Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(3): 705-709

Received: 09-03-2018
Accepted: 10-04-2018

P Yuvarajan
PG Research Scholar
Department of Aquaculture
Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University Ponneri, Thiruvallur, Tamil Nadu, India

S Felix
Vice Chancellor Tamil Nadu Dr. J. Jayalalithaa Fisheries University Nagapattinam, Tamil Nadu, India

Cheryl Antony
Professor and Head
Department of Aquaculture
Fisheries College and Research Institute Tamil Nadu Dr. J. Jayalalithaa Fisheries University Ponneri, Thiruvallur, Tamil Nadu, India

A Gopalakannan
Assistant Professor
Department of Aquatic Animal Health Management
Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University Ponneri, Thiruvallur, Tamil Nadu, India

M Menaga
Ph.D Research Scholar
Department of Aquaculture
Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University Ponneri, Thiruvallur, Tamil Nadu, India

S Ezhilmathi
PG Research Scholar
Department of Aquaculture
Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University Ponneri, Thiruvallur, Tamil Nadu, India

Correspondence
P Yuvarajan
PG Research Scholar
Department of Aquaculture
Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University Ponneri, Thiruvallur, Tamil Nadu, India

Nursery intensive rearing of GIFT tilapia in outdoor lined pond utilizing aerobic microbial floc technology (AMFT)

P Yuvarajan, S Felix, Cheryl Antony, A Gopalakannan, M Menaga and S Ezhilmathi

Abstract
The present study was conducted to evaluate the Aerobic Microbial Floc Technology (AMFT) on water quality and growth performance of GIFT tilapia (*Oreochromis niloticus*) fry in outdoor lined nursery pond. The experiment consisted of treatment (AMF) and control (non-AMF) group in duplicate. Spent wash was utilized for floc development (Treatment) and to establish a carbon/nitrogen (C/N) ratio of 10:1. The stocking density was 50 numbers per m^3 (average body weight of 0.2054 g per fish) in each 100 ton capacity of outdoor lined pond. Ammonia level in the AMF treated group was lower (0.004 mg l^{-1} ± 0.00 to 0.011 mg l^{-1} ± 0.001) than non - AMF due to the addition of suitable carbonaceous substrate as spent wash. Total suspended solids concentration continuously augmented in AMF group (139 mg l^{-1} ± 1.0 to 590 ± 75) than non- AMF (10 ± 1 to 66 ± 8) throughout the culture period. Total weight gain, individual weight gain, average body weight and daily growth rate were higher (11937 g ± 560, 3.85 g ± 0.014, 4.09 g ± 0.019 and 0.128 g day^{-1} ± 0.00) in AMF system than control. FCR (1.39 g ± 0.01) was found to be lower even after reducing 20% feeding rate in AMF system than control. Significant difference ($p<0.05$) was observed on 24th day. From the present study it is evident that AMF can improve the quality of culture water and results in best growth of GIFT tilapia.

Keywords: Aerobic microbial Floc, GIFT tilapia, lined pond, spent wash, heterotrophs, growth performance

Introduction

The increasing global population and limiting global capture fisheries situation mainly depends on the production of aquaculture. Aquaculture is now the fastest growing sector. But, facing few problems such as land shortage with seepage, water scarcity, poor nursery management and disease outbreaks [1]. To curtail these problems a shift towards the advanced technologies like raceway technology, lined pond culture, re-circulatory aquaculture system (RAS), Aerobic Microbial Floc Technology (AMFT), periphyton technique and aquaponics [2]. AMFT is an ecofriendly sustainable aquaculture system with limited water exchange which enhances the water quality, immunity, act as live food and reduces FCR. In well aerated aerobic condition, it recycles the nutrients continuously by maintaining carbon/nitrogen (C/N) ratio in the water which stimulates heterotrophic bacterial growth and converts ammonia into microbial biomass [3]. Selection of a carbonaceous substrate should be based on local availability and a cheap source. The C:N ratio of 15:1 to 20:1 aids good AMF production [4]. Fish and shrimp diets supplemented with AMF can improve growth [5]. Species such as shrimp and tilapia have physiological adaptations that allow them to consume AMF and digest microbial protein. These species can tolerate high solids concentration in water. Based on these characteristics, tilapia and shrimp are considered as best candidate species for culturing in AMF system [6]. Omnivorous habit of nile tilapia in utilizing AMFs as source of food can help to meet up of 50% protein requirements [7]. Hence, GIFT tilapia has been selected for the study.

