Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(3): 594-601

Received: 22-03-2018
Accepted: 23-04-2018

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Comparative efficacy of different doses of pig dung on the growth performance and survival of Indian major carps fingerlings in rain-fed pond ecosystem

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Abstract
The present study was conducted in 13 earthen ponds measuring 0.1 ha for 3 months to study the efficacy of different doses of pig dung *i.e.* 4,000 kg ha^{-1}, 6,000 kg ha^{-1}, 8,000 kg ha^{-1} and 10,000 kg ha^{-1} on growth performance and survival of Indian major carps. Supplementary feed was used twice daily @ 3% body weight per day for entire experiment. Water quality parameters in all the experimental ponds (T_1, T_2, T_3 and T_4) were within normal range except for turbidity which showed higher values. Abundance of plankton groups among the treatments did not differ significantly. Highest abundance of phytoplankton ($48.32 \pm 6.32 \times 10^6$ Nos./l) and zooplankton (688.81 ± 75.47 Nos./l) was observed in T_4. Survival rate of Catla (75 ± 1.12), Rohu (71.66 ± 1.54) and Mrigal (65.83 ± 1.23) was found to be highest in T_1. Highest production (5354.0 ± 167.37 kg $ha^{-1}yr^{-1}$) was observed in T_3.

Keywords: Indian major carps (IMC), phytoplankton, zooplankton, turbidity, pig dung

1. Introduction

Pond culture systems in Indian sub-continent is traditionally dominated by carps usually in polyculture and/or integrated with animal husbandry [1]. Indian major carps enjoy a prime position in the Indian freshwater aquaculture sector and recognized for their taste and fast growing nature [2]. These highly prized fishes are original inhabitants of the Ganga-Brahmaputra river system of North India and the rivers of neighbouring Pakistan, Bangladesh, Nepal and Burma [2]. These species are also transplanted into rivers of central as well as peninsular India and imported by many African nations (Madagascar, Mauritius, Zimbabwe), Asian countries (Israel, Japan, Malaysia, Sri Lanka, Philippines, Thailand) and former USSR for aquaculture purposes [2]. The three Indian major carps (IMCs), namely Catla (*Catla catla*), Rohu (*Labeo rohita*) and Mrigal (*Cirrhinus mrigala*) contribute 70-75% of the total fresh water fish production of India [3]. Research and development efforts over the last six decades resulted in improving the national mean production levels in still-water ponds from about 600 kg ha^{-1} $year^{-1}$ in 1974 to over 2900 kg ha^{-1} $year^{-1}$ at present, with several instances of even higher production levels to the tune of 8000-12000 kg ha^{-1} $year^{-1}$ and placed carp farming as an important economic enterprise and fast growing industry in India [4]. The revolution in terms of raising the average production from ponds by five times can be attributed to the successful demonstration, dissemination and adoption of semi-intensive carp culture technology.

Extensive fish farming system is the most common practice followed by fish farmers in India [5]. In both these systems manuring the pond with organic fertilizers is an essential step to augment natural food production. Cow-dung @ 5000-20000 kg ha^{-1} $year^{-1}$ depending on the organic carbon content of soil and presence or absence of supplementary feeding [6] is one of the most widely used organic fertilizer. Application of animal dung/wastes in fish ponds for natural fish production is important to sustainable aquaculture and to reduce expenditure on costly feeds and fertilizers which form more than 50% of the total input cost. However, if used indiscriminately it may have adverse effects [7]. Therefore, it is essential to know the standard doses of these organic fertilizers which would result in optimum conditions for the survival and growth of fish.

A lot of research has gone into application and utilization of poultry droppings, cow dung and biogas slurry in fish ponds [8, 9], only few reports on the use of pig dung [10, 11, 12] in fish ponds is available. Different strategies have been employed over the year to improve fish production either by employing certain innovative techniques on the part of farmers as reported by Borah *et al*. [13] or through scientific interventions in the form of feed manipulation [14]. Therefore, the present study was undertaken to evaluate the response of different levels of pig dung on water quality, plankton productivity, growth performance and survival of Indian major carp fingerlings viz. *Catla catla* (Hamilton, 1822), *Labeo rohita* (Hamilton, 1822) and *Cirrhinus mrigala* (Hamilton,1822) to table size fishes in pond ecosystem.

