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Effect of Organic and Inorganic Fertilizers on Natural Food Composition and Performance of African Catfish (*Clarias gariepinus*) Fry Produced Under Artificial Propagation

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Abstract

Two experiments were conducted to assess the effect of organic and inorganic fertilizers on natural food composition and performance of African catfish (*Clarias gariepinus*) fry produced under artificial propagation. In both experiments chicken manure, di-ammonium phosphate and no fertilizer were used as treatments. The first experiment was conducted to determine the abundance and diversity of natural food produced in tanks fertilized with chicken manure and di-ammonium phosphate fertilizer. The second experiment was conducted to assess growth performance and survival of catfish fry produced in chicken manure and di-ammonium phosphate at 5fry/m^2 and 10fry/m^2 stocking densities. Nine concrete tanks and eighteen concrete tanks were used in experiment 1 and 2, respectively. The results indicated that abundance of natural food (*phytoplankton*) were significantly higher ($P<0.05$) in di-ammonium phosphate (DAP) fertilizer applied tanks compared to other treatments. *Zooplankton* diversity was higher in tanks applied with chicken manure, followed by tanks applied with DAP fertilizer and least in tanks with no fertilizer. Fry growth performance was higher in fertilized tanks compared to unfertilized tanks. At low stocking density (5fry/m^2) fry had better growth performance compared to high stocking density (10fry/m^2) across all fertilizer types. Survival rates were not significantly different ($P>0.05$) between chicken manure and DAP fertilized treatments across stocking densities though significantly differed ($P<0.05$) from the control. Water quality parameters were found to be within the optimum range for cat fish in both experiments. In conclusion, the study indicated that higher *phytoplankton* abundance are attained with DAP fertilized tanks and *zooplankton* diversity were higher in chicken manure applied tanks. Therefore, it is recommended that for better growth and survival in aquaculture practices, catfish fry should be raised in DAP or chicken manure fertilized tanks at low stocking density as suggested by this study.

Keywords: DAP fertilizer; Chicken manure; Catfish fry; Stocking density; Fry performance

Introduction

In recent times, the African catfish, *Clarias gariepinus,* has gained popularity in aquaculture sector of Tanzania. However, the rearing of *C. gariepinus* larvae to juveniles has proved to be challenging due to their small size and lack of functional digestive system [1,2]. Great losses are in the hatchery, as fry weans over from yolk absorption to exogenous feeding [3]. This is due to inability to accept large sized feeds and assimilate protein from dry formulated diets [1,4]. According to Agadjihouede et al. [5], *Artemia* constitutes an excellent starting food in larviculture of *C. gariepinus*. However, its cost is high and not available in developing countries especially in the rural fish farming [6]. Due to this fact, it has been found important to provide the larvae with live feeds such as *zooplankton* or algae first before they are sequentially acclimatized to accepting formulated diets [2,7].

Primary production in fish pond/tank is limited by phosphate, in particular, and nitrogen in general [8]. Fertilizer application stimulates the growth of decomposers such as bacteria and fungi which breakdown toxic waste products that can accumulate with the use of prepared feeds [9]. It is an inexpensive method of feeding and plankton is necessary for smaller fish which are small to eat supplemental feeds [10]. Ponds/tanks with fertilized water will turn a rich green or reddish color when the plankton becomes abundant and food will be available for the fish [11].

Survival and growth of catfish larvae and fry are influenced by several factors such as stocking density [12,13] and water quality [14,15]. Growth of juvenile African catfish is directly density dependent and is normally highly aggressive when confined in small numbers in a large volume of water [16,17]. Aggressiveness, territorial defense and development of hierarchies and individual dominance are often reduced at high stocking density and fish may start to be stressed once certain threshold densities are attained [18,19]. Aggression can result in stock losses, reduced food conversion efficiency and slower growth. So, there must be a density from which both growth and production decreased with increasing stocking density [17]. Water quality, mainly dissolved oxygen and pH levels are considered as the limiting factors in intensive fish culture. According to Brazil and Wolters [14]; Pangni et al. [15], growth increase in channel catfish larvae reared in tanks was due to high levels of dissolved oxygen. The decreasing trend of dissolved oxygen in tanks with high stocking densities would be attributed to the gradual increase in biomass, resulting in higher oxygen consumption at varied stocking densities [15].

