmanee[1*] and Isao Tsutsui[3]

[1*] Department of Animal Production Technology and Fisheries, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand
[2] Aquaculture and Aquatic Resources Management, School of Environmental Resources Development, Asian Institute of Technology, Patumthani, Thailand
[3] Japan International Research Center for Agricultural Sciences, Ibaraki, Japan

Abstract

Acomparative study of two different feeding methods; fixed station feeder (AF) and mobile blower feeder (BF), on growth, water quality and economical performance in Nile Tilapia (*Oreochromis niloticus*) were done in earthen pond commercial farm in Petchaburi province, central Thailand. Monosex tilapias (average initial body weight of 300 g) were stocked in six 8000-11200 m^2 earthen ponds at a density of ca. 1 fish/ m^2 and cultured for 120 days. Fish were fed with a MN 11 commercial tilapia pellet feed (30% protein). Results showed survival, yield, body composition and feed utilization in fish fed using (AF) and (BF) were not statistically difference (P>0.05). However, growth performance was higher in fish fed using blower feeder. Distribution of fish in earthen pond during feeding time between 2 feeder machines was different. Most fish in pond fed using (AF) method aggregated near the outlet (feeding area), while the uniform distribution was observed in pond fed by (BF) method. There were no significant differences in almost all water quality parameters and perform at the optimal level. In addition, there was no significant difference in the economic performance between two feeding methods. Therefore, the (AF) might be the considerable options of feeding machine which can improve growth performance for Nile tilapia commercial farming.

Keywords: Fixed Station Feeder, Mobile Blower Feeder, Nile Tilapia, Growth, Commercial Farming

1. Introduction

Introduced from Japan in 1965, Nile Tilapia is one of the most economically freshwater fish species in Thailand [1]. Cultivation of the species has expanded rapidly because of its high growth rate and tolerance to environmental stresses. The production techniques improved and undesirable flavors were controlled, so Nile Tilapia moved into the mainstream market with a variety of product processing such as fresh fish, dry, frozen and fresh fillets [2]. There are many tilapia farms in Thailand both small and large scales which can contribute to 155000 tons per year, ca. 42% of all fresh water fish production in Thailand [3].

*Corresponding author: E-mail: kkmontho@gmail.com

Recently, culture of tilapia has gained even more popularity because of the high market demand for tilapia fillets in the United States and other industrialized countries [4]. In intensive tilapia farming, fish are stocked in very high densities in earthen ponds, and fed with high quality pellet feed. Apart from many important considerations for intensive tilapia aquaculture systems, such as pond design, seed stocking, and harvesting, feeding profile is the most important factor in commercial tilapia farming. Farmers have to manage feeding regimes and feeding methods suitable for a high density of fish in order to make a high profit.

Cost of fish-feeding is both labor-intensive and expensive. Fish can be fed by hand, blower, automatic feeder or demand feeder. Hand-feeding is labor intensive but has advantages over other methods because it allows the feeder to observe feeding activity and behavior. The feeding method is not suitable for large commercial farms. The most common method to feed pellet in large ponds is blowing by using a mechanical device that is either mounted on or pulled behind vehicles. A study by Lovell [5] found that *O. niloticus* gained 72% more body weight when fed by demand feeder than when hand-fed once a day, however, feed conversion was 45% poorer for fish fed by demand feeder. However, feeding pellet by using fixed station still has many disadvantages including it is does not reflect fish appetite, requires electrical power and high power consumption, its high operation cost [6]. Moreover, aggregation of fish may use a lot of energy to compete in the feeding areas. Water quality in the feeding areas may become worse than in the rest of the ponds. Therefore, a mobile feeder is considered as an alternative option. With this method, feed might spread much more efficiently. Hepher and Pruginin [7] reported that some farmers in Israel use a feeding blower tank mounted on a truck or a single-axle feeding blower tank pulled by a tractor and operated on its own power. It is equipped with an impeller which blows the feed through a slanted pipe a distance of about ten meters into the pond. A company [8] used a blower feeder driven by a three to five horsepower engine to feed fish and shrimp. Regarding from a mobile blower working system, it may lead to an even distribution of fish within the ponds, improved water quality, and reduced variation in fish size. Fish may be able to consume more natural food and reduce the competition of feeding resulting in higher growth rate and production. However, such feeding machine has never used in large scale commercial fish farm in Thailand. The present study aimed to compare the efficiency of mobile blower feeding and fixed feeding method on growth, yield, distribution, size variation, water quality and economic performance by comparing with fixed station in Nile tilapia commercial farming.

