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EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON THE GROWTH OF JUVENILE *OREOCHROMIS SHIRANUS*

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Abstract

The experiment to investigate the effects of organic and inorganic fertilizers on primary production and growth of *Oreochromis shiranus* was conducted in fifteen $3m^2$ concrete tanks at the Aquaculture Fish Farm, Bunda College, University of Malawi. Fish with mean weight of 8 ± 1g were stocked at 30fish/m^2. There were five treatments (inorganic and feed, inorganic only, chicken manure and feed, chicken manure only, and feed only) which were replicated three times. After 84 days, fish raised on chicken manure and feed were significantly (P<0.05) larger and had higher net annual yields than the rest of the treatments. For treatments with either feed and fertilizer only, organic fertilizer had the highest fish growth rate and primary production. Significantly (P<0.05) higher amounts of chlorophyll *a* were produced in tanks fertilized with chicken manure. Overall, results obtained in this study, suggest that the use of chicken manure only, chicken manure and feed combination produces better results than inorganic fertilizer with either feed or no feed combination.

Keywords: Fertilization, organic fertilizer, inorganic fertilizer, *Oreochromis shiranus,* chlorophyll *a*

Introduction

Farmed fish obtain their food partly from natural production in the pond and partly as supplementary feed given by the farmer (Kang'ombe, 2004). Maize bran is used as a supplementary feed because it is the most potentially available ingredient for fish production and has been recommended as a pond input to Malawian fish farmers since the 1940s and is used by 90% of fish farmers in Malawi (Brummet, 1995).

For natural feed production, organic fertilizers are an efficient and economical means of increasing pond productivity. Organic fertilizers improve soil structure and fertility, encourage bacterial growths which in turn favour the production of zooplankton (FAO, 1997) which is nutritious and preferred food to many aquaculture species (Pillay, 1993). Inorganic fertilizers are also used in pond fertilization because of their quick nutrient release when applied, minimum mineral variability for fertilizer of the same type, easy distribution and that they can be stored for a long time. Although use of inorganic fertilizers usually result in high returns there is low consumption/use in Africa with a mean of 21kg/ha (Wallance and Knausenberger, 1997). Its use by farmers is constrained by its high cost (Miller, 2000).
The aim of study was to compare a) fish production from a commercial inorganic fertilizer, 23:21:0 + 4S with an organic fertilizer, chicken manure b) growth of *Oreochromis shiranus* and primary production in concrete fish tanks fertilized with organic and inorganic fertilizers.

Materials and methods

Study area

The study was conducted at Bunda College of Agriculture fish farm in Lilongwe, Malawi for three months from February to April, 2008.

Experimental layout and design

Thirty (30) fingerlings of *O. shiranus* with a mean weight of 8±1g were stocked in each of the 15 concrete tanks of approximately $3m^3$. The tanks were prepared by laying 10cm clay-loam soil at the bottom to act as a substrate for primary production and to simulate an earthen pond. The tanks were filled with water from the nearby dam. An initial pond fertilization using both types of fertilizers was done. Organic fertilizers were applied two weeks before stocking. Inorganic fertilizers were applied a week before stocking. The initial fertilization was done to ensure that production of plankton had occurred before the fish were stocked. The initial pond fertilization rates were 50kg/ha for inorganic fertilizer and 500 kg/ha for organic fertilizer. The fertilization rates were adjusted according to the water quality parameters.

The experiment was laid out in a Completely Randomized Design (CRD) with five treatments , replicated three replicates. First treatment was inorganic fertilizers plus feed, treatment two was inorganic fertilizers only, treatment three had organic fertilizers and feed, treatment four had organic fertilizers only and the fifth treatment had feed only.

Inorganic fertilizers were applied by broadcasting the feed on the water surface while organic fertilizers were soaked before application to reduce the amount of suspended solids and time of suspension on the water sur-

face. Fish were fed a diet of 30% crude protein feed that was formulated from maize bran, soybean, mineral and vitamin premix. Feeding was done twice a day at 08h:00 and 14h:00 at 2% per day.

Fish sampling and data collection

Twenty fish (20) fish were sampled per tank. Data on fish body weight (g), standard and total length (mm) was collected every fortnight using an electronic weighing balance and a measuring board. Quantity of feed was adjusted during every sampling time. At the end of the experiment, the tanks were drained and the fish were weighed, counted and measured.

Water quality parameters pH, temperature and turbidity were measured twice daily at 07h:00 and 14h:00 using a pH and temperature meter and secchi disk respectively. Dissolved oxygen, ammonia and chlorophyll *a* were measured weekly using a titration method.

