Ethiop. J. Biol. Sci. **20(2): 87–99, 2021**
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RESEARCH ARTICLE

GROWTH PERFORMANCE AND FEED UTILIZATION OF NILE TILAPIA (*OREOCHROMIS NILOTICUS* L.) FED ON COMMERCIAL AND FARM-MADE FEEDS IN PONDS

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ABSTRACT: The growth performance of Nile tilapia (*Oreochromis niloticus*) fingerlings were compared between fish fed with commercial feed and formulated farm-made feeds in ponds. The experiment was conducted in duplicate ponds, each measuring 50 m^2 at a stocking density of 2 fish/m^2 based on a completely randomized design (CRD). Before the commencement of the actual experiment stocked fish were left to acclimatize in ponds for about two weeks. All fish were fed 3% of their body weight per day, and the ration was given twice a day in the morning (10:00 am) and afternoon (4:00 pm) for all treatment groups. The initial size of the fish was made uniform (mean size of 10.35–11.43 cm TL and mean TW of 24.7–31.9 g) at the beginning of the experiment and samples of 50% of stocked fish were measured monthly to follow the growth rate and adjust the daily ration accordingly. Total length (TL) and total weight (TW) of sampled fish were taken to the nearest 0.1 cm and 0.1 gm, respectively on monthly basis from September 2019 to March 2020 for a period of six months. Fish fed with commercial feed (27% CP) showed the highest daily growth rate (0.40 g/fish/day) followed by fish fed with either feed II (SYB, 0.28 g/fish/day) or feed III (EWB, 0.28 g/fish/day). The results of the experiment showed significant variations on the growth of fish between the commercial feed and the two farm-made feeds, feed II (soya bean-based) and feed III (earthworm-based), ($p<0.01$) but no significant growth variation was observed between the two farm made feeds ($p=0.147$). The feed conversion ratio (FCR) values computed for both commercial and farm-made feeds were high ranging from 2.84–4.85 indicating the poor utilization of the feeds by the fish. Thus, the low growth rate of *O. niloticus* fingerlings recorded in this study might be attributed to the combined effects of low quality feed ingredients used and unfavourable physico-chemical environment of the pond. The overall survival rate was high and varied from 80.2% to 92% per treatment. Some physico-chemical parameters such as low water temperature, and alkaline pH might have contributed for the poor growth of the fish. Therefore, future studies should focus on formulating complete quality feeds and management of pond environment which promote better growth and production of *O. niloticus*.

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Key words/phrases: Commercial feed, Farm made feeds, Food conversion ratio, *Oreochromis niloticus*, Ponds.

INTRODUCTION

The Nile tilapia, *Oreochromis niloticus* L. is a tropical fish indigenous to most Ethiopian water bodies inhabiting nearly all river systems as well as lakes and reservoirs in the country (Kassahun Asaminew, 2005; Redeat Habteselassie, 2012). It is commercially the most important fish in Ethiopia constituting some 50% of fish harvested from inland water bodies for the period 1998–2010 (Gashaw Tesfaye and Wolff, 2014).

Globally, the Nile tilapia (*O. niloticus*) is the fourth most cultured finfish following the carps (FAO, 2018). Because of its high growth performance and ease of adaptation to tropical environments under confined systems, it has been alternatively referred to as the aquatic chicken of the tropics. The success of any aquaculture depends on three basic inputs like fish seed, feed and a conducive water environment. Thus, research should focus on optimizing the basic needs of fish, particularly, appropriate feed which results in better growth and inexpensive to make the venture economically viable and cost-effective.

Our knowledge of the food and feeding biology of fish originates from studies done in lakes and reservoirs. The feeding biology of the Nile tilapia (Zenebe Tadesse, 1988; 1999; Yirgaw Teferi *et al*., 2000) has been reported from Rift Valley lakes and other lakes located in the highlands of Ethiopia. Results of these studies revealed the herbivorous and detrivorous feeding habits of the fish. Therefore, such studies provide clue on the nutrient requirements of the fish for growth and survival. Moreover, such information can be used as input while selecting and formulating feeds for the cultured fish.