Tilapia has become the shining star of aquaculture and also popularly known as 'aquatic chicken' [8, 9]. Tilapia culture is popular in tropical, sub-tropical and temperate regions. Tilapia is being farmed in about 120 countries and second in sales and volume in international trade after salmonids [10]. Genetically Improved Farmed Tilapia (GIFT) farming technology is a major milestone in the history of tilapia aquaculture (Eknath and Acosta, 1998) [11].

The GIFT strain was developed by World Fish Centre (WFC; formerly known as International Centre for Living Aquatic Resources Management, ICLARM) through several generations of selection from the base population involving 8 different strains of Nile tilapia *Oreochromis niloticus*. GIFT program succeeded 12-17% average genetic gain per generation over five generations and cumulative increase in growth rate of 85%. in *O. niloticus* [12]. GIFT tilapia is a hardy fish, which can survive in wide environmental conditions and is a good converter of organic matter into high quality protein [10]. The progressive growth of world tilapia production has exceeded 5 million tonnes per year with steady growth rate of 5-8 percent [13]. In Asia, tilapia farming is very profitable. The productivity, cost of production and profitability of tilapia farms vary significantly among countries and production environments. Tilapia is a consumer friendly fish because of its relatively low price compared to other fish species [14]. It indicates that tilapia has made a significant contribution to food production and an impact on poverty alleviation and livelihoods support in the Asia and the Pacific.

The present study was prototyped to study the effect of AMF application on water quality and production performance of GIFT tilapia in outdoor lined pond.

Materials and methods

Experimental design

Experiment was conducted in duplicate in synthetic fabric fibre (SFF) outdoor lined pond of 100 ton capacity. Completely randomized designed (CRD) pond without aerobic microbial floc (non-AMF) was taken as control and the pond with aerobic microbial floc (AMF) as treatment. In the treatment C/N ratio at 10:1 was maintained by adding spent wash as carbon source to develop aerobic microbial floc (AMF).

Experimental fish and Stocking

GIFT tilapia seeds were procured from the State Fisheries Department, Krishnagiri, Tamil Nadu, India. Fish seeds were acclimatized to pond environmental condition and one week fed with a commercial larval rearing diet. Fishes were graded according to their weight prior to the experiment. Fishes were stocked at the density of 50 numbers per m^3 (each fish with average weight of 0.2054 g). GIFT fry was reared to fingerling in the intensive nursery culture system for the period of 30 days.

Feeding

Manual feeding method was followed with a feeding frequency of 4 times a day initially from 9 to 9.30 am in the morning based on the temperature and dissolved oxygen levels in the pond with an interval of 3 – 4 hrs. The feeding rate and feeding time was fixed based on check trays inspection and biomass (feeding time should not be changed but feed ration may change due to the excess feed in the tray)

Water quality monitoring

Water samples were analyzed at three days interval of the experiment. DO, Temperature, pH, Alkalinity, Hardness, calcium, magnesium, Total ammonia–nitrogen (TAN), nitrite (NO_2-N) and nitrate (NO_3-N). TSS and biochemical oxygen demand (BOD_5) were analyzed 5 days interval by using APHA method [15].

Growth performances

Growth parameters were analyzed at six days interval of the experiment. Total weight gain, % weight gain, Average body weight (ABW), Growth rate day^{-1}, % Specific growth rate (SGR), Food conversion ratio (FCR), Food efficiency ratio (FER), Protein efficiency ratio (PER) and % Survival rate (SR) were calculated by using formulas

1. Weight gain (%)= W_F-W_I/W_I ×100
2. Average body weight(g)= W_T/N
3. Growth rate(GR)= W_F- W_I/t
4. SGR(%)= ln W_F-ln W_I/t ×100
5. FCR= Feed consumed/WG
6. FER=1/FCR
7. PER=WG_N/Protein consumed
8. Survival rate(%)= N_F/ N_I ×100

Where; W_F= Final weight, W_I= Initial weight, W_T= Total weight, N= Total number of animals, t= number of days, WG_N = Net weight gain, N_F= Total number of animals harvested and $N_{I=}$ Total number of animals harvested.