Data analysis

Data was analyzed using analysis of variance (ANOVA) using a general linear model (GLM) with repeated measurements of weight over time. One-way ANOVA analysis was also performed for each time for weight. Means of treatments were separated using Duncan's multiple range test (DMRT) test at 0.05 level of significance. Specific growth rate (SGR) and Fulton's condition factor were computed using formulae described by De Silva (1995) and Kang'ombe (2004) respectively. Gross yield, net yield and survival of fish were computed as shown below:

- Gross yield of fish/ha = Harvested fish (kg) / unit area (ha)
- Net yield of fish/ha = (harvested fish weight kg – initial weight kg)/ unit area (ha)
- Survival Rate (%) = (initial number of fish – (number of harvested fish– initial number of fish) * 100

Results

Growth performance indices

Lower fish growth rate was observed in TRT2 than the rest of the treatments where there was an increase in weight by at least 1g every fortnight. However, all the mean weight gains between treatments with time were significantly different (P<0.05). TRT 3 (Organic fertilizers and feed) had significantly higher final mean weight (18.96g) than TRT 1 (inorganic plus feed, 16.18g), TRT 4 (organic only,15.68g), TRT 5 (feed only, 15.96g) and TRT 2 (inorganic fertilizer only, 9.45g) as shown in Figure 1 and Table 1.

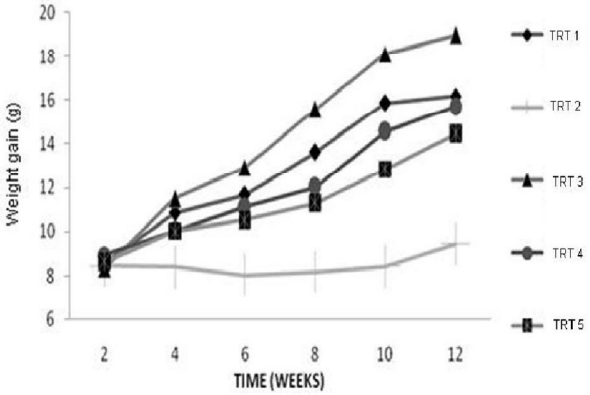

Figure 1: Mean weekly weight gain of *Oreochromis shiranus* grown in concrete tanks under different fertilization regime for 84 days. TRT 1 = Inorganic fertilizers plus feed, TRT 2 = Organic fertilizers only, TRT 3 = Organic fertilizers plus feed, TRT 4 = Organic fertilizer only and TRT 5 = Feed only.

Interaction effects of fertilizers and feed were also observed. For instance, fish in TRT1 (inorganic fertilizer plus feed) recorded 16.18g and TRT2 (inorganic fertilizer only) recorded 9.45g only as the final mean weight. Similary, a combination of organic fertilizer and feed (TRT3) resulted into a higher final mean weight(16.18g) while organic fertilizer only (TRT 4) resulted in mean fish weight of 15.68g.

TRT3 which had the highest final mean weight also showed highest growth rate(127.7%), mean daily weight gain (0.127g), gross yield (4234 kg/ha/year) and net yield (2375.15 kg/ha/year) as shown in Table 2. The opposite was observed in TRT2 which had the lowest values.

Table 1: Growth parameters of *Oreochromis shiranus* grown in concrete tanks under different fertilization regime for 84 days

	*TRT1	TRT2	TRT3	TRT4	TRT5
Initial mean weight (g)	8.69±0.21^a	8.45±0.24^a	8.33±0.24^a	8.93±0.24^a	8.61±0.25^a
Final mean weight (g)	16.18±0.38^a	9.45±0.26^b	18.96±0.47^c	15.68±0.47^d	15.96±2.38^d
Mean weight gain (%)	89.467^a	11.938^b	127.748^c	75.506^d	67.867^d
Mean daily weight gain(g)	0.091^a	0.012^b	0.127^c	0.080^d	0.070^d
SGR (% day^{-1})	0.76077^a	0.13425^b	0.97984	0.66965^d	0.61667^d

Values with same superscripts in a row are not significantly different (P>0.05), *TRT 1 = Inorganic fertilizers plus feed, TRT 2 = Organic fertilizers only, TRT 3 = Organic fertilizers plus feed, TRT 4 = Organic fertilizer only and TRT 5 = Feed only.