Fish farming is comparatively the least developed practice in Ethiopia as compared with most African countries including sub-Saharan Africa. As a result, fish production from the aquaculture sub-sector is almost negligible contributing less than 20 tons per year (FAO, 2014; MoLF, 2014). Fish feed constitutes over 50% of the running cost of fish farming depending on the intensity of the farming system (Emmanuel *et al*., 2014). Therefore, research should focus on developing supplementary feeds enhancing the growth and production of the fish cultured (FAO, 2018).

So far there have been few attempts made in evaluating the importance of agro-industrial by-products as supplementary feeds for Nile tilapia in ponds. In this regard, the effects of single and compound feeds have been evaluated on the growth of *O. niloticus* in pond systems (Zenebe Tadesse *et al*., 2012; Abelneh Yimer *et al*, 2015; Mesay Eniyew *et al*., 2016). Although the feeds tested showed better growth in most cases, the feeds require further trials before they are recommended to be used on a wider scale. Hence, in this study, an attempt was made to compare two formulated farm-made feeds with a commercial feed produced by a private feed company in Ethiopia.

MATERIALS AND METHODS

The pond experiment was conducted at Sebeta National Fisheries and Aquatic Life Research Centre (NFALRC), which is located about 23 km south-west of the capital city, Addis Ababa at an altitude of 2,200 metres above sea level. The area is characterized by a moderately warm climate with a mean annual temperature of about 20°C.

The growth and feeding experiment was conducted in ponds, each measuring 50 m^2. A total of six ponds were used for the feeding trial in duplicate on a completely randomized design. The experiment was carried out for six months between September 2019 and March 2020. In each pond, 100 fingerlings of mixed sex were stocked at rate of 2 fish/m^2 and left for two weeks to acclimatize with the pond environment. The initial size of the fish stocked in each pond was nearly uniform with mean of 10.35–11.43 cm TL and mean of 24.7–31.9 g TW.

O. niloticus fingerlings raised artificially in the centre were used for the feeding experiment. The feeding trial was designed to evaluate the growth of fish fed with two formulated farm-made feeds in the centre (feed II or soya bean-based feed (SYB) and feed III or earthworm-based feed (EWB) and the commercial Nile tilapia feed (feed I or Comm. feed) purchased from a feed factory. The proportion of each ingredient included in the farm-made feeds formulated is shown in Table 1. For confidentiality, we have analyzed and included only the total protein contents of the commercial feed used. At the beginning of the experiment total length and total weight of about 50% of the total fish stocked in all ponds were measured to the nearest 0.1 cm and 0.1 gram, respectively. Similarly, TL and TW of 50 fish were recorded every month. The daily ration was calculated and adjusted regularly according to the weight gain of the fish on monthly basis. Fish were fed with test diets at 3% of their total weight daily throughout the experiment. The pelleted daily ration feed was given twice a day by hand casting, in the morning (10:00 am) and in the afternoon (4:00 pm). The mortality of fish was monitored and recorded continuously throughout the experiment.

Table 1. Percent composition of ingredients used to formulate farm-made and commercial feed used in the growth experiment.

Feed ingredients	**Crude protein**	**Feed I Comm. feed**	**Feed II (SYB)**	**Feed II (EWB)**
Earthworm	55.2	-		20
Soya bean	44	-	20	-
Brewery waste	29	-	61.8	7.3
Wheat bran	18		18.2	72.7
Total protein (%)		27	30	30

Fish production parameters were determined in terms of fish mean weight gain, daily growth rates (DGR), specific growth rates (SGR), feed conversion ratio (FCR) and rates of survival (%). Growth and feed utilization parameters were calculated following standard equations given below (Adebayo *et al*., 2004).

Daily growth rate DGR (g/day) = Final weight (g) – Initial weight (g)/culture period

Weight gain (g) = Final weight (g) – Initial weight (g)

$$\text{Percent weight gain (\%WG)} = \frac{(Wf - Wi) \times 100}{Wi}$$

$$\text{Specific growth rate (SGR)} = \frac{(\ln Wf - \ln Wi)}{\ln Wi}$$

Where Wf=final weight of fish; Wi= initial weight of fish.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed offered for fish (g)}}{\text{Weight gain by fish (g)}}$$

Survival rate (%) = (Number of fish harvested/Number of fish stocked) x100

Water temperature of each pond was measured twice a day, in the morning and afternoon, with a thermometer. Other parameters such as pH, dissolved oxygen, water conductivity were also measured *in situ* using a portable digital multiline probe (Model, HQ 40d).