Statistical Analysis

Water quality and growth performance data were analyzed by the Independent sample‘t’ test using SPSS Version 24 software.

Results and Discussion

Physico chemical parameter

Water temperature, dissolved oxygen, pH, Alkalinity and Hardness were observed within the range in both control and treatment (Table 1), the range of temperature between 25.2 - 27.3 ^{0}C was observed. Similar results were reported by keer *et al*. (2018) [16]. The level of pH was fluctuated during nursery rearing period (8.3 -8.9). Similar results were observed by Rahman and Rahman (2003) [17]. The dissolved oxygen (4.4 - 6.5 mg l^{-1}) and alkalinity (34 - 63 mg l^{-1}) indicates the optimal pond productivity. Similar observations were studied by Rahman (2005) [18].

Concentration of ammonia level in the AMF group was lower (0.004 to 0.011 mg l^{-1}) than non - AMF (fig 1a) due to the addition of carbonaceous substrate ammonia converted into microbial mass. Similarly, Felix *et al*. (2015) assured that ammonia converted into heterotrophic bacteria in GIFT tilapia rearing in indoor raceway under AMFT [3]. Levels of Nitrite – nitrogen decreased in the treatment groups and degree of fluctuations were observed in control group throughout the experiment and the levels of NO_3-N were generally higher (0.065 mg l^{-1} ±0.020 to 0.242 mg l^{-1} ± 0.013) in the AMF group than the non-AMF group. Similar results were reported by Perez-Fuentes *et al*, 2016 [19]. Phosphate concentration in both AMF and non-AMF groups were observed within the optimal range. However, phosphate level was slightly lower in treatment groups compared to non-AMF. This may be due to nutrient recycling by heterotrophic bacteria (Table 1). Luo *et al*. (2014) observed similar results in culture of GIFT tilapia where, concentration of phosphate substanciously lower in AMF pond than that of RAS [20].

Total suspended solids concentration was continuously increased in AMF group than non- AMF throughout the culture period (fig 1b) due to the addition of suitable carbon source as spent wash with the C/N ratio of 10:1. It recycles the nutrient and stimulates the production of heterotrophic bacterial activity which indicates that heterotrophic bacteria is responsible for enhanced water quality in AMF system. Significant difference was observed between the groups (p<0.005). Similarly, where sweet potato was used as carbon source in AMF system by Choo *et al*. (2015) [21], it showed continuous increasing level of TSS with heterotrophic bacterial activity.

Table 1: The ranges of water quality parameters were observed during culture period

Parameters	Control	Treatment
Dissolved oxygen (mg l^{-1})	4.4 – 6.5	5.3 – 6.6
Temperature (^{0} C)	25 – 27	25 - 27
pH	8.3 – 8.5	8.5 – 8.9
Alkalinity (mg l^{-1})	40 - 63	34 - 63
Hardness (mg l^{-1})	225 - 282	225 - 274
NH_3 (mg l^{-1})	0.003 – 0.023	0.004 – 0.011
NO_2 (mg l^{-1})	0.005 – 0.024	0.004 – 0.011
NO_3 (mg l^{-1})	0.109 – 0.198	0.051 – 0.242
Phosphate (mg l^{-1})	0.042 – 0.151	0.045 – 0.100
TSS (mg l^{-1})	16 - 66	139 - 589

