Journal Brief

GROWTH PERFORMANCE OF NILE TILAPIA FARMED IN FERTILIZED FISH PONDS IN WESTERN KENYA

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ABSTRACT

Demand for Nile tilapia (*Oreochromis niloticus* L.) is expected to increase due to the global population increase. In Kenya, the use of manure to enhance primary productivity in fish ponds has been on the rise. The objective of this study was to assess the growth performance of Nile tilapia from fish ponds fertilized with organic and inorganic fertilizers in Western Kenya. Three fish farms in Kakamega County, each with three ponds measuring 300 m^2 and stocked with 1,000 Nile tilapia, were sampled for total fish length using a measuring board, weight using a scale and water quality. On each of the farms, the three ponds consisted of an unfertilized pond (UF), inorganic manure fertilized pond (IF), and organic manure fertilized pond (OF) in randomized complete block design (RCBD). Results showed that the value of regression coefficient *b* obtained from the length-weight relationship had isometric growth, with 2.57 to 3.14 in all three fertilizers. Relative condition factors ranged from 1 to 1.14. There were differences ($P<0.05$) among the mean weights and lengths of fish, with the IF having the highest mean weight and length. However, the specific growth rate did not differ ($P>0.05$). The results showed that the fertilization of fish ponds improved the growth of Nile tilapia fish in ponds. The organic and inorganic fertilizers in this study provide a good environment for pond fish. However, further research should be done to ascertain the environmental impacts of this practice.

Keywords: Fertilization, Nile tilapia, aquaculture

INTRODUCTION

The worldwide demand for fish has increased in the last few years due to technological development, a rise in incomes and increased awareness of the health benefits derived from eating fish (FAO, 2020). Despite projections that world aquaculture production will decelerate, it will still fill the supply-demand gap (FAO, 2020). Kenyan freshwater aquaculture production has been declining (KEMFRI, 2017); despite Kenya having a greater capacity for fish production (Nyandat and Owiti, 2013). Nile tilapia is the leading aquaculture species, accounting for approximately 80% of the total aquaculture production (KEMFRI, 2017).

Feeding is one of the main factors required for the fast growth of cultured Nile tilapia (Limbu and Jumanne, 2014). However, longstanding hurdles to enhancing Nile tilapia production in the supply of quality fish feeds remain a challenge (Ogello *et al*., 2014). Supplementary feeds are the most expensive input in intensive and semi-intensive cultures (Opiyo e*t al*., 2014). Combining fertilization and supplemental feeding has been shown to reduce production costs. (Prabaharan and Murungan, 2012).

The feeding of Nile tilapia under semi-intensive ponds varies significantly in different countries and is influenced by the socioeconomic status and knowledge of the farmer (Yakubu *et al*., 2012). In Kenya, assessment of pond fertilization with supplementary feeding has shown good growth performance (Mbugua, 2008). However, understanding the morphometric characteristics of such fertilized pond environment is still inadequate. The growth performance of tilapia in ponds could be improved by using organic and inorganic fertilizers with formulated feeds at a reduced ratio (Green, 1992; Diana *et al*., 1994). Organic and inorganic fertilizers decompose and release nitrogen, phosphorous, and potassium used by phytoplankton for growth and reproduction. (Knud-Hansen, 1998).

Kakamega County is well endowed with a vast water resource that can be harnessed for fish farming. In 2018, Kakamega County had 7,939 fish farmers operating 8,540 fish ponds covering an area of 2,260,945 m^2 (Fisheries Department, 2018). In the same year, 1,730,000 fingerlings of Nile tilapia and catfish fingerlings valued at KES13 million were stocked in the County. Fish weighing approximately 1,600 t, valued at about KES 500 million were harvested and sold in the same year

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(Fisheries Department, 2018). Fish ponds used in this study were earthen Nile tilapia ponds that were well-constructed and retained water throughout the cycle.

The choice of fertilization method in this study was based on a survey done among fish farmers of Kakamega County, which revealed that 87.6% of fish farmers fertilized their ponds, while 12.4 % did not. Among the farmers fertilizing their ponds, 64% used animal manures (41% chicken manure, 49% cow dung and 11% other manures), while 36% used inorganic fertilizers.

Therefore, it is important to know critical quantitative tools for studying fish biology, including growth, length-weight relationship, and condition factors (Lizama *et al*.,2002; Moutopoulos and Stergiou,2002). The length-weight relationship is also beneficial in converting growth in length equations to estimate stock biomass from limited sample sizes (Simon *et al*., 2008). Therefore, this study aims to determine the effects of fertilization on the growth performance of Nile tilapia under semi-intensive pond culture.