2. Materials and Methods

2.1 Study site and experimental design

The field experiment was laid out at the fish farm of the College of Fisheries, Assam Agricultural University, Raha in Nagaon, Assam, India (26°13′14" N and 92°30′40" E). The experiment was conducted for a period of three (3) months in thirteen earthen ponds with each pond having a surface area of 0.1 ha and with average depth of 1.5 m. The experimental ponds were similar in terms of their rectangular size, depth, basin conformation, contour and bottom type. Four doses of fresh pig-dung *i.e*. 4000 kg ha^{-1}, 6000 kg ha^{-1}, 8000 kg ha^{-1} and 10000 kg ha^{-1} were used during the experimental period.

2.2 Pond preparation, stocking and management

The ponds were dewatered, cleared of aquatic vegetation and exposed to sunlight. All the ponds had a well designated system of inlet and outlet for easy drainage. The standard method of pre-stocking pond preparation was followed. Liming was done seven days prior to application of pig dung. The rate of liming was adjusted based on the pH of water. After 7 days of liming, the ponds were manured with required quantity of pig dung. One third of the total requirement of the dung was mixed with water and spread evenly on the surface of pond water as a first installment and the rest were applied in heaps in equal installment at 15 days intervals. The stocking density of fishes was maintained at 8000 fingerlings ha^{-1} and species combination was maintained at 4: 3: 3 for Catla, Rohu and Mrigal, respectively. The ponds were stocked with advance fingerlings of IMCs having an initial weight of 55±1.34 g, 40±1.02 g and 40±0.97 g for Catla, Rohu and Mrigal, respectively.

2.3 Water quality parameters

The water quality parameters viz. temperature, turbidity, pH, free CO_2, total alkalinity, biological oxygen demand (BOD), ammonia, nitrate and phosphate were monitored at fortnightly intervals between 08.00 - 10.00 hours in the morning. Dissolved oxygen was measured twice between 08.00-10.00 hours in the morning and between 14.00-16.00 hours in the evening to determine the diurnal fluctuations that may occur due to application of pig dung. Temperature (°C) was measured directly with a mercury bulb thermometer, pH by a digital pH meter (WTW pH 340i; Merck, Germany) and turbidity (NTU) by the Nephelo-Turbidity meter (Systronics model 131; Systronics India Ltd., Ahmedabad). Dissolved oxygen (mg l^{-1}), total alkalinity (mg l^{-1}), free CO_2 (mg l^{-1}), BOD (mg l^{-1}), ammonia (mg l^{-1}), nitrate (mg l^{-1}) and phosphate (mg l^{-1}) were measured following standard methods [15].

2.4 Plankton monitoring

Quantitative and qualitative analysis of plankton were done at fortnightly intervals by following methods of Pillay [16] as well as Needham and Needham [17]. Fifty litres of water, collected from different locations and depths (surface, column and bottom) between 07:00 and 08:00 hours from each pond were filtered through bolting silk net (No. 25, mesh size 64 µm) to obtain a 50 ml sample. The samples were then preserved immediately in 4% formalin and stored in plastic bottles. Further analysis was done using Sedgwick–Rafter counting cell under a trinocularstereo-zoom microscope fitted with DIGI 510 CCD camera (Dewinter, India).

2.5 Estimation of growth, survival and production of fish

Twenty individuals from each pond were sampled on fortnightly intervals to determine the increase in weight and specific growth rate (SGR) of fishes. Specific growth rate (SGR) was estimated by the formula given by Dhawan and Kaur [7].

$$SGR = \frac{\ln\text{(Final wet body weight)} - \ln\text{(Initial wet body weight)}}{\text{Time duration (days)}} \times 100$$

At the end of three months, all fishes from each pond was harvested by repeated netting and weighed to calculate the total fish production (kg ha^{-1} yr^{-1}). Live fishes were counted to determine the survival rate (%).

$$\text{Survival rate} = \frac{\text{Number of live fish harvested}}{\text{Number of fish stocked}} \times 100$$

2.6 Statistical analysis

Statistical analysis was done with one-way ANOVA using SPSS version 16.0 (Chicago, IL, USA) program to find out whether any significant difference existed among treatment means [18] at 5% level of significance. Statistical methods were calculated and expressed as mean ± SD.