A one-way ANOVA was used to test the effect of supplementary feeds on the growth performance of cultured fish. Tukey and Dunett multiple comparisons were applied to examine differences between means of different parameters considered. Differences were considered significant at p<0.05. All data were statistically analyzed using the SPSS software program (Mead *et al*., 1993).

RESULTS

The size of the fish stocked at the beginning of the experiment was nearly uniform with mean initial total length ranging from 10.35–11.43 cm TL and mean total weight varying from 24.7–31.9 g in all treatment groups (Table 2). However, the final size of the fish at the end of the experiment varied significantly (p<0.05) between the treatment groups (Table 2). Similarly, the growth of the fish varied significantly (p<0.05) between fish fed with the commercial feed (feed I) and farm-made feeds (feed II and feed III). However, no significant variation was observed between fish fed with the farm-made feeds (feed II and feed III) (p=0.147) (Table 3). The daily growth rate of fish fed with commercial feed (feed I; 0.40 g/day) was significantly higher (p<0.05) than fish fed with the two farm-made feeds (0.28 g/day). However, the growth of individual fish varied remarkably as can be noticed from the size range and large standard variations observed at the end of the experiment. This variation was more pronounced in fish fed with the commercial feed and ranged from 21 g to 1,190.3 g TW.

The growth of the fish also varied between months both in fish total length and total weight as shown in Figs. 1 and 2. All groups showed comparatively lower growth rate during the cold September 2019 to December 2019 months. The growth rate increased at a faster rate when the water temperature increased in the warm months of January to March 2020. This growth rate was more pronounced in fish fed with the commercial feed than fish fed with the farm-made feeds (Figs. 1 and 2). The feed conversion ratio (FCR) recorded in this study was generally high ranging from 2.84 to 4.85 and varied significantly (p<0.05) between the test diets.

Table 2. Growth performance of *O. niloticus* (mean± sd) fed on commercial and farm made feeds. The size range is indicated in brackets.

Parameters	**Treatments**		
	Feed I (Comm. Feed)	**Feed II (SYB)**	**Feed III (EWB)**
Mean initial TL (cm)	11.43±1.98 (6.3–16.3)	11.38±1.61 (6.5–13 cm)	10.35±1.57 (6.5–12.6 cm)
Mean final TL (cm)	16.57±2.9a (10.0–22.0 cm)	14.86±1.6b (11.5–18 cm)	14.90±1.49b (11–17.5 cm)
Mean initial TW (g)	31.88±6.95a (8.9–60.5 g)	30.62±9.88a (15.6–59.5 g)	24.66±8.66a (8.2–55.0 g)
Mean final TW (g)	83.51±49.66a (21.0–190.3)	59.03±34.2b (25.6–100.3)	58.00±29.83b (25.8–89.4)
Change in weight (g)	51.63	29.03	33.36
Percent weigh gain (%WG)	162.1	94.9	135.1
Daily growth rate (g/fish/day)	0.40a	0.28b	0.28b
Specific growth rate	0.46	0.31	0.41

Parameters	Treatments		
	Feed I (Comm. Feed)	**Feed II (SYB)**	**Feed III (EWB)**
(SGR) % day			
Feed conversion rate (FCR)	2.84°	4.85b	4.28b
Survival rate (%)	80.5	87.5	92

Letter with the same letters are not significantly different at 5% level.