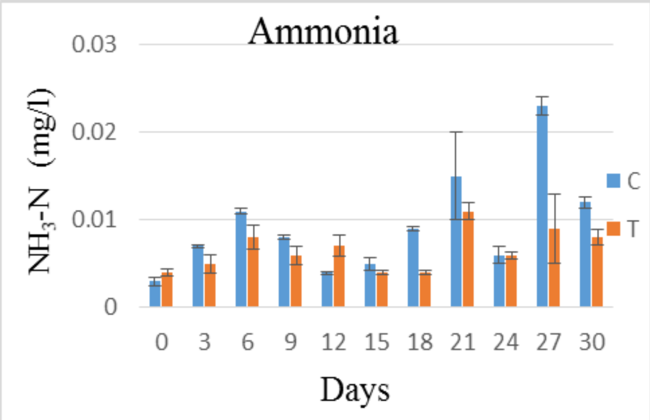

Fig 1a: Total ammonia nitrogen

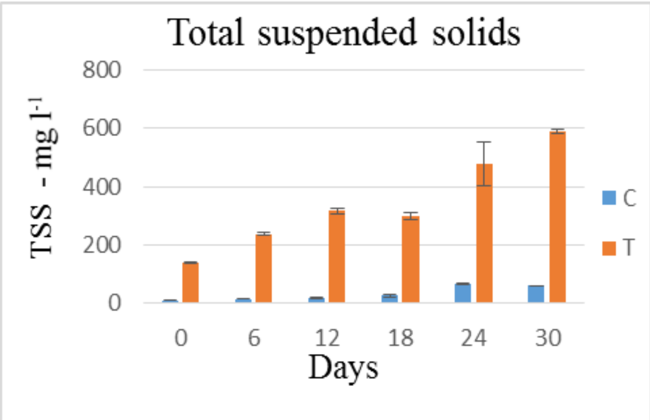

Fig 1b: Total suspended solids

Growth performances

Total weight gain (TWG), Individual weight gain (IWG), Average body weight (ABW), Food conversion ratio (FCR), Feed conversion efficiency (FCE) and Protein conversion efficiency (PCE) showed positive results in AMF based culture system compare to non-AMF. Significant difference (p<0.005) in growth performance was observed in nursery rearing of GIFT tilapia in outdoor lined pond under AMF system. Higher percentage weight gain, Specific growth rate (SGR) and Survival rate (SR) observed in AMF system than non-AMF. Significant difference was observed (p<0.05) between the group (Table 2).

Total weight gain was higher (19124 g ± 123) in AMF group compare to non-AMF group. Significant difference was observed (P<0.005) on 24th day. This may be due to the ideal stocking density (50 numbers seed per m^3) and uniform size which minimizes the shooting (aggressive) behavior in nursery rearing. Similar results were observed by Ekasari and Maryam (2012) in red tilapia culture under AMF with stocking density of 50 numbers per m^3 [22]. Individual weight gain, Average body weight (fig 2a) and daily growth rate were higher (3.85 g ± 0.014, 4.09 g ± 0.019 and 0.128 g day^{-1} ± 0.00) in AMF system than control. These three parameters were significantly different on 24th and 30th day of culture period. Similarly, Long *et al.* (2015) reported that Individual weight gain, average body weight and daily growth rate was increased in GIFT tilapia culture under AMF system [23]. FCR (1.39 ± 0.01) was found to be lower in AMF system than control. Even after reducing 20% feeding rate in AMF system significant difference was observed between the group (P<0.005) on 24th day. This may be due to low protein feed (16.75%) and fed on suspended particles leading to higher growth of GIFT tilapia consequently in the pond confined flocs as a potential live feed. This proteinaceous feed is available for 24 hours day^{-1} in AMF system. Similar effect was observed in tilapia culture in AMF pond than conventional pond by Avnimelech *et al.*, 1994; Avnimelech, 1999 [4, 24]. FER and PER of cultured GIFT tilapia was greater (0.72 ± 0.005 and 0.23 ± 0.001) and found to be significantly different in AMF system than non-AMF on initial and 24th day. Similar results were studied by Long *et al.* (2015) [23].

Final survival rate was greater (99.26% ± 0.26) in AMF system than control (fig 2b). There was no significant difference in survival rate between groups. Higher survival rate (94.60% ± 2.03%) was obtained in Nile tilapia culture in AMF system compare to control. Specific growth rate and % weight gain were significantly greater (9.485% ± 0.085 and 1627% ± 25) in AMF system than control. Perez-Fuentes *et al.* (2016) observed higher survival, specific growth rate and % weight gain in indoor AMF system [19].