2. Materials and Methods

2.1 Experimental management

The 120 days (October 2007 - February 2008) on-farm experimental trials were carried out in six earthen pond (8000 to 11200 m^2 or 0.8 to 1.12 ha) at Manit Farm, a large commercial fish farm located in Petchaburi Province. Prior to the experiment, ponds were dried for 1 week and adjust pH by added calcium carbonate 375 kg/ha. EM (effective microorganism) was used twice a month at rate 187.5 L/ha. Nile tilapia (*Oreochromis niloticus*) juveniles (300 ± 24 g) were obtained from on-site ponds. They were stocked at a density of 1 fish/m^2. Fish were fed with commercial tilapia pellet feed contained of 30% protein content. The experiment consisted of two treatments and three replicates, for a total of six ponds arranged using a Complete Randomized Design (CRD). The main factor was feeding method, fix station automatic feeding method (AF) and mobile blower feeding method (BF). The AF dispensed the feed the whole day. It spread pellet feed onto feeding area (outlet) approximately 10 m^2. The BF dispensed the feed 2 times/day at 0900 hrs and 1400 hrs. The blower was set on a 4 wheels vehicle and spread pellet feed far away from pond dike around 10 m. along culture pond. Every ten days, 10-20 fish were randomly sampled by using catch net to weigh and adjust feeding volume according to the feeding table of the farm (1-2.5 % of body weight).

2.2 Experimental parameters

2.2.1 Water quality

Water in each pond was sampled every 10 days to monitor water quality. Temperature, dissolved oxygen and pH were measured by dipping a thermometer, DO meter and pH meter, respectively. Nitrite-nitrogen and total ammonia-nitrogen; *In situ* measurement by a test kit (colorimetric method) was used to determine total ammonia-nitrogen at 1500 hrs at three areas.

2.2.2 Fish growth and yield

Fish in each pond were harvested, counted and bulk-weighed after finish the experiment and were sold into two different markets, processing market and local market, after finished the experiment. The fish which body weight less than 700 g were sold in the local markets whereas more than 700 g fish were sold in the processing market. The fish yield was analyzed using the following parameters:

$$\text{Processing marketable fish yield (ton/crop/ ha)} = \frac{\text{Total final processing fish weight (ton)}}{\text{Pond area (ha)}}$$

$$\text{Local marketable fish yield (ton/crop/ha)} = \frac{\text{Total final local fish weight (ton)}}{\text{Pond area (ha)}}$$

$$\text{Gross fish yield (ton/crop/ha)} = \frac{\text{Total final fish weight (ton)}}{\text{Pond area (ha)}}$$

$$\text{Net fish yield (ton/crop/ ha)} = \frac{\text{[Final total fish weight (ton) - initial total fish weight (ton)]}}{\text{Pond area (ha)}}$$

Fish growth and survival performance was evaluated using the following parameters

$$\text{Mean weight (g/fish)} = \frac{\text{Final batch weight (g)}}{\text{Number of harvesting fish}}$$

$$\text{Daily weight gain (DWG, g/fish/day)} = \frac{\text{[Mean final fish weight - Mean initial fish weight]}}{\text{Culture period (days)}}$$

$$\text{Specific growth rate (SGR, \%)} = \frac{[(\ell\text{n final weight - }\ell\text{n initial fish weight})] * 100}{\text{Culture period (days)}}$$

$$\text{Survival rate (\%)} = \frac{\text{Number of fish harvested} * 100}{\text{Number of fish stocked}}$$

2.2.3 Feed utilization

Three fish sample in each pond was collected before stocking and after completion of the experiment to analyze the proximate body composition. The proximate body composition was analyzed as moisture and dry matter, ash content, crude protein, crude lipid and crude fibre following the AOAC method [9]. The feed utilization of fish was analyzed using the following parameters

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Total feed wet (kg)}}{\text{Total wet weight fish gain (kg)}}$$

$$\text{Apparent net proteinutilization (ANPU)} = \frac{\text{Fish final body protein - Fish initial body protein}}{\text{Protein intake}}$$

* protein intake = Feed intake × (% protein /100)

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Weight gain}}{\text{Protein intake}}$$

2.2.4 Fish distribution

Distribution of fish in each pond was determined by using catch net sampled triplicate at three positions; two pond edges and the middle of the pond. A catch net was used to sampled fish at 1500 hrs by the same worker for three times sampling. A partial budget analysis was used to analyze the economic performance of the various feeding methods used in this experiment.