Among fertilizers used to increase natural food in ponds and tanks, chicken manure and di-ammonium phosphate (DAP) fertilizers are very cheap and locally available to fish farmers [20]. They contain a good combination of nitrogen and phosphorus in different proportions which increase the quantity of primary producers [21,22]. According to Lin et

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al. [23], fertilization in fish ponds/tanks is known worldwide to improve pond productivity by promoting the growth of *phytoplankton* thereby increasing natural food available to fish. A lot of progress has been made so far in aquaculture, however, larvae rearing remains the bottleneck in *C. gariepinus* production. The use of natural live food at earlier stage of fry development seems to be one of the solutions to improve growth performance and survival. Therefore, the study was designed to assess the growth performance and survival rate of the fry reared in chicken manure and DAP applied tanks at different stocking density.

Materials and Methods

Experimental design

The study was conducted from the last week of March 2015 to June 2015 at aquaculture research facility in Magadu farm at Sokoine University of Agriculture (SUA) Morogoro, Tanzania. Two experiments were conducted for 1 week and 2 months, respectively. Experiment 1, involved determination of abundance and diversity of natural food in tanks applied with different type of fertilizer. While Experiment 2, involved evaluation of growth performance and survival of African catfish fry stocked under two stocking densities (5fry/m^2 and 10fry/m^2), in tanks applied with different type of fertilizer [24].

Experiment 1: Determination of abundance and diversity of natural food

(a) Fertilizer application: Fresh chicken manure from layers kept in the cages were collected from poultry unit belonging to Department of Animal Science and Production, SUA [25]. Nitrogen (2.55%) and Phosphorus (0.95%) in chicken manure was determined using proximate analysis at Animal Science laboratory according to Association of Official Analytical Chemists [26]. Di-ammonium phosphate fertilizer was purchased from a local agro-input shop in Morogoro containing 18% N and 46% P as indicated on the package [27]. Several trials were conducted to find the appropriate rate of fertilizers application which produced algae bloom in the tanks before starting the experiment. Nine concrete tanks having a area of 7 m^2 each were laid out with 10 cm of soil and then filled with water to depth of 0.8 m. Three treatments: 2 kg of chicken manure, 42 g of di-ammonium phosphate fertilizer and no fertilizer (control) were randomly assigned to the tanks and replicated three times.

(b) Water sampling for plankton analysis: One week after fertilization water samples were collected with 10 L bucket from 4 locations within each concrete tank and this was done for all 9 tanks at 08:00 am. Water sample was placed into plankton net (KC Denmark A/S Denmark) with a 20 µm mesh size and left for 20 min. The concentrated sample from plankton net was transferred to 200 ml plastic bottles. Five drops of 70% alcohol were added to each sample to fix the organisms and taken to Faculty of Veterinary Medicine Laboratory (SUA) for analysis.

(c) Plankton fidentification and quantification: Plankton identification was done on a light microscope (BRESSER, Germany) 100X magnification using identification keys according to UNESCO [28]. 1 ml of water sample was taken from the collecting bottles (200 ml bottles) using micropipette and transferred to a Sedgewick Rafter cell (Wild Supply Company, England) then covered with slide at the top and placed under microscope. From 10 randomly selected squares of cell, planktonic organisms were enumerated and numerical abundance was calculated. *Phytoplankton* and *Zooplankton* abundance were calculated using the following formulas as described by Greenberg et al. [29] and Wetzel and Likens [30], respectively:

$$Phytoplankton\text{Abundance} = \frac{\text{C}}{\text{FxV}}$$

Where C is the number of organisms counted, F is the number of fields counted and V is the volume of sample settled.

$$Zooplankton\,/\,L = \frac{\text{C x V}_a}{\text{V}_b\text{xV}_c}$$

Where C is the number of *zooplankton* counted, V_a is the volume of the concentrated sample (L), V_b is the volume of counted sample (L) and V_c is the volume of water filtered (L).

In case of plankton diversity Shannon-Wiener diversity index (H') and evenness (J') were used. Diversity index of plankton was calculated by using the formula as described by Krebs [31]:

$$H' = \frac{n\ln(n) - \sum_{i=1}^{k} f_i \ln(f_i)}{n}$$

Where k is the number of categories, f_i is the number of observations in category i, n is the sample size.

Species evenness or homogeneity or relative diversity (J`) was calculated from the observed species diversity and from the equation of H_{max} as described by Sundar et al. [32]. Index of species evenness was measured by using the following formula:

$$J' = \frac{H'}{H'_{\max}}$$

Where, $H'_{\max} = \ln(k)$

After plankton quantitative analysis, *phytoplankton* and *zooplankton* were further identified up to genus level following the guide of Bellinger [33].