MATERIALS AND METHODS

Study area

The study was conducted in Kakamega County (0.2827° N, 34.7519° E), in Western Kenya. It covers an area of 1,395km^2 with a population of 1,868,000 (F). Kakamega is mainly tropical, with variations due to altitude with an average elevation of 1,523 meters (GOK, 2010). It experiences heavy rainfall, with two seasons, namely the long rains (April to July) and short rains (August to November). Rainfall ranges from 156 - 663 mm/month with a temperature range of 9.95-26.0 ^{o}C (GOK, 2010). The coldest month is July, with an average of 9.95-12.0 ^{o}C, whereas the hottest season is experienced between December to February, with a temperature range of 24.5-26.0 ^{o}C (GOK, 2010).

Study design and method

Three fish farms in Kakamega County, each with three ponds measuring 300 m^2, were sampled for total fish length and weight using a measuring board and scale. Water quality was also determined. On each of the farms, the three ponds consisted of an unfertilized pond (UF), inorganic fertilizer fertilized pond (IF), and organic manure fertilized pond (OF) in a randomized complete block design (RCBD).

All the ponds were stocked with 1,000 male Nile tilapia fingerlings (*Oreochromis niloticus* L.) from the same hatchery, with an average weight of 0.5 g. and an average length of 1.9 cm. The fish were fed daily with equal amounts of feed, totalling 50 kg for the whole experimental period. The organic manures used in this study were chicken manure with a Carbon to Nitrogen ratio of 11.66; cow dung manure (Carbon to Nitrogen ratio of 14.73), applied at a weekly rate of 20 g/m^2. In contrast, the inorganic fertilizer used was Di-Ammonium Phosphate, applied weekly at 2 g/m^2.

Sampling

Sampling of pond water

Water quality parameters, including temperature, dissolved oxygen, pH and conductivity, were measured *in-situ* using a Hydrolab MSIP-REM-HAH-QUANTA (USA) at three points of each pond (inlet, middle and outlet).

Sampling of fish

A total of 1,233 Nile tilapia were sampled during the study period from June to December 2021. This comprised 411 fish from each unfertilized pond, inorganic fertilized and organic fertilized ponds. Thirty (30) fish per pond were collected using a seine net, after which each fish was measured for length (using a measuring board-0.1 cm) and weight using Acculab VI-1200 (USA) scale, 0.1g precision.

Fish feeding

Fish in each pond were fed a total of 50 kg during the entire cycle, with fish feed proximate components as follows:

CTABLE I- PROXIMATE COMPOSITION OF FISH FEED

Component	(%)
Crude proteins	42.50
Crude fats	7.64
Crude fiber	13.13
Moisture	8.52
Ash	18.94

Data analysis

All data were analyzed using SPSS version 26 and considered significance at P = 0.05. One-way ANOVA (Snedecor and Cochran, 1968) compared the length, weight, specific growth rate (SGR) and water quality treatment. The Turkey's test was used to separate the mean differences.

Length-weight relationship

The length-weight relationship (LWR) was calculated according to Pauly (1983). The LWR was used to get the slope of the regression line of weight and length, while the parameter b (weight at unit length) was estimated using the equation $W= aL^b$, where:

W-the weight of fish in grams

L-Total length of fish in cm

a-exponent describing the rate of change of weight with length

b-weight at unit length.

Relative condition factor

The relative condition factor, Kn, was calculated according to Le Cren (1951) using the formula:

$Kn= W/ aL^b$ where:

W-Actual weight of fish in grams

aL^b-Expected weight from the Length-weight relationship

Specific growth rate

This was done by calculating the specific growth rate (SGR) as in Ricker (1975).

$SGR = 100 [(\ln Wt – \ln W0)/t]$

Where: W_0 and W_t are the fish's initial and final live weight (g), respectively, and (t) is the culture period in days.

RESULTS

Mean weight, mean length and specific growth rate

In this study, Nile tilapia from ponds fertilized using inorganic fertilizer recorded the highest mean weight (29.40 ±16.51 g), followed by organically fertilized ponds (28.48±17.77 g), and lastly, the unfertilized ponds (23.41±13.86 g). Nile tilapia from ponds fertilized using inorganic fertilizer recorded the highest mean length (11.11±0.91 cm), followed by organically fertilized ponds (10.98±2.35 cm), and lastly, the unfertilized ponds (10.25±2.28 cm)(Table II). There were differences ($P<0.05$), in weight and length on the three treatments with the inorganic and organic fertilized ponds being higher than unfertilized ponds. However, there were no differences (>0.05) in weight and length when organic and inorganic pond fertilized fish were compared (P=0.689 and 0.510, respectively). The SGR ranged from 0.35 to 5.97% per day in all the treatments. There were no differences ($P>0.05$) in SGR among the treatments.