2.2.5 Statistical analysis

The difference between two treatments was analyzed by t-test for two sample comparisons of mean using Microsoft Excel. The comparison of fish distribution between three areas was analyzed by using K-S test and the comparison between treatment 1 (fixed station feeder, AF) and treatment 2 (mobile blower feeder, BF) was analyzed by using Chi-square test. The water quality parameters were analyzed by using Univariate model of ANOVA, followed by Duncan's multiple range at 0.05 significant levels.

3. Results and Discussion

3.1 Fish growth and survival

The final mean weight, DWG, SGR, survival rate, fish yield, body composition, FCR, ANPU and PER are presented in Table 1. The mean individual fish weights and lengths of both treatments increased with time. The mean final weights of fish fed by mobile blower feeder (969 ± 16 g; BF) was significantly higher than that fed by fixed station feeder (903 ± 25 g; AF). The DWG and SGR of fish fed by AF (5.0 ± 0.2 g/fish/day and 0.92 ± 0.02 %/day respectively) were lower than those fed by BF (5.6 ±0.1 g/fish/day and 0.98 ± 0.01 %/day respectively). The survival rates in both treatments were high at more than 99%, and there were no significant differences between the two treatments. Although the mean weight of fish fed by BF higher than fed by AF, their growth was not better because fish consume a greater amount of feed which could be resulting in a slightly higher FCR. These results are in agreement with those obtained by Hagerman Hatchery Evaluation Team [10] who evaluated that fish growth of the intermittently fed group was significantly higher ($P<0.05$) than the continuously fed group during the grow-out period. However, Casillas-Hernandez *et al*. [11] cultured Pacific white shrimp (*Litopenaeus vannamei*) in pond with two different feeding strategies, feeding trays and mechanical feed dispersal device. Individual final weight of Pacific white shrimp fed using feeding tray (fixed feeding area; 32.3 g) was significantly higher than shrimp fed by mechanical feed dispersal device (feed were delivered by air blower; 29.5 g). Paspatis *et al*. [12] grew sea bass from about 2.8-260 g by four different feeding methods, self feeding, automatic feeding, hand feeding and combined feeding. The result showed that sea bass weight using self feeding method was significantly lower than other methods. There were no significant differences in sea bass weight between automatic feeding method continually fed for 5 hr/day, and hand feeding method fed 2 times/day. In addition, Boujard and Medale [13] conducted an experiment on juvenile rainbow trout fed by hand (2 times/day) or by self feeder (5 hr/day) with different diets, and found that the specific growth rate of rainbow trout fed by self feeder was significantly higher than those fed by hand.

The proximate composition in fish was similar between the two treatments. There were no significant differences in moisture, ash, crude protein, crude lipid, crude fibre and NFE (nitrogen free extract) in the fish. The feeding method did not make the differences in FCR, ANPU and PER between the two treatments as well. The feeding method did not have much effect on these proximate compositions because fish were fed with the same high quality artificial pellet feed in both treatments, and the proximate composition of fish directly depends on feed type and feeding rate. Hagerman Hatchery Evaluation Team [10] reported that there were no significant differences in percent moisture, percent protein and percent lipid of steelhead between the two treatments. Moreover, fish fed by BF can be affected by birds more than fed by AF because BF had a larger feeding area and did not have a net to protect the fish, which can affect the feed utilization of fish. In addition, fish fed by fixed station feeder did not familiar with human, so the smaller fish was easier to be caught than big fish during sampling time. Therefore, this was the one reason that the feeding adjustment was inaccuracy which could affect to FCR. Boujard and Medale [13] reported that regardless of the diet, voluntary feed intake of juvenile rainbow trout fed by hand (feed 2 times/day) and by self feeder (continuously feed for 5 hr/day) were not significantly different. The FCR of Pacific white shrimp fed using feeding trays and mechanical feeding dispersion were not significantly different. However, this study's results are not in agreement with those obtained by Paspatis *et al.* [12] who found that automatically fed sea bass had poorer FCR than hand fed sea bass.