3. Results

3.1 Water quality parameters

Water quality parameters (mean values) over the 3-month culture period of Indian major carp fingerlings are presented in Table 1. Mean water temperature did not differ significantly across treatments and it was found to be 30.86±0.32, 30.86±0.32, 30.87±0.32 and 30.86±0.32, respectively for T_1, T_2, T_3 and T_4. Mean turbidity, pH, DO (morning), DO (evening), BOD and nitrate-nitrogen showed significant difference across treatments. Mean CO_2 levels showed no significant differences between T_1 and T_2 and between T_3 and T_4, while showed significant differences among control; T_1 and T_2; T_3 and T_4. Mean alkalinity values showed no significant differences across the four treatments but were significantly different between control and treatments. Mean ammonium-nitrogen and phosphate-phosphorus values showed no significant differences between T_1 and T_2, while the rest of the treatments (T_1 and T_2; T_3; T_4) and control are significantly different from each other. Water quality parameters in all the experimental ponds (T_1, T_2, T_3 and T_4) were within the normal range for fish culture except for turbidity which showed higher values; DO (morning) which is below the desirable limit; BOD (in T_3 and T_4) which showed higher values than the desirable limit.

3.2 Plankton abundance

In respect to total phytoplankton production the highest mean levels was seen in T_4 followed by T_3, T_2, T_1 and Control respectively (Table-2). Cynophyceae, with maximum mean levels 41.99 ± 5.43 ml/50L recorded in T_4 followed by T_3, T_2, T_1 and Control respectively, Chlorophyceae, with highest mean levels 6.86 ± 2.59 ml/50L recorded in T_3 followed by T_1, T_2, T_4 and Control and Bacillariophyceae, with highest mean levels 0.22 ± 0.05 ml/50L recorded in T_1 followed by T_3, T_2, T_4 and Control (Table 2).

Total zooplankton production 688.81 ± 75.47 per liter, with maximum mean level was observed in T_4 followed by T_3, T_2, T_1 and Control, respectively (Table 2). Copepoda with maximum mean levels 434.59 ± 88.99 per liter was observed in T_4 followed by T_3, T_2, T_1 and Control, respectively; Cladocera with maximum mean levels 263.26 ± 55.82 /l was observed, in T_3 followed by T_4, T_2, T_1 and Control, respectively (Table 2).

3.3 Growth performance of IMC fingerlings

The results of fortnightly weight increment of Catla, Rohu and Mrigal in indirect integrated fish-pig farming system using dung @ 4000 kg ha^{-1}, 6000 kg ha^{-1}, 8000 kg ha^{-1} and 10000 kg ha^{-1} are showed in figure 1, 2 and 3 respectively. The details about weight gain, survivability, specific growth rate and production are presented in Table 3. In all the treatments the survivability percentage of Catla was found to be the best, the highest survivability was observed in T_1 (75 ± 1.12) followed by T_2 (72.81 ± 1.31) T_3 (71 ± 1.62) and T_4 (61.87 ± 1.54). The fish also showed better survivability in control (74.06 ± 0.95). Catla being the surface feeder, the highest survivability may be due to appropriate production of plankton in the treated ponds due to addition of pig manure. Survivability of Mrigal was found to be better than Rohu, being 71.66 ± 1.54, 70.40 ± 1.45, 68.75 ± 1.32, 58.33 1.21 and 44.14 ± 1.32 in T_1, T_2, T_3, T_4, and the control, respectively. Out of all the three, Rohu survivability was found to be least, being 65.83 ± 1.23, 65.41 ± 1.54, 63.75 ± 1.32, 55.00 ± 1.32 and 65.00 ± 1.22 in T_1, T_2, T_3, T_4, and the control, respectively. The highest fish production during the 3 months of experimental period was achieved in T_3 (5354.0±167.37 kg $ha^{-1}yr^{-1}$) followed by T_2 (5002.4±37.29 kg $ha^{-1}yr^{-1}$), T_1 (4951.2±125.1 kg $ha^{-1}yr^{-1}$), T_4 (4014.8±148.38 kg $ha^{-1}yr^{-1}$) and in the control (2172.4±108.61 kg $ha^{-1}yr^{-1}$). Though the survival percentage was higher in T_1, control and T_2 respectively, the growth of fishes were not found satisfactory. In T_3, all the species of fishes showed better weight gain, Catla showed the best weight gain in all the treated ponds, followed by Rohu and Mrigal. It was observed in the present study that though the survival percent was found to be best in $T_{1,}$ total yield was found to be low. The highest production was observed in T_3, with pig dung dose at the rate of 8000 kg ha^{-1}. In T_2 and T_3, growth and survival of all carps were found to be good, which may be attributed to the increase in the amount of pig dung. Increased dung load resulted in improved nutritional status of soil and water and plankton production. However further increased in organic load was not observed to augment growth of fishes in $T_{4,}$ due to the imbalance of production and consumption of primary producers, coupled with deterioration of water quality parameters, mainly morning DO level (2.08±0.03 mg l^{-1}) and accelerate the production of ammonia (0.80±0.062 mg l^{-1}).