Length-weight relationship

The *b* values of Nile tilapia sampled from unfertilized (UF), inorganically fertilized (IF) and organically fertilized ponds (OF) ranged from 2.734-3.097; 2.450-3.059 and 2.566-3.140, respectively (Table II and Figure 1). The relative condition factor from all the treatments ranged from 1 to 1.14, while length and weight were highly correlated (r range: 0.85 to 0.99).

TABLE II - MEAN WEIGHT, LENGTH, SPECIFIC GROWTH RATE (%SGR) AND RELATIVE CONDITION FACTOR (Krel) OVER SIX MONTHS CYCLE IN UNFERTILIZED (UF), INORGANICALLY FERTILIZED (IF) AND ORGANICALLY FERTILIZED (OF) NILE TILAPIA PONDS

Treatment	Month	Length (cm)	Weight (g)	SGR (%)	a	b	R^2	(Krel)
UF	July	5.10	2.5	5.36	0.0277	2.734	0.97	1.05
	Aug	7.29	8.30	4.00	0.0287	2.812	0.98	1.08
	Sep	9.80	18.45	2.66	0.0281	2.826	0.95	1.06
	Oct	10.13	21.39	0.49	0.0159	3.097	0.98	1.04
	Nov	12.24	35.83	1.72	0.021	2.960	0.97	1.05
	Dec	12.89	39.80	0.35	0.017	3.025	0.96	1.02
	Mean	10.25	23.41	2.43	0.025	2.881	0.99	1.14
IF	July	5.10	2.5	5.36	0.0277	2.734	0.97	1.05
	Aug	8.41	12.43	5.35	0.041	2.653	0.97	1.08
	Sep	10.38	22.11	1.92	0.071	2.447	0.89	1.01
	Oct	11.27	28.20	0.81	0.042	2.680	0.85	1.01
	Nov	12.76	40.60	1.22	0.040	2.696	0.98	1.04
	Dec	14.11	52.50	0.86	0.016	3.059	0.93	1.00
	Mean	11.16	29.40	2.59	0.029	2.830	0.99	1.11
OF	July	5.20	3.0	5.97	0.026	2.89	0.97	1.04
	Aug	8.15	11.40	4.45	0.017	3.062	0.97	1.05
	Sep	9.97	18.43	1.60	0.049	2.566	0.91	1.02
	Oct	10.82	24.62	0.97	0.047	2.625	0.85	1.02
	Nov	13.13	44.97	2.01	0.038	2.729	0.95	1.03
	Dec	14.02	52.71	0.53	0.013	3.140	0.97	1.03
	Mean	10.98	28.48	2.59	0.023	2.927	0.99	1.13

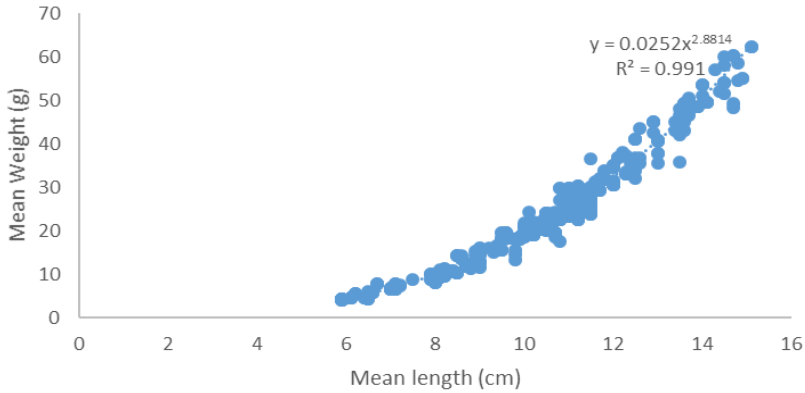

Figure 1a: Length-weight relationship of Nile tilapia in unfertilized fish pond

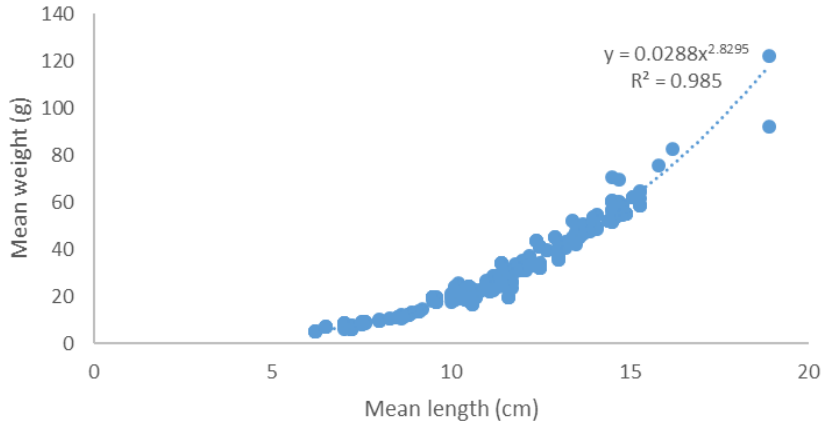

Figure 1b: Length-weight relationship of Nile tilapia in inorganically fertilized pond