Table 1 Growth parameters, proximate body composition and feed utilization of Nile Tilapia fed using fixed station feeder (AF) and mobile blower feeder (BF) for 120 days culture period

Parameters	Treatment 1 (AF)	Treatment 2 (BF)
Growth		
Mean weight (g)	903 ± 25 [a]	969 ± 16 [b]
DWG (g/fish/day)	5.0 ± 0.2 [a]	5.6 ± 0.1 [b]
SGR (%/day)	0.92 ± 0.02 [a]	0.98 ± 0.01 [b]
Survival rate (%)	99.7 ± 0.07 [a]	99.9 ± 0.17 [a]
Proximate body composition		
- Moisture (%)	69.0 ± 2.5 [a]	70.2 ± 2.8 [a]
- Ash (%)	20.1 ± 1.3 [a]	17.6 ± 1.4 [a]
- Crude protein (%)	53.7 ± 3.8 [a]	53.5 ± 0.9 [a]
- Crude lipid (%)	25.4 ± 3.4 [a]	28.0 ± 2.3 [a]
- Crude fibre (%)	0.37 ± 0.15 [a]	0.33 ± 0.14 [a]
- NFE (nitrogen free extract) (%)	0.46 ± 0.63 [a]	0.63 ± 0.25 [a]
Feed utilization		
- FCR	1.23 ± 0.02 [a]	1.34 ± 0.11 [a]
- ANPU	1.52 ± 0.15 [a]	1.39 ± 0.10 [a]
- PER	2.65 ± 0.05 [a]	2.45 ± 0.19 [a]

***Note*:** Values are mean ± SD. Different superscripts in the same row indicate the significantly difference (P>0.05)

3.2 Fish yield

The processing marketable yield (weight more than 700 g), gross yield and net yield of fish fed by fixed station feeder (AF) was slightly lower than fed by mobile blower feeder (BF), but there were no significant differences in these parameters among the treatments (Table 2). This might be because fish fed by AF competed more to get feed than those fed by BF. The gross yield of fish fed by AF was about 9.17 ton/crop/ha, and 9.29 ton/crop/ha was obtained from BF. The increasing of stocking rates and using of high quality formulated feed were involved in tilapia intensive system. The yield of tilapia which were cultured in fertilized and fed ponds in Thailand stocked with 3 fish/m^2 for 5-8 months was 11-15 ton/crop/ha [14-15]. DOF [16] stated that tilapia yield in earthen pond was 4.76 ton/crop/ha of fish sized 350-500 g. Casillas-Hernandez *et al.*[11] compared the yield of Pacific white shrimp between fixed station feeding (feeding trays) and mechanical feed dispersal device and found that there were no significant differences in yield . Therefore, according to the results of this study and others, the different feeding methods did not have much effect to fish yield which is related to the survival rate.

Table 2 Yield responses of Nile tilapia fed using fixed station feeder and mobile blower feeder for 120 days culture period

Parameters	Treatment 1 (AF, fixed station feeder)	Treatment 2 (BF, mobile blower feeder)
Stocking weight (ton/crop/ha)	2.84 ± 0.09^{a}	2.72 ± 0.13^{a}
Fish yield		
Local marketable yield (ton/crop/ha)	0.16 ± 0.07^{a}	0.06 ± 0.03^{a}
Processing marketable yield (ton/crop/ha)	9.01 ± 0.53^{a}	9.23 ± 0.45^{a}
Gross yield (ton/crop/ha)	9.17 ± 0.60^{a}	9.29 ± 0.49^{a}
Net fish yield (ton/crop/ha)	6.33 ± 0.51^{a}	6.58 ± 0.50^{a}

Note: Values are mean ± SD. Different superscripts in the same row indicate the significantly difference (P>0.05)

Local marketable yield refers to fish which the weight less than 700 g. Processing marketable yield refers to fish which the weight more than 700 g.