Fish survival and condition factor

As shown in Table 2, TRT3 had the highest survival rate of 97% seconded by organic and feed which had a survival rate of 94%. There was better fish survival for TRT5 treatment (92%). Low survival rates were observed TRT2 and TRT4 only which had 85% and 89% respectively. However, there were no significant differences (P<0.05) in the initial fish's condition between treatments. This was also true for the final health condition of the fish. However, differences were observed between initial and final conditions for individual treatments (Table 2).

Table 2: Yield and Fulton's condition factor of *Oreochromis shiranus* grown in concrete tanks under different fertilzation regime for 84 days.

	TRT1	TRT2	TRT3	TRT4	TRT5
Gross fish yield (Kg/ha/84 days)	1078.91	630.33	1264.00	1045.33	963.56
Gross fish yield (kg/ha/year)	3614.35	2111.62	4234.40	3501.87	3227.91
Net fish yield (kg/ha/84 days)	509.47	55.89	709.00	449.72	389.56
Net fish yield (kg/ha/year)	1706.71	187.23	2375.15	1506.57	1305.01
Survival rate (%)	97.778	85.556	94.444	88.889	92.222
Initial condition	0.003131[a]	0.0034[a]	0.003114[a]	0.003049[a]	0.003071[a]
Final condition	0.003374[a]	0.003022[a]	0.004252[a]	0.003317[a]	0.003463[a]

Values with same superscripts in a row are not significantly different (P>0.05). TRT 1 = Inorganic fertilizers plus feed, TRT 2 = Organic fertilizers only, TRT 3 = Organic fertilizers plus feed, TRT 4 = Organic fertilizer only and TRT 5 = Feed only.

Water quality

Temperature and Chlorophyl *a*

There was significant differences in chlorophyll *a* production in combined treatments of organic fertilizer plus feed and inorganic fertilizers and feed (P<0.05) compared to uncombined treatments of organic fertilizer only, inorganic fertilizer only and feed only. Temperature was was not significantlt different (P>0.05) in all the five treatments. (Table 3).

Table 3: Values (±SD) of temperature and chlorophyll a in concrete tanks under different fertilization regime for 84 days.
Dissolved oxygen, Ammonia and Turbidity

Temperature (^{0}c)		pH		chl *a* (µg/l)
07h:00	14h:00	07h:00	14h:00	
22.4085±2.24[a]	27.6158±19.69[a]	8.2714±0.28	8.1486±0.31	50.4688±12.18[a]
22.5964±2.21[a]	25.7280±1.79[a]	8.0547±0.10[a]	8.7389±0.14[a]	49.2072±9.81[a]
22.6707±2.19[a]	25.8772±1.81[a]	8.0597±0.18[a]	8.2973±0.29[ab]	67.3892±27.75[b]
22.5061±2.20[a]	25.6912±1.83[a]	8.1873±19[b]	8.38±0.19[b]	61.8332±11.38[b]
22.4637±2.80[a]	25.74±1.83[a]	8.1698±14[b]	8.4889±0.20[b]	59.8692±13.38[b]

Values with the same superscript in a column were not significantly different (P>0.05). TRT 1 = Inorganic fertilizers plus feed, TRT 2 = Organic fertilizers only, TRT 3 = Organic fertilizers plus feed, TRT 4 = Organic fertilizer only and TRT 5 = Feed only.

There were no significant differences (P>0.05) in the mean dissolved oxygen levels in all the treatments. Ammonia levels were significantly high TRT 1 (organic fertilizers plus feed) and TRT 3 (organic fertilizers only) compared to treatments with inorganic fertilizers and feed only; TRT 2 (Inorganic plus Feed), TRT 4 (feed only.) and TRT 5 (Inorganic only). Turbidity was high in TRT3 and low in TRT2. In terms of turbidity TRT1, TRT4 and TRT5 were not significantly different (P>0.05) (Table 5).

Table 5: Values of dissolved oxygen, ammonia and turbidity in concrete tanks under different fertilization regime for 84 days

	Dissolved Oxygen (mg/l)		Ammonia	Turbidity
	07h:00	14h:00	(mg/l)	(cm)
TRT 1	12.19[a]	12.29[a]	0.289[a]	21±0.7[a]
TRT 2	12.40[a]	12.56[a]	0.200[b]	28±0.3[b]
TRT 3	12.08[a]	12.10[a]	0.328[a]	18.2±0.9[c]
TRT 4	12.69[a]	12.66[a]	0.220[b]	22±0.9[a]
TRT 5	12.85[a]	12.83[a]	0.250[c]	20±0.8[a]

Values with same superscripts in a row are not significantly different (P>0.05). TRT 1 = Inorganic fertilizers plus feed, TRT 2 = Organic fertilizers only, TRT 3 = Organic fertilizers plus feed, TRT 4 = Organic fertilizer only and TRT 5 = Feed only.