Experiment 2: Determination of growth and survival of African catfish (*C. gariepinus*) fry

Fertilization of tanks in this experiment was done one week before fry stocking. Total 18 concrete tanks (7 m^2 each) were used. Six tanks were fertilized with chicken manure and the other 6 tanks fertilized with diammonium phosphate at a rate of 286 g/m^2 and 6 g/m^2, respectively. While the remaining 6 tanks were not fertilized (control). The experiment was laid out in a Factorial Design where catfish fry assigned randomly in 18 concrete tanks. *Clarias gariepinus* fry (1 month old) an average weight of 0.5 g ± 0.01 g from hatchery tank were randomly assigned to treatment tanks. Two stocking densities (5fry/m^2 and 10fry/m^2) were used. Each stocking density was assigned at once and replicated three times. All 18 concrete tanks were covered with plastic nets to prevent predators. Fertilization was repeated every week for a period of 2 months. During this period, all treatments were supplemented with a formulated diet containing 55% crude protein and fed at 25% body weight per day.

(a) Data collection: Once every week in the rearing period of 2 months, the catfish fry from each concrete tank were harvested by using seine net. Then placed in 10L buckets and taken to hatchery building where they were weighed by using analytical balance (BOECO, Germany) and recorded. The following formula was used to determine fry performance and survival rate as outlined by Kang'ombe et al. [34].

Weight gain (g) = Final mean weight (g) - Initial mean weight (g)

$$Increase\ mean\ weight(\%) = \frac{Final\ mean\ weight(\text{g})\ - Initial\ mean\ weight(\text{g})}{Initial\ mean\ weight(\text{g})} x100$$

$$Specific\ growth\ rate(\%) = \frac{\ln\left(Final\ mean\ weight(g)\ - Initial\ mean\ weight(g)\right)}{Time(days)} x100$$

$$Survival\ rate\ (\%) = \frac{Initial\ number\ of\ fry\ -\ Number\ of\ dead\ fry}{Initial\ number\ of\ fry} x100$$

(b) Physico-chemical parameters of water: In both experiments, water quality parameters were monitored. Temperature (^{0}C) and dissolved oxygen (mg L^{-1}) were measured on daily basis (08:00-16:00hrs) using a multi-probe water checker (OAKTON, Singapore). The pH was measured every day at 8:00 hrs using pH meter (EXSTICK, USA). Ammonia and nitrite (ppm) were calculated once a week by using Salicylate Method and Diazotization Method, respectively.

(c) Statistical data analysis: One way and two way analysis of variance (ANOVA) (Experiments 1, 2 respectively) were used to compare differences between treatment means at 5% level of significance. Post-hoc analysis was done where significant differences existed between treatments means using Tukey's Test. Analyses were performed using SPSS software version 20 [35].

Results

Abundance and diversity of different species of live food produced in chicken manure and di-ammonia phosphate (DAP) fertilizers

Generally, fertilized tanks had higher abundance and diversity of *phytoplankton* and *zooplankton* compared to unfertilized tanks (Tables 1 and 2). *Phytoplankton* abundance was represented by four diverse groups, namely *chlorophyta, cynophyta, euglenophyta* and *diatomae* [36]. Among the *phytoplankton*, *chlorophyta, cryophyta* and *diatomae* were highly significant (P<0.05) in tanks fertilized with chicken manure and DAP fertilizer compared to control. *Euglenophyta* showed to be highly significant (P<0.05) when DAP fertilizer was used in comparison to other treatments (Table 1). *Phytoplankton* diversity was higher in tanks applied with DAP fertilizer, followed by tanks applied with chicken manure and least in tanks with no fertilizer. The diversity was indicated with the high values of Shannon-Wiener indices (H') and evenness (J'). *Zooplankton* was represented by major three groups, namely rotifers, copepods and cladocerans [37]. All *zooplankton* groups had significantly (P<0.05) higher abundance in tanks fertilized with DAP fertilizer as compared to chicken manure and control. Chicken manure had high values of Shannon-Wiener indices (H') and evenness (J') compared to other treatments. This indicated that *zooplankton* diversity was higher in tanks applied with chicken manure compared to other treatments (Table 2).