3.3 Fish size variation

The final fish weight was range between 400-1600 g for fixed station feeder (AF) and 500-1700 g for mobile blower feeder (BF). Figure 1 shows that final individual fish weight distribution for both treatments. The frequency of weight classes for BF shows a shift to the right, but this shift is not significantly different from AF. While the highest frequency of fish weight for AF was found to be in the 800-900 g range, the highest frequency of fish weight fed by BF was found to be in the 900-1000 g range. However, there were some local marketable fish (weightless than 700 g) in both treatments which means that the best feeding method should make the fish weight distribution shift to the right until the minimum fish weight is higher than 700 g Zakes *et al*. [17] compared the size variation of pikeperch between different feeding strategies, fish fed once per day, three times per day and continually. Their results indicated that a body weight variation of the juvenile pikeperch was not significantly affected by the different feeding methods. Juvenile Atlantic salmon groups which were fed by self feeder tended to become more homogeneous in weight than those which were fed by automatic feeder [18]. The result of this experiment can be indicated that the feeding method did not much affect on fish size variation. The grading method of initial fish before stocking might be the better method to control size variation during grow-out period. Saoud *et al*. [19] reported that size grading is practiced in fish farming for increase growth in small fish, reduce cannibalism behavior, and decrease size variation of harvested fish. There are many sizes of graders which are applied in commercial farm. The 96 cm diameter VAKI grader can grade the 0.2–100 g fish size for 17–1,000 kg / time and 140 cm diameter grader can grade 5-800 g fish size for 25–6000 kg/time [20].

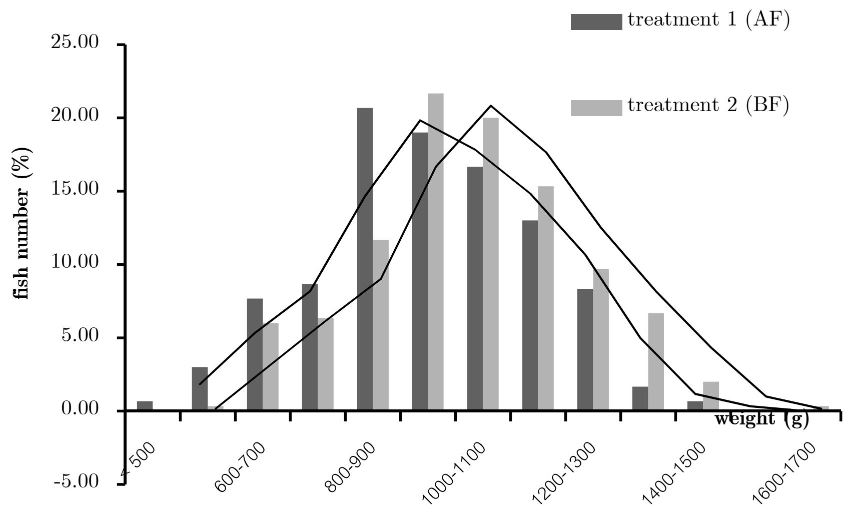

Figure 1 Final weight variations of fish fed using fixed station feeder and mobile blower feeder for 120 days culture period

3.4 Fish distribution in the pond during feeding time

Table 3 shows the fish distribution at three parts of the pond, outlet (fixed feeding area), mid area and inlet (opposite to fixed feeding area). There were significant differences in number of fish between the three areas for fixed station feeder (AF). The fish distribution between 3 areas was non-homogenous for all three sampling times. However, for mobile blower feeder (BF), the number of fish at outlet, mid area and inlet were not significantly different as result in this fish distribution was homogenous for every sampling time. Chi-square test demonstrated that the feeding method had an effect on fish distribution in the pond. Most fish in treatment 1 gathered at the outlet area (average of about 12 fish) whereas there was only average of one fish at mid area and the inlet. Tilapia shows the behavior of diurnal feeding, so during day time, fish spent more time for feeding. Therefore, it was better for fish to be fed in the large feeding area where they have more chance to access the feed. Fish fed by AF always gathers at the outlet during feeding time because this part is the feeding area, thus they usually compete together to achieve food. The blower dispersion feeding for BF can spread pellet feed throughout the cultured pond, so it can reduce the competition of fish feeding. However, the fish sampled in this experiment were caught during the feeding time only, so fish fed by AF might have been equally distributed throughout the pond outside feeding time. The fish fed by AF spent more time in the feeding area than those fed with BF because their distribution or activities usually depends on the food. A fish's day is spent either following food or escaping predators. In the current study, the swimming activity of fish fed by BF was higher than fish fed by AF because of the difference in feed availability throughout the day. According from, Helfman [21] and Almazan-Rueda *et al.*[22] who recommended that the time of fish spent on browsing and foraging might be reduced while the time spent on resting may have increased for fish fed by self-feeding (constant available of feed). Almazan-Rueda *et al.* [22] indicated that juvenile African catfish fed by hand (2 times/day) had more activity in the morning than in the afternoon, whereas this activity was not observed in fish fed using automatic feeding method. They also showed a higher activity before each meal than afterwards.