Discussion

Fish Growth performance

Fish in treatments with organic fertilizers had growth rates than fish in the other treatments. Similary, Kang'ombe *et al.* (2006) reported that fish in ponds fertilized with chicken manure grew significantly better compared to cattle and pig manure. Chicken manure has high levels of nitrogen, phosphorous and potassium; 1.23, 1.39, 0.61, respectively (Kang'ombe *et al.*, 2006).

Feeding also contributed significantly to the growth of *Oreochromis shiranus* where fertilization was involved with the best performance for chicken manure. It was observed that single treatments (organic, inorganic and feeding only) did not result into the optimum growth rates of *Oreochromis shiranus*. Although this was the case, each treatment had an effect on fish growth. For instance the control treatment (feed only) resulted in addition of 2g weight after two weeks. The treatment where organic fertilizer only was applied produced superior results to feeding only.

At the end of the experiment the highest fish growth performance was noticed in the treatment of a combination of organic fertilizer and feeding seconded by a combination of inorganic fertilizer and feeding. Hence, combined treatments had better results.

Organic fertilizers treatments had higher yields, because organic fertilizers serve as direct food to invertabrates, fish food organisms and fish or decompose releasing nutrients that stimulate plankton growth. organic fertilizers are efficient in increasing the abundace of zooplankton andbenthic organisms (Boyd, 1990).

Interms of single treatments, organic fertilizer produced better results compared to inorganic ferilizer. There are several factors that could have been the possible causes: firstly, the inorganic fertilizer used for this investigation (23:21:0 + 4S) had higher nitrogen levels responsible for primary production. However, inorganic nitrogen quickly declines when applied in water (Boyd, 1990) due to several factors which include plant absorption, volatilization which could possibly be the major cause of nitrogen loss from ponds where afternoon pH values are high (Boyd, 1990). Secondly, the inorganic fertilizer used also had high phosphorous which is likely to be absorded by the mud in the aerated tanks which is also a limiting factor also recognised in Boyd (1990).

Similarly, good condition factors were recorded in all treatments except for inorganic fertilizer only pond treatment which may have decreased due to inadequate natural feed production levels.

In terms of fish growth and chlorophyll *a* production, a direct relationship was observed. Organic fertilizer and feed treatment had the highest fish growth rates than the rest which is also the case interms of chlorophyll a production. This observation is supported by Knud-Hansen (1998) that there is a strong positive relationship between Net algal Productivity (NAP) and the Net Fish Yield (NFY) for fish whose diet consists of natural produced food. The results also show that the treatments with feed combined with fertilization also had high fish growth rates and chlorophyll *a* production than single treatments.

Water quality

The minimum level of chlorophyll *a* that was produced was 49.21 µg/l and the highest levels were over 67.39µg/l on average. Chicken manure and feeding treatment had the highest chlorophyll *a* production. In a study by Kang'ombe *et al.* (2006) chicken manure also had significantly high chlorophyl *a* levels.

The treatments with inorganic fertilizer did not differ significantly (P<0.05) because the inorganic fertilizer-had added the same quantities of nutrients and had the same effect on water quality. Therefore, there were limited sources to variation in chlorophyll *a* production. The same applies for treatments which had organic fertilizer. It is well established that phytoplankton productivity is positively correlated with nutrient concentrations (Boyd, 1990).

Conclusion

High productivity levels (fish and primary production) were observed in treatments which had both fertilization and feeding. However, treatment TRT3 (organic fertilizer plus feed) had the higher productivity than treatment TRT1 (inorganic fertilizer plus feed). For uncombined treatments, organic fertilizer had the highest fish growth rates, seconded by feed only and inorganic fertilizer had the poorest growth rates. Although the combination of organic fertilizer plus feed gave the superior results, it is not yet practically feasible for

local fish farmers to formulate or purchase high protein feed. Therefore, the high fish yield returns due to use of chicken manure gives an opportunity to Malawian fish farmers as the poultry population was estimated at 11.5 million (83% chickens) in 1998 (Kang'ombe *et al.*, 2006). According to Safalaoh (1997), chickens are widely and equitably distributed among households of poor and marginalized people in Malawi. This means chicken manure could be one of the best and reliable sources of manure that fish farmers can easily access and utilize.

In general, the results suggest that supplementary feeding and pond fertilization is a necessicity in aquaculture although there were differences in the effects depending on type of pond fertilization.

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