Effect of fertilizers type and stocking density on growth performance of (*C. gariepinus*) fry

Fry performance was higher in fertilized tanks compared to unfertilized tanks. At low stocking density (5fry/m^2) fry had better growth performance compared to high stocking density (10fry/m^2) across all fertilizer types (Figure 1). Individual final mean weights (g), weight gain (g) and specific growth rate (%) were significantly different (P<0.05) between stocking densities. While were not significantly different (P>0.05) between chicken manure and di-ammonium phosphate (DAP) fertilizers but significant higher than the control. Initial mean weight (g) and increase mean weight (g) were not significantly different (P>0.05) across stocking densities and fertilizers type (Table 3).

Effect of fertilizers type and stocking density on survival of (*C. gariepinus*) fry

Survival rate was significantly (P<0.05) higher under stocking density and the interaction but were not significantly different among fertilizer types. Higher survival rate observed in tanks fertilized with DAP fertilizer and control tanks under low stocking density (Table 3).

Effect of fertilizers type and stocking density on water quality parameters

There were no significant differences (P>0.05) in morning and afternoon temperature, dissolved oxygen (morning), and ammonia between stocking density and fertilizer type. Afternoon dissolved oxygen and nitrite were significantly (P<0.05) higher among stocking densities and fertilizer types. The range in pH values were similar to all stocking densities under chicken manure and DAP fertilizer while under control different ranges were observed (Table 4).

Discussion

The results indicated that abundance of plankton was higher in tanks fertilized with DAP fertilizer than in chicken manure and the control. Similar results have been reported by Gamal [38], Padmavathi [39] and Kumar et al. [22]. The significantly higher abundance and diversity of *phytoplankton* is likely due to easily available of nutrients to the water. Boyd and Massaut [40] reported that inorganic fertilizers have much higher concentrations of nutrients such as nitrogenous compounds than manures.

Rotifer, copepods and cladocerans showed a higher abundance as *phytoplankton* trend. This might be due to feeding effects of *zooplankton* on *phytoplankton* [41,42]. Similarly, Ghosh et al. [43]; Kumar et al. [22]

Treatments	Phytoplankton				Zooplankton		
	Chlorophyta	*Cynophyta*	*Euglenophyta*	*Diatomae*	Rotifers	Copepods	Cladocerans
Chicken manure	52750 ± 10528^a	18833 ± 3346^a	9917 ± 1109^a	10375 ± 2376^a	157 ± 23^a	257 ± 8^a	167 ± 14^a
DAP fertilizer	71833 ± 11383^a	25458 ± 4616^a	14917 ± 1500^b	19833 ± 3840^b	1207 ± 388^b	667 ± 133^b	640 ± 69^b
No fertilizer	12542 ± 2648^b	3333 ± 417^b	2500 ± 224^c	1542 ± 384^b	33 ± 4^a	40 ± 10^a	17 ± 7^a
P-Values	0.001	0.001	0.0001	0.001	0.004	0.0001	0.0001
Means with different superscript within columns indicate significant differences (Tukey's multiple range test at P<0.05).							

Table 1: Phytoplankton and zooplankton abundance (individuals/L) observed in tanks fertilized with different type of fertilizers (Mean ± SE).

Treatments	Phytoplankton/L			Zooplankton/L		
	H'	H'_{max}	*J*	*H'*	H'_{max}	*J*
Chicken manure	1.13	1.3863	0.8151	1.0728	1.0986	0.9765
DAP fertilizer	1.1797	1.3863	0.8509	1.0526	1.0986	0.9581
No fertilizer	1.0489	1.3863	0.7566	1.0431	1.0986	0.9494

Table 2: Shannon-Wiener indices of phytoplankton and zooplankton diversity (individuals/L) in tanks applied with chicken manure DAP fertilizer and no manure application.