Table 3 Nile Ttilapia distribution in the pond during feeding time compared between using fixed station feeder (AF) and mobile blower feeder (BF)

Treatment	Sampling fish number (fish/throwing net sampling)		
	Outlet	Mid area	Inlet
1 (AF)	12 ± 5^a	1 ± 0^b	1 ± 1^b
2 (BF)	2 ± 2^a	2 ± 1^a	1 ± 1^a

Note: Values are mean ± SD. Different superscripts in the same row indicate the significantly difference (P>0.05)
outlet = fixed feeding area, mid area = the middle of pond and inlet = opposite of fixed feeding area

3.5 Water quality at different areas of the pond

DO concentration is usually the first limiting factor in intensive fish pond. The morning DO concentration at outlet was significantly higher than mid area and inlet in both fixed station feeder (AF) and mobile blower feeder (BF) (Table 4). This might be because paddle wheel aerators were opened for the whole night in both treatments. Lawson [23] mentioned that the rate of diffusion of atmospheric oxygen into water is low; therefore, opening aerators at night improves DO concentration in the morning. In the present study, the morning DO at mid area (2.82 mg/L) was significantly higher than inlet area (2.72 mg/L) for AF, while BF, the morning DO at inlet (2.55 mg/L) was significantly higher than mid area (2.44 mg/L). This might be because the feeding area in AF pond was far from mid area and inlet, but feeding area in BF pond was throughout the pond. The both morning and afternoon temperatures was in the safe level and did not have any effects on fish. Egna and Boyd [24] suggested that the preferred temperature for tilapia growth is between 28 and 32°C, and growth rates decline rapidly at temperatures below 20°C. Also, Fast [25] reported that the optimum temperature for growing tilapia is 25-33ºC. The pH of this experiment was about 7.65 to 8.03 which were found to be within the range for optimum growth. This indicates that feeding method does not affect pH in the fish pond. Coche *et al*. [26] reported that waters ranging in pH from 6.5 to 8.5 are most suitable for pond fish culture. In treatment 1, total ammonia nitrogen (TAN) at inlet area (opposite fixed feeding area) was significantly lower than outlet area (fixed feeding area) and the middle of the pond. There were no significant differences of TAN between the three areas in BF pond. This result indicates that feeding area had higher TAN than rest of pond because of waste from fish and pellet feed. However, TAN in this study was between 0.29 and 0.39 mg/L which did not affect fish growth or survival. In addition, there were no significant differences in nitrite concentration between the three areas in both ponds fed by AF and BF. The safety point of TAN at pH 8 and temperature 28ºC was1.00 mg/L [27].

Table 4 A Comparison of water quality parameters between outlet, mid and inlet areas in Nile Tilapia culture with different feeding method

Parameter	Fixed station feeder (AF)			Mobile blower feeder (BF)		
	Outlet	Mid Area	Inlet	Outlet	Mid Area	Inlet
Morning DO (mg/L)	3.02 ± 0.97 [c]	2.82 ± 1.00 [b]	2.71 ± 1.02 [a]	2.62 ± 0.92 [c]	2.44 ± 0.93 [a]	2.55 ± 0.90 [b]
Afternoon DO (mg/L)	6.16 ± 2.10 [a]	6.90 ± 2.40 [b]	8.29 ± 2.14 [b]	7.36 ± 2.87 [b]	6.63 ± 2.40 [a]	6.43 ± 2.15 [a]
Morning Temp. (°C)	26.81 ± 1.72 [a]	26.84 ± 1.73 [b]	26.81 ± 1.72 [a]	26.98 ± 1.62 [a]	27.03 ± 1.63 [c]	27.00 ± 1.62 [b]
Afternoon Temp. (°C)	28.29 ± 1.83	28.3 ± 1.80	28.29 ± 1.87	28.52 ± 1.74	28.49 ± 1.78	28.55 ± 1.90
Morning pH	7.70 ± 0.26 [b]	7.67 ± 0.22 [ab]	7.65 ± 0.22 [a]	7.65 ± 0.21 [b]	7.63 ± 0.21 [a]	7.63 ± 0.21 [a]
Afternoon pH	8.05 ± 0.30 [a]	8.13 ± 0.27 [b]	8.14 ± 0.29 [b]	8.23 ± 0.40 [a]	8.15 ± 0.30 [ab]	8.11 ± 0.31 [b]
TAN (mg/L)	0.39 ± 0.37 [b]	0.35 ± 0.38 [b]	0.30 ± 0.32 [a]	0.29 ± 0.37 [a]	0.30 ± 0.38 [a]	0.32 ± 0.39 [a]
Nitrite (mg/L)	0.19 ± 0.11 [a]	0.17 ± 0.12 [a]	0.17 ± 0.13 [a]	0.14 ± 0.15 [a]	0.15 ± 0.15 [a]	0.14 ± 0.16 [a]