During the experimental period some physico-chemical parameters of the pond water were recorded (see Table 4). Important parameters like water temperature, dissolved oxygen, conductivity and pH were found to vary diurnally as well as between months (Tables 4). The level of dissolved oxygen was generally high in all months showing slight variation between months. Similarly, the mean monthly water temperature varied between months ranging from 18.3°C to 24.2°C (Table 4). In most months the temperature was slightly over 20°C except in the cold months of October to December (17.2–19.5°C). The water temperature was relatively lower in the morning and increased in the afternoon with an increase in sunlight intensity in all months. Similarly, the monthly mean water temperature varied between months. Generally, the level of oxygen recorded in all ponds was high (8.5–12.7 mg/L) which is more than the minimum oxygen level required for optimum growth of the Nile tilapia. Comparatively, higher oxygen level was measured in the afternoon than in the morning. This could be due to the release of more oxygen by the phytoplankton growth in ponds. The pH of the pond water in most cases was between 8.8 and 9.9 which was slightly alkaline throughout the experimental period (Table 4).

Table 3. Multiple comparison test on the growth performance of *O. niloticus* (mean±sd) fed on commercial and farm-made feeds.

	(I) trt	**(J) trt**	**Mean Difference**	**Std. Error**	**Sig.**	**95% confidence interval Lower bound**	**Upper Bound**
Tukey HSD	Feed I (Comm. Feed)	Feed II	17.262*	1.5343	0.000	13.664	20.861
		Feed III	20.114*	1.5407	0.000	16.500	23.727
	Feed II	Feed I	−17.262*	1.5343	0.000	−20.861	−13.664
		Feed III	2.852	1.5237	0.147	−0.722	6.425
	Feed III	Feed I	−20.114*	1.5407	0.000	−23.727	−16.500
		Feed II	−2.852	1.5237	0.147	−6.425	0.722
Dunnett T (2-sided)b	Feed 1	Feed III	20.114*	1.5407	0.000	16.703	23.525
	Feed II	Feed III	2.852	1.5237	0.110	−0.521	6.225

The mean difference is significant at 0.05 level.

Table 4. Monthly and diurnal variations (mean±sd) recorded in some physico-chemical parameters of the experimental ponds.

Month	**Dissolved oxygen (mg/ l)**		**Temperature (°C)**		**pH**		**Conductivity (μs/cm)**	
	9:00 am	**5:00 pm**	**9:00 am**	**5:00 pm**	**9:00 am**	**5:00 pm**	**9:00 am**	**5:00 pm**
Sept. 2019	11.1±0.8	12.4±0.7	20.9±0.2	22.1±0.4	8.8±0.3	8.8±0.2	101.7±8.7	108.7±7.5
Oct. 2019	12.4±1.6	13.7±1.3	18.3±0.1	18.7±0.01	9.0±0.00	9.6±0.1	107.4±4.9	108.9±4.1
Nov. 2019	11.4±1.0	12.5±0.9	17.2±0.2	21.0±0.3	9.2±0.1	9.4±0.2	108.2±10.4	111.3±2.5
Dec. 2019	10.2±1.7	11.0±1.0	18.5±0.2	19.0±0.2	9.0±0.00	9.4±0.0	122.0±6.7	122.6±6.6
Jan. 2020	9.5±1.2	11.2±0.5	20.9±0.1	23.7±0.3	9.2±0.2	9.5±0.1	118.1±4.7	120.3±2.0
Feb.2020	10.5±1.4	12.2±0.5	21.9±0.1	23.7±0.3	9.5±0.2	9.8±0.1	128.1±5.9	130.3±2.7
Mar. 2020	8.5±1.4	10.2±0.5	20.9±0.1	24.2±0.3	9.5±0.2	9.7±0.1	124.1±6.4	135.3±3.8