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Parameters	Initial mean weight (g)	Individual final mean weight (g)	Weight gain (g)	Increase mean weight (g)	Specific growth rate (%)	Survival rate (%)
Stocking densities						
5fry/m^2	0.5 ± 0.01	24.1 ± 2.1^a	6.3 ± 0.4^a	90.7 ± 10.9	21.6 ± 1.7^a	97.8 ± 0.9^a
10fry/m^2	0.5 ± 0.01	18.3 ± 2.1^b	4.6 ± 0.4^b	80.6 ± 10.9	16.5 ± 1.7^b	87.2 ± 0.9^b
P-values	0.17	0.047	0.008	0.62	0.034	0.0001
Fertilizers						
Chicken manure	0.5 ± 0.01	25.6 ± 2.5^a	6.5 ± 0.5^a	90.8 ± 13.4	22.5 ± 2.1^a	92.1 ± 1.2
DAP Fertilizer	0.5 ± 0.01	20.5 ± 2.5^a	5.2 ± 0.5^a	84.3 ± 13.4	18.7 ± 2.1^a	93.9 ± 1.2
No fertilizer	0.5 ± 0.01	17.5 ± 2.5^b	4.5 ± 0.5^b	81.7 ± 13.4	15.8 ± 2.1^b	91.5 ± 1.2
P-values	1.0	0.047	0.034	0.886	0.042	0.32
Stocking density*Fertilizer						
5fry/m^2*chicken manure	0.5 ± 0.01	29.2 ± 3.6	7.6 ± 0.8	92.6 ± 19.0	25.6 ± 2.9	93.3 ± 1.7^a
5fry/m^2*DAP Fertilizer	0.5 ± 0.01	24.3 ± 3.6	5.9 ± 0.8	90.9 ± 19.0	20.6 ± 2.9	100.0 ± 1.7^b
5fry/m^2*no fertilizer	0.5 ± 0.01	18.8 ± 3.6	5.2 ± 0.8	88.5 ± 19.0	15.6 ± 2.9	100.0 ± 1.7^b
10fry/m^2*chicken manure	0.5 ± 0.01	21.9 ± 3.6	5.4 ± 0.8	89.0 ± 19.0	19.6 ± 2.9	90.8 ± 1.7^a
10fry/m^2*DAP Fertilizer	0.5 ± 0.01	16.7 ± 3.55	4.4 ± 0.8	77.7 ± 19.0	16.7 ± 2.9	87.9 ± 1.7^a
10fry/m^2*no fertilizer	0.5 ±0.01	16.3 ± 3.6	3.9 ± 0.8	74.9 ± 19.0	13.1 ± 2.9	82.9 ± 1.7^c
P-values	1.0	0.73	0.87	0.95	0.94	0.0001
Means with different letters in the same columns are significantly different (Tukey's multiple range test at P<0.05)						

Table 3: Growth parameters and survival observed in chicken manure, di-ammonium fertilizer and no fertilizer at different stocking densities (Mean ± SE).

Parameters	Temp (^{0}C) at am	Temp (^{0}C) at pm	DO (mgL^{-1}) at am	DO (mgL^{-1}) at pm	NO_2 (ppm)	NH_3 (ppm)	pH ranges
Stocking densities							
5fry/m^2	26.8 ± 0.1	28.6 ± 0.1	4.2 ± 0.1	6.2 ± 0.1	0.2 ± 0.07	0.5 ± 0.2	5.0-8.0
10fry/m^2	26.8 ± 0.1	28.5 ± 0.1	4.3 ± 0.1	6.3 ± 0.1	0.3 ± 0.07	0.5 ± 0.2	5.0-8.0
P-values	0.61	0.71	0.29	0.43	0.21	0.86	
Fertilizers							
Chicken manure	26.7 ± 0.1	28.6 ± 0.1	4.3 ± 0.8	6.1 ± 0.1^a	0.2 ± 0.09^{ab}	0.3 ± 0.2	6.0-8.0
DAP Fertilizer	26.8 ± 0.1	28.5 ± 0.1	4.3 ± 0.8	6.5 ± 0.1^b	0.4 ± 0.09^a	0.8 ± 0.2	5.0-7.0
No fertilizer	26.8 ± 0.1	28.6 ± 0.1	4.3 ± 0.8	6.0 ± 0.1^a	0.04 ± 0.09^b	0.3 ± 0.2	7.0-8.0
P-values	0.78	0.85	0.96	0.016	0.031	0.113	
Stocking density*Fertilizer							
5fry/m^2*chicken manure	26.7 ± 0.2	28.7 ± 0.2	4.2 ± 0.1	6.1 ± 0.2^a	0.1 ± 0.1^a	0.4 ± 0.3	6.0-8.0
10fry/m^2*chicken manure	26.8 ± 0.2	28.5 ± 0.2	4.3 ± 0.1	6.1 ± 0.2^a	0.3 ± 0.1^a	0.3 ± 0.3	6.0-8.0
5fry/m^2*DAP fertilizer	26.8 ± 0.2	28.5 ± 0.2	4.2 ± 0.1	6.3 ± 0.2^b	0.3 ± 0.1^b	0.9 ± 0.3	5.0-7.0
10fry/m^2*DAP fertilizer	26.8 ± 0.2	28.5 ± 0.2	4.3 ± 0.1	6.7 ± 0.2^b	0.5 ± 0.1^b	0.9 ± 0.3	5.0-7.0
5fry/m^2*no fertilizer	26.8 ± 0.2	28.7 ± 0.2	4.2 ± 0.1	6.0 ± 0.2^a	0.02 ± 0.1^c	0.3 ± 0.3	6.0-8.0
10fry/m^2*no fertilizer	26.9 ± 0.2	28.6 ± 0.2	4.3 ± 0.1	6.0 ± 0.2^a	0.07 ± 0.1^c	0.3 ± 0.3	7.0-8.0
P-values	0.95	0.88	0.92	0.03	0.018	0.99	
Means with different letters in the same columns are significantly different (Tukey's multiple range test at P<0.05)							