Table 2: Growth determining parameters of GIFT tilapia in AMF and Non-AMF system.

Groups	Total weight gain (g)	% weight gain	Individual weight gain (g)	Average body weight (g)	Daily growth rate(g day $^{-1}$)
Control	11937 ± 560	1050 ± 140	2.44 ± 0.109	2.67 ± 0.085	0.081 ± 0.003
Treatment	19124 ± 123	1627 ± 25	3.85 ± 0.014	4.09 ± 0.019	0.128 ± 0.000
95% confidence interval					
P value	0.006*	0.05*	0.006*	0.004**	0.005**

Groups	Specific growth rate (%)	FCR	FER	PER	Survival rate (%)
Control	8.14 ± 0.36	1.99 ± 0.07	0.51 ± 0.017	0.146 ± 0.007	98.02 ± 0.2
Treatment	9.485 ± 0.085	1.39 ± 0.01	0.72 ± 0.005	0.23 ± 0.001	99.26 ± 0.24
95% confidence interval					
P value	0.068	0.013*	0.007*	0.006*	0.047*

* Significant (p<0.05)
** Significant (p<0.005)

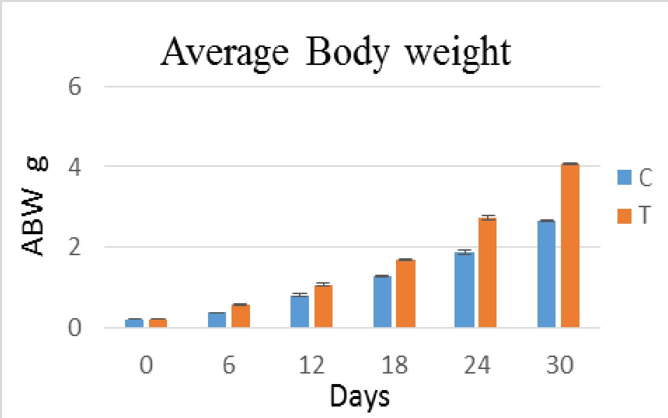

Fig 2a: Average body weight (g)

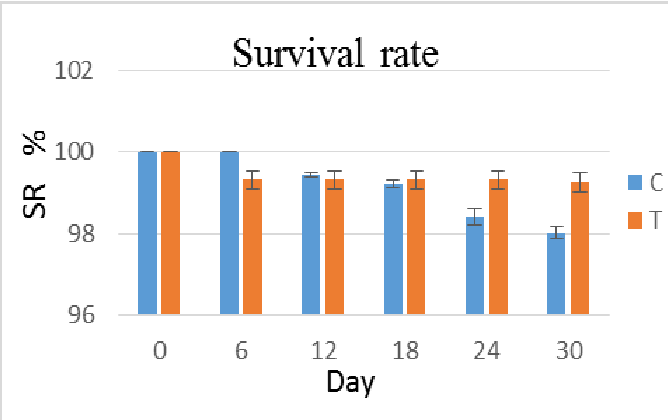

Fig 2b: Survival rate (%)

Conclusion

Tilapia considered as "Poorman's Protein". An application of Aerobic microbial floc contributes to the enhancement of water quality and better growth performance in GIFT tilapia. The stocking of seed with the ideal number (50 numbers fry per m^3) and uniform size minimized the shooting behavior which inturn maximized the growth of GIFT tilapia in nursery rearing outdoor lined pond. FCR was found to be lower, even after reducing 20% feeding rate in AMF system than control. Furthermore, study need to investigate the feed utilization of GIFT tilapia in AMF system.

Acknowledgement

We gratefully acknowledge the funding support by Advanced Research Farm Facility (ARFF), Madhavaram campus, Fisheries College and Research Institute, Ponneri. TNJFU, Nagapattinam, Tamilnadu. I would like to express sincere thanks to The Vice Chancellor, TNJFU, Nagapattinam, Tamilnadu for his support and encouragement.

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