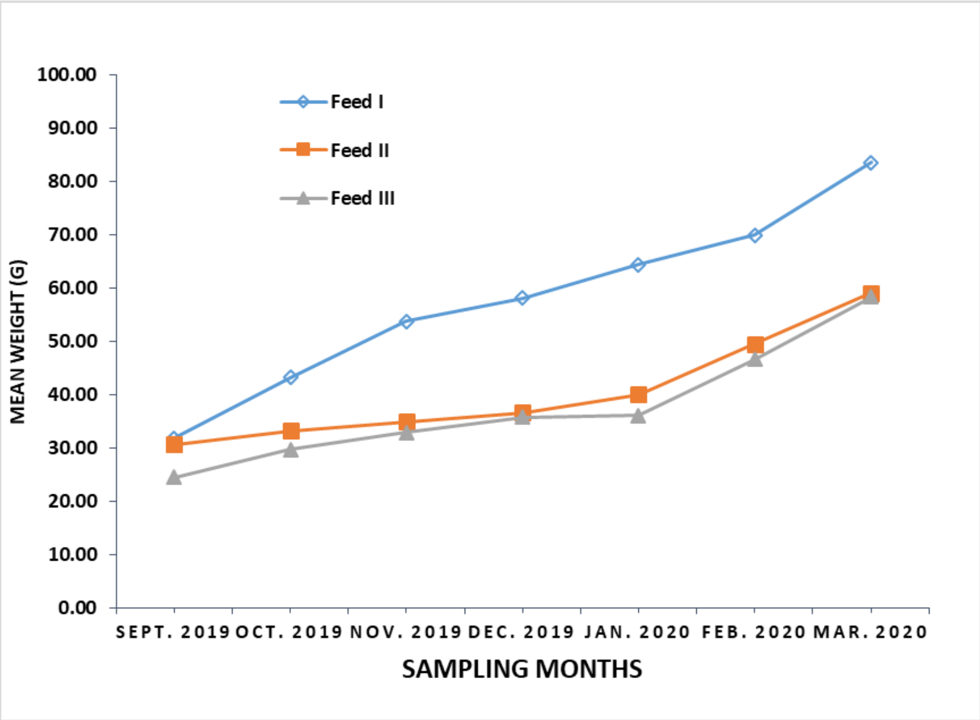

Fig. 1. Variations on monthly mean total weight of *O. niloticus* fed on commercial feed (Feed I) and two farm-made feeds (Feed II and Feed III) between September 2019 and March 2020.

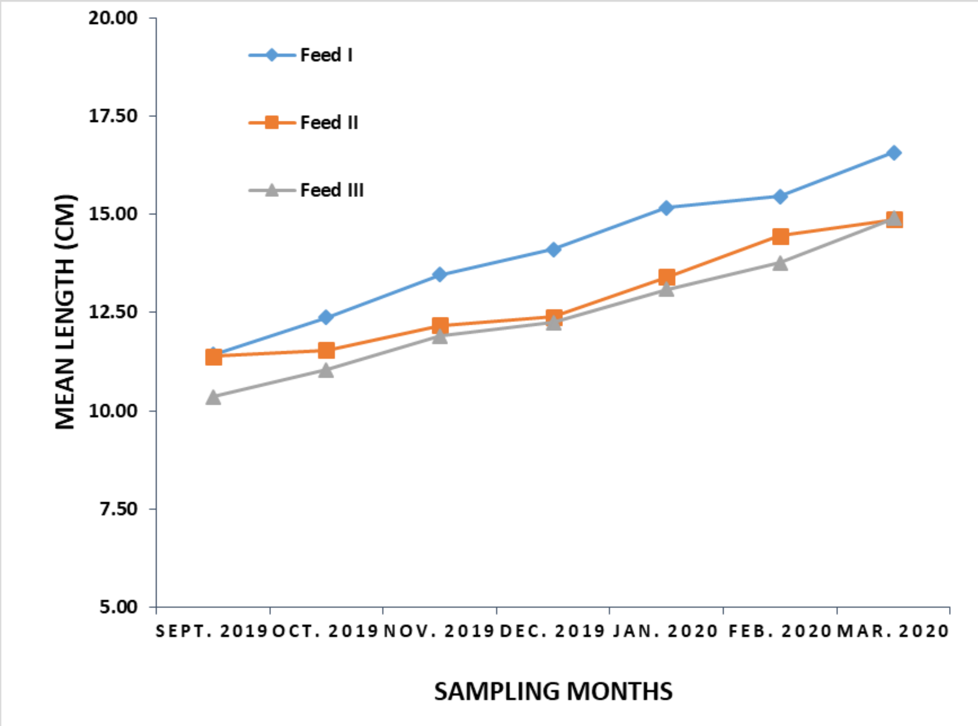

Fig. 2. Variations on monthly mean total length of *O. niloticus* fed on commercial feed (Feed I) and two farm-made feeds (Feed II and Feed III) between September 2019 and March 2020.