Table 4: Water quality parameters observed in fertilizer type and different stocking densities (Mean ± SE).

reported rotifers to be the common and dominant *zooplankton* group in fertilized ponds. In addition, Mischke and Zimba [44] reported that copepod nauplii and cladocerans were significantly higher in ponds fertilized with inorganic fertilizer (Urea + Super phosphate) than in control ponds and organically fertilized ponds. Higher *zooplankton* diversities were recorded in chicken manure compared to other treatments. This might be due to *phytoplankton* particle size and cell abundance which influences *zooplankton* communities [45]. The larger size of *phytoplankton* cells were not consumed by smaller *zooplankton* hence high abundance of *phytoplankton* communities in DAP fertilized tanks than *zooplankton*. Similarly, Soderberg [46] reported that organic fertilizers require bacteria and other microbes for decomposition, and thus offer a wider diversity of fish ponds, particularly *zooplankton*. Also, chicken manure have been reported to provide a substrate for *zooplankton* production [47,48] which enhance high diversity.

Among water quality parameters, temperature and dissolved oxygen were within the optimal range. In the present study, pH ranges were similar to those reported by Kumar et al. [22]. Concentration of NO_2 and NH_3 were high in the chicken manure and DAP fertilizer treatments as those reported by Boyd [49]. The reason might be due to temperature and pH dependence of ammonia and ammonium ion from the fertilizer. Ammonium fertilizer such as DAP increases total ammonia nitrogen concentrations in water while manures have low nitrogen content and tend to decompose slowly and incompletely [49].

African catfish fry had higher performance in fertilized tanks than unfertilized. The same results have been reported by Muendo et al. [50]. Individual mean weight and weight gain showed to be high at low stocking density (5fry/m^2) compared to high stocking density (10fry/m^2) across all fertilizers type (Table 3). This indicated that the performance of catfish fry was influenced by stocking density and fertilizers type. Similarly, Jamabo and Keremah [51] reported significantly higher growth rate at a stocking density of 5fry compared

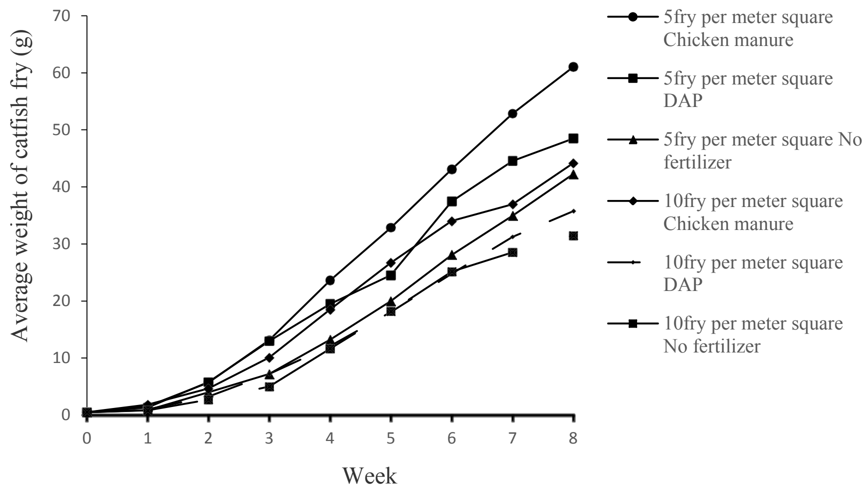

Figure 1: Average weight of catfish fry reared in tanks fertilized with different types of fertilizer at different stocking densities for 8 weeks.