Note: Values are mean ± SD. Different superscripts in the same row of each treatment indicate the significantly difference ($P>0.05$)
outlet = fixed feeding area, mid area = the middle of pond and inlet = opposite of fixed feeding area

3.6 Economic performance

Data used in economic analysis are showed in Table 5. The local marketable fish were sold at 15 baht/kg, while processing marketable fish were sold at 40 baht/kg at the end of the experiment for both treatments. The total cost of Tilapia cultured by fixed station feeder (AF) was 206,675.02 baht/crop/ha, and by mobile blower feeder (BF) cost was 220,112.82 baht/crop/ha. The total cost between two treatments was not much different. The cost of BF method was higher than AF method because fish in pond fed by BF eat more pellet feed than fish fed by AF. Therefore, the higher cost of BF was because of the larger amount of feed. Feed cost is the main operating cost in fish farming and the variable costs increase much more because of the increased cost of feed [28]. In addition, the seed cost of two treatments were not equal because this experiment was conducted on a commercial scale and it was very difficult to control exactly seed density between two treatments. The net profit of Tilapia culture using AF and BF was 156,745.73 and 149,322.63 baht/crop/ha respectively, but there was no significant difference. Another point to be considered for the commercial farm is how much the profit can obtain from every unit of input cost. The farmer may not attempt to increase the production and input cost if the new feeding strategy cannot make the profit higher than the current profit. Hepher and Pruginin [7] explained that the major interest of the fish farmer obviously lies in the profitability of their farm rather than in its production per section. The result from the present study showed that the net profit of using AF method seems to be higher than BF method, but there were no significant differences between the two. Therefore, if consider to the profit and labor working, the AF is preferred to be used in commercial tilapia farm than BF.

Table 5 The comparison of partial budget in Nile tilapia culture using fixed station feeder (AF) and mobile blower feeder (BF) for 120 days

Parameter	Fixed station feeder (AF)	Mobile blower feeder (BF)
Fixed costs		
- Feeding machine (baht/crop)	366.67	250.00
Variable costs		
- Feed (baht/crop/ha)	140,833.63	157,588.58
- Seed (baht/crop/ha)	61,480.72	58,536.37
- Electricity (baht/crop)	3,744.00	2,737.88
- Labor for feeding (baht/crop)	250.00	1,000.00
Total variable cost (baht/crop/ha)	206,306.35	219,862.82
Total cost (baht/crop/ha)	206,675.02 ^{a}	220,112.82 ^{a}
Income		
Revenue of local marketable fish (baht/crop/ha)	2,464.35	928.65
Revenue of processing marketable fish (baht/crop/ha)	360,956.40	368,506.80
Gross revenue (baht/crop/ha)	363,420.75	369,435.45
Profit		
Net profit (baht/crop/ha)	156,745.73 ^{a}	149,322.63 ^{a}

Note: Different superscripts in the same row of total cost and net profit indicate the significantly difference (P>0.05)

4. Conclusions

Our experiment results indicate that the mean weight, DWG and SGR of Nile tilapia in commercial farm fed using mobile blower feeder (BF) was higher than those fed using fixed station feeder (AF). However, it did not show the better growth because fish fed by BF also consumed more feed than fed by AF. Feeding methods did not have effect on survival rate, body composition, yields and feed utilization of Nile tilapia. Also, it could not improve the fish size variation. The size grading before stocking might be the better method which should be done in commercial farming. Fish in the pond fed by BF had a better distribution in pond than those fed by AF during the feeding time. However, they might show similar distributions outside the feeding time. The mobile blower feeding method can improve the water quality in the pond especially at the outlet area which was the fixed feeding area. However, the water quality in the pond fed by two different feeding methods was in the optimum range and did not affect to fish growth and survival. The profit from fish fed by AF seems to be higher than mobile blower feeder because the feed cost, the major cost in commercial fish farming, of AF was lower. However, there was no significant difference among the two treatments

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