DISCUSSION

The success and profitability of any fish aquaculture venture depend on the quality of inputs used and the environment where the operation is undertaken. In this study growth performance of *O. niloticus* was compared between treatments fed with commercial feed and two farm-made formulated feeds. The formulated diets were composed of plant and animal ingredients as shown in Table 1. In this study, significantly higher ($p<0.05$) daily growth rate (0.40 g/day) was recorded in fish fed with commercial feed (feed I) than fish supplied with farm-made feeds (0.28 g/day). Similar to our results, lower daily growth rates were reported (0.3 g/fish/day – 0.65 g/fish/day) for *O. niloticus* grown in ponds supplemented with single ingredients like wheat bran and Noug cake (Zenebe Tadesse *et al*., 2012, Mesay Eniyew *et al*., 2016).

The relatively lower growth rate of fish reported in previous studies was attributed to the use of male and female combined sex fingerlings which lowered the growth of the fish resulting from early maturity and investing nutrients for reproduction instead of growth. In this study, we also found newly hatched larval/juvenile fish in some ponds confirming the spawning of the fish at a small size. On the other hand, comparatively higher growth rates of *O. niloticus* were earlier reported by Liti *et al*. (2005), with daily growth rate of 1.3 g/day to 1.6 g/day grown in earthen ponds. The higher growth rate of the fish was attributed to the quality of supplemental diets given and the use of sex-reversed all-male tilapia where the energy and nutrients of the feeds were used mainly for the growth of the fish. Therefore the relatively lower daily growth rate of fish recorded in the present study could be due to the combined effects of low-quality feed ingredients used and stocking of combined sex fingerlings which retard the fish growth.

Moreover, values of feed conversion ratio (FCR) indicate the quality and utilization of feed given for the fish. A lower FCR indicates better utilization of the feed by the fish (Mugo-Bundi *et al*., 2013). In this experiment, the FCR values ranged from 2.84 to 4.85 and varied significantly ($p<0.05$) between treatments (Table 2). However, comparatively lower values (FCR=2.84) were recorded in fish fed with commercial feed indicating that the fish utilized the feed better than the other farm-made feeds. The low FCR might be due to the better quality of ingredients used to formulate the commercial diet which is better digested. On the other hand, comparatively higher (FCR=4.28 and 4.85) values were recorded in the farm-made diets (feed II and feed III) which were mainly composed of agro-industrial by-products and plant materials that are less digestible. Similar FCR values of 3.40–4.04 were earlier reported for *O. niloticus* supplemented with maize, wheat and rice bran diets in ponds (Liti *et al*., 2006). Unlike our results comparatively lower FCR values of 1.61 were reported for *O. niloticus* reared in ponds using formulated diets (Liti *et al*., 2005). Generally, FCR values of 1.2–1.5 have been reported as optimum values for fish reared with a properly compounded diet (Ogunji *et al*., 2008). Thus, considering the low daily growth rate and high FCR values recorded for both commercial and farm-made feeds used in this study, more experiments have to be done to improve the feeds in the future.

The overall survival rate of the fish was high ranging from 80–92% per pond indicating the high tolerance of the fish under a controlled pond system. Similar survival rates of over 90% survival rate have been reported for *O. niloticus* under pond conditions (Zenebe Tadesse *et al*., 2012;

Abelneh Yimer *et al*., 2015). In contrast to our findings, low survival rate of *O. niloticus* ranging from 49.5–63% have been reported in ponds (Liti *et al*., 2006). Comparatively high mortality rate of about 20% was recorded in this experiment on fish fed with commercial feed. This might be due to better growth and large variations in fish size recorded (21 g to 190.3 g) which resulted in bullying and intimidation of the smaller fish (Gashaw Tesfaye and Zenebe Tadesse, 2008; Zenebe Tadesse *et al*., 2012; Mesay Eniyew *et al*., 2016). It is therefore, recommended to regularly sort and keep bigger fish in separate ponds to enhance growth of smaller fish and reduce bullying of bigger fish in commercial fish farming.