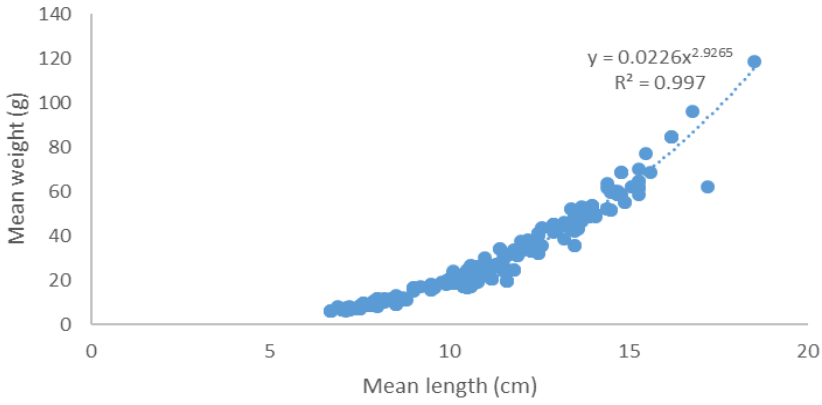

Figure 1c: Length-weight relationship of Nile tilapia sampled for six months.

Water quality parameters

The results obtained from the water quality parameters (Table III) showed no differences among the treatments (P>0.05).

TABLE III- WATER QUALITY PARAMETERS DURING THE STUDY CYCLE

Treatment	Parameter	Mean ± SD
UF	Temperature	26.82±1.96
	Dissolved oxygen	4.23±1.36
	pH	7.70±0.66
	Conductivity	85.28±29.74
IF	Temperature	26.50±2.04
	Dissolved oxygen	4.79±1.52
	pH	7.46±1.26
	Conductivity	90.39±26.47
OF	Temperature	26.60±2.30
	Dissolved oxygen	4.47±1.57
	pH	7.67±0.73
	Conductivity	78.90±16.70

DISCUSSION

The improved growth in fertilized ponds observed in this study agrees with Uddin *et al*., 2012, who attributed the higher weights to the availability of primary productivity of planktons in fertilized ponds when compared to unfertilized ponds. According to Diana *et al.,*1994, the growth performance of tilapia can be improved by adding inorganic and organic fertilizers, as demonstrated in this study.

The *b* values from this study showed isometric growth and agrees with Froese (2006), who reported that the expected range of *b* values ranges from 2.5 to 3.5 for tropical fish stocks. Though the *b* values were within the expected range, most of them were below value three, showing negative allometric growth (Ighwela *et al.,* 2011), meaning that the fish grew faster in length than in weight. This could be attributed to food availability (Yilmaz *et al*., 2012; Ali *et al*., 2016). The ponds in the current study only received 50 kg of feed.

The relative condition factors above value one in all the treatments indicated that all the environments provided good fish health conditions for the fish. The results are below the condition factors recommended for normal growth and utilization of nutrients by a normal freshwater fish (Banegal and Tesch 1978), which recommended a value of 2.9-4.8. This difference could be because the fish were not fed to satiation, with each pond receiving 50 kg of feed during the entire production cycle. According to Dampin *et al.* (2012) and Dagne *et al.* (2013), water quality parameters such as dissolved oxygen, temperature, and pH affect *O. niloticus* because they are required for optimum feeding growth and excretion of wastes in water. The water quality parameters measured in this study did not differ (P>0.05) between the fertilization treatments and were within the optimum range for *O. niloticus* rearing (Alabaster and Lloyd, 2013). The water quality parameters also agreed with those reported by Rukera *et al*. (2012) for *O. niloticus* reared in earthen ponds.

CONCLUSION AND RECOMMENDATION

Pond fertilization, whether with organic manure or inorganic fertilizers, improves the growth of Nile tilapia in ponds. The weight at unit length values were within an acceptable range. However, further research needs to be conducted to ascertain the environmental impacts of this practice, especially on the greenhouse gas emissions to the environment.

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