4. Discussion

The success of fish culture operation depends on the favourable aquatic environment for production of desirable fish food organisms. Water and soil of an aquatic system play an important role in the growth of fish and water being the prime requisite to support aquatic life, its physico-chemical properties is responsible for maintaining aquatic environment and makes it favourable for aquatic organisms. The range of water temperature in the experimental pond was within the tolerance limit for Indian major carps throughout the experimental period, which corroborate with the study of Bhatnagar [19] and Santhosh and Singh [20]. Generally, water becomes turbid due to presence of organic matter as well as silt, clay and other inorganic materials [21]. Turbidity may also be caused by planktonic population in pond water. In the present study, less turbidity was observed in the control pond, while in the treated ponds, turbidity was high (Table 1). The high turbidity in all the treated ponds was not due to the high growth of plankton, but due to the suspended organic matters, as the initial dose of pig dung in all treated ponds was mixed with water and spread over the water surface. As the bulk of organic waste increased turbidity likewise it was also found to increase in the treated ponds. During the experiment, the mean pH of all the experimental ponds was found to be 7.22±.05, 7.38±0.06, 7.07±0.05, 6.84±0.05 and 6.48±0.03 in T_1, T_2, T_3, T_4 and control, respectively. As the pond received high organic load, the dosage of lime was fixed at 125 kg ha^{-1} for the experimental period so as to maintain the pH in alkaline side for acceleration of the mineralization process. This is supported by the findings of Ellis [22]. Santhosh and Singh [20] pointed out that aquatic organisms prefer pH between 6.7 and 8.4. Das [23] and Banerjee [24] also suggested that slightly alkaline water is highly suitable for fish production. In integrated fish-pig farming due to addition of large quantity of pig excreta, the DO shows wide diurnal fluctuation, which was evident in the present study. DO was found to be in declining trend in treated ponds during morning hours with the increasing manure load. The lowest mean morning DO (2.08±0.03 mg l^{-1}) was found in T4 and may be due to very high load of pig waste which augmenting the production of phytoplankton. The findings were similar with that of Cruz and Shehadeh [25] where they recorded early morning DO between 1.2 mg l^{-1}-3.0 mg l^{-1} in conditions where a stocking density of pig at the rate 40-60 nos. ha^{-1} was maintained, without any mortality of fish. Bwala and Omoregie [26] also found the range of DO between 1.5-15.30 mg l^{-1} in an integrated farming system. Low value of Free Carbon Dioxide (FCO_2) in treated ponds may be attributed to high value of pH and very active photosynthesis activities. The higher values of FCO_2 in control ponds may be attributed due to low photosynthetic activities. Pahwa and Mahrotra [27], Gautam [28] and Ray and David [29] reported similar observation. Results of the present study showed that total alkalinity value in control was low, where productivity was also found in decreasing trend. Higher alkalinity values in treated ponds were due to high dose of organic waste in the form of pig dung, corroborating the observations of various researchers over the years [30, 31, 32, 33]. The mean BOD_5 value in the present study was found to be high in the treated ponds i.e. 3.43±0.06, 3.70±0.12, 5.50±0.14, 5.99±0.18 mg l^{-1} in T_1, T_2, T_3 and T_4 respectively. This is to be attributed to the increase of pig dung load leading to accelerated heterotrophic activity of aerobic bacterial biomass. Detailed information of variation of BOD_5 in such integrated farming system is scanty in literature. Fang [34] observed BOD value of 4.23±0.93 mg l^{-1} while applying pig manure at the rate of 3-4% of wet weight of fish. Almost similar result was observed in the treated ponds in the present study. In the present study the major cause of entry of ammonia (NH_3) in treated pond was through decomposition of organic matter (pig dung) and fish metabolism while in the control pond it was only through fish metabolism. No phytoplankton die off was observed during the period of study. Production of ammonia nitrogen was within the tolerance limit of reared fish in the treated ponds. This result correlates the findings of Bwala and Omoregie [26] who stated that major cause of ammonia production in the treated pond was due to the decomposition of organic matter and fish metabolism. However, highest mean value 0.80±0.062 mg l^{-1} was observed in T_4 which may be one of the factors for low survivability of fish in that treatment. Sharma and Olah [35] found ammonia-nitrogen to the range between 0.1 mg l^{-1} to 2.1 mg l^{-1} in Hungary and between 0.3 mg l^{-1} to 3.6 mg l^{-1} in India in pig-fish integrated system. Major nutrients *viz.* Phosphate-phosphorous and nitrate-nitrogen were found to be in increasing trend from T_1 to T_4 as manure loads were increased accordingly, while in the control, values were found to be almost constant in the entire period. Sharma and Olah [35] observed phosphate-phosphorus that fluctuated between 0.8 mg l^{-1} to 0.93 mg l^{-1} in pig dung treated water. Sharma and Saini [36] found nitrate-nitrogen in the range of 0.3-0.4 mg l^{-1} in such water which conforms to the values that were observed in the present study.