The Nile tilapia is known to tolerate and adapt to a range of environmental conditions such as water temperature, oxygen level, salinity, and pH. However, optimum growth and survival rate of *O. niloticus* was reported at water temperature ranging from 25–32°C (El-Sherif and El-Feky, 2009; Khater *et al*., 2017). Therefore, water temperature in ponds is crucial for ensuring existence, production and normal metabolic activities in fish (Marimuthu *et al*., 2011). In this experiment, the water temperature ranged from 17.2°C to 24.2°C which was mostly below the optimum temperature required for normal growth of tropical fish. It is reported that when the water temperature in ponds remains between 16 and 26°C feed intake by *O. niloticus* gets reduced. Thus, the growth rate declines as a result of high FCR and stress of the fish (Zenebe Tadesse *et al*., 2003). In this experiment, the water temperature in most months was below 26°C especially in the morning and this might lower the feeding rate and movement of the fish.

The DO level measured in this study was high (over 10 mg/L) in all months indicating that the fish was not stressed due to oxygen limitation in ponds. Thus, the fish benefitted from the high DO which was more than the minimum limit (5 mg/L) required for normal growth and production of fish (Ogunji and Awoke, 2017). Another important factor is pH which affects the physiology and metabolic activity of cultured fish. An acceptable pH for satisfactory growth and production ranges from 6.5 to 8.7 (Ogunji and Awoke, 2017). However, the pH recorded in this study was slightly higher (8.8–9.7) and alkaline. It is known that at higher pH (between 9 and 11), fish tend to show retarded growth which enhances the production and accumulation of un-ionized ammonia which is toxic for fish. Similarly, fish get stressed and experience slow growth rate, poor feed intake and high FCR when the pH lowers between 4 and 6. Thus, the slightly alkaline pH recorded during all months might stress the fish and contribute for the reduced growth of the fish.

In general, analysis of physico-chemical parameters of the pond water was crucial in explaining the feeding regime and growth of the fish stocked. Favourable water environment enhances fish growth and production. Optimum growth and production of fish in culture systems can be achieved when both the feed quality and the rearing environment of the water is maintained suitable for the fish. Thus, the low growth rate of *O. niloticus* observed in this study might be due to the combined effects of low quality feed, low water temperature and slightly alkaline environment of the pond.

CONCLUSION AND RECOMMENDATIONS

The Nile tilapia, *O. niloticus* is one of the most farmed candidate culture fish in Ethiopia. Semi-intensive type of pond culture system will be the major production system in the future. Therefore, research should focus on formulating quality feeds and management of the pond environment for better fish production. Thus, the results and conclusions obtained in this study can serve as baseline information for the culture of the species in Ethiopia. From the present study, the following points can be concluded and recommended:

Fish fed with the commercial feed (feed I) showed significantly ($p<0.05$) better growth rate (0.40 g/fish/day) as compared with fish fed with farm-made feeds (0.28 g/fish/day). However, the daily growth rate recorded for the commercial feed was still very low as compared with previous reports. Similarly, the FCR values reported for both commercial and farm-made feeds were high ranging from 2.84–4.85 indicating the poor utilization of the feeds by the fish.

Thus, the low growth rate of *O. niloticus* fingerlings recorded in the present study might be attributed to the combined effects of poor quality feed ingredients and unfavourable physico-chemical environment, mainly low water temperature and use of combined sex fish fingerlings.

Therefore, similar feed experiments should be conducted under different agro-ecologies and water management using sex-reversed all-male tilapia. Future studies should focus on formulating high-quality and complete feed with low FCR and high rate of digestibility which promote fast growth and production of *O. niloticus*.

ACKNOWLEDGEMENTS

We acknowledge the National Fisheries and Aquatic Life Research Centre (NFALRC) of the Ethiopian Institute of Agricultural Research (EIAR) for financial and material support provided for the study. We also thank Roman

Kebede and Abeba W/Gebriel for their assistance during monthly data growth data collection and feeding the fish. Finally, we acknowledge the critical comments of the two anonymous reviewers which considerably improved the final version of the manuscript.

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