to 10fry and 15fry per 55m³ tank. Specific growth rate of African catfish (*Clarias gariepinus)* fry were observed to be improved in tanks fertilized with chicken manure and DAP fertilizers compared to unfertilized tanks under both stocking densities. Hossain et al. [52], Jamabo and Keremah [51] reported that growth of catfish fry was strongly influenced by stocking density. This might be due to high natural food organisms and good water quality found in fertilized tanks at low stocking densities compared to high stocking densities [53]. Therefore, these results indicated that the addition of fertilizers to the fish ponds/tanks increase the level of nitrogenous compounds and minerals which considered as a good source for *phytoplankton* growth. Lin et al. [54], Dang and Dalsgaard [55]; Saad et al. [56] reported that addition of manures and fertilizers to the fish ponds improve the level of *phytoplankton* that is responsible for growth fish. This was supported by Silva et al. [57] who reported that *phytoplankton* and *zooplankton* are rich source of protein often containing 40-60% protein on a dry matter basis and is sufficient to support excellent fish growth. Saad et al. [56] found that, nitrogenous and phosphorus compounds fertilizers improve the growth *phytoplankton* and *zooplankton* that in turn improve growth performance of the fish.

Survival rate can be influenced by stocking density and fertilizers type. Similarly, Haylor [58] found that survival rates in African catfish fry were directly related to stocking density. The study recorded high survival rate in DAP fertilized tanks and unfertilized tanks compared to chicken manure under low stocking density. While the lowest survival rate recorded in tanks with no fertilizer at high stocking density. This might be due to low dissolved oxygen recorded. Similar results with different fish species were reported by Sophin and Preston [59] that poorer survival rates of tilapia were observed in the ponds fertilized with fresh manure as compared to the inorganic fertilizers (urea and DAP) and unfertilized ponds. In addition, aggressive behavior of catfish in taking in food and cannibalism in control tanks might influence low survival rate. Similar results have been reported by Gamal [38] who found that high stocking density (5fishingerlings/m²) using chemical fertilizer (urea + monophosphate) and chicken manure had the highest survival rate (96.48%) of catfish and indicated that predation behavior of catfish increased in the higher stocking densities. In addition, Baskerville-Bridges and Kling [60] reported greater risk of mortality at high stocking densities as a result of deteriorating water quality.

Water quality parameters in this study were within recommended range for growth and survival of catfish fry. There were no significant differences (P>0.05) in temperature, dissolved oxygen during the morning and ammonia within stocking densities and fertilizer types. Temperature in all fertilizer types and stocking density was within optimal growth and survival range of catfish fry which is 26°C to 29°C [61,62]. Dissolved oxygen during the afternoon was higher in DAP fertilized tanks compared to chicken and control which was above recommended value of 6mg/l [63]. This might be due to high abundance of planktons [38]. The concentration of NO_2 was high at 10fry/m² under DAP fertilizer compared to other treatments. This might be due to ammonia utilization by *phytoplankton* [64] or oxidation of ammonia nitrite especially in high dissolved oxygen level conditions [65]. In addition pH ranges were optimal as recorded by Tucker 1991. However, were similarly higher under both stocking densities in chicken manure and DAP fertilized tanks compared to control. Boyd [66] reported that the application of ammonium and urea-based fertilizers can cause acidification of pond water because of nitrification, which produces two hydrogen ions from each ammonium ion. Similarly, Saad et al. [56] reported high pH values in treatments that received inorganic and organic fertilizers compared to group given feed only. Therefore, the results indicated that addition of fertilizers to the fish tank increased some of the physicochemical properties of the water.

Conclusion

In conclusion, the study indicated that, DAP fertilizer had highest plankton abundance and diversity compared to chicken manure and no fertilizer application. Hence it is thus recommended to use DAP fertilizer for production of live food in fish tanks. Higher growth performance was recorded at low stocking density (5fry/m²) across all fertilizer types. Survival rate of catfish fry did not depend on fertilizer type but it was depended on stocking density. Water quality parameters were no significant differences in chicken manure and di-ammonium phosphate at different stocking densities. Hence it is recommended to raise catfish fry in DAP or chicken manure fertilized tanks at low stocking density (5fry/m²) for better growth and survival in aquaculture practices.

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