The biological productivity of any aquatic body is generally judged through the qualitative and quantitative estimation of plankton, which form the natural food of fish [37]. Animal wastes lead to increase biological productivity of ponds through various pathways, which result in an increase in fish production. In the present study, the biological parameters of water total phytoplankton and its subgroups Cyanophyceae, Chlorophyceae and Bacillariophyceae and total zooplankton were significantly higher in ponds receiving pig dung than in control pond. This may be due to a high level of water-soluble phosphates in the pig dung [7] which fosters plankton growth. However, maximum production of phytoplankton and zooplankton was recorded in the pond manured with 10000 kg ha^{-1} of pig dung. Application of pig dung at above mentioned rates have resulted in similar production of plankton [10]. In the present study, among phytoplankton, Cyanophyceae was the dominant group followed by Chlorophyceae, whereas, Bacillariophyceae was poorly represented; among zooplankton, Copepoda was the dominant group followed by and Cladocera in all the treatments including control.

In the integrated pig fish farming system (indirect) developed in the present study, the productivity level achieved in T_3 was found comparable to most of the results obtained so far in India and abroad [11, 25]. Sharma *et al*. [10] conducted pig-fish farming experiment in 0.1 ha pond with pig and fish density at the rate of 40 and 8500 ha^{-1} pig and fish, respectively with a productivity of 6791.70 kg^{-1} ha^{-1} yr^{-1}. In the present experiment with similar density of fish, the highest productivity to the tune of 5354.0±167.37 kg $ha^{-1}yr^{-1}$ was observed in T_3 with the pig dung load at 8000 kg ha^{-1}.

When contribution to total production was calculated, the contribution of surface feeder *i.e*. Catla was found to be the highest to the total production in all treated pond. Similar results were also achieved by many workers [11, 38, 39]. Such performance of the surface feeder is attributable to the abundance of fish food organisms at the surface layer of water in pig-fish farming system. Moreover in the present study 40% of the total stocking density comprise of Catla. In this study weight gain (%) and SGR (%) of Rohu was found to be highest and similar findings have been reported by Dhawan and Kaur [7]. Survival rate of fishes in pig dung treated ponds ranged from 55-75% which is much lower compared to the findings of Bhattacharjya *et al*. where they reported 70-85% survival [11]. Ponds with higher dose of pig dung (T_4) showed the lowest survival rate, which may be attributed to the poor water quality parameters owing to high organic load.

The growth of the cultured fishes was better in T_3 and almost uniform in spite of heavy stocking density and very high load of organic waste. The resultant better yield of fish yield can be attributed to the pig excreta that served as direct feed and pond fertilizer for enhancing natural food production and thereby improving the fish yield. Besides these also acted as substratum for multiplication of microbial community that provided essential nutrition for fish feeding on it [8, 11, 40]. The uniform satisfactory growth indicates minimum inter-specific competition for food. The main reason for the best production in T_3 and comparatively lower production in T_1 and T_2 may be attributed to the higher abundance of fish food organisms more particularly phytoplankton and zooplankton along with benthic insects, worms, larvae and great number of microorganisms in T_3 as compared to the other two treatments. Moreover physico-chemical parameters of water and nutrient level were also found to be in favourable range. Qualitative as well as quantitative estimation of plankton which forms natural food base for fishes helps in determining the biological productivity of an aquatic ecosystem [41]. There are reports of higher phytoplankton production in ponds treated with pig dung [42]. Besides consuming the natural food organisms, the fish in the treated pond were also observed to feed directly on pig excreta, exhibiting their coprophagus nature corroborating the findings of Le Mare [43], where he observed direct feeding of pig-dung by carps. The probable reason for low fish production in T_4 may be attributed to very high organic load in water which deteriorated the water quality, resulting in low morning DO and high ammonia production. Fishes were constantly under stress condition which is reflected in overall low survivability, low individual growth rate and final production profile in all the replications of T_4. Oxygen concentration in water decreases or shows high fluctuations owing to factors like plankton blooms, which is the result of high organic matter content in water. Oxygen depletion in water results in stress which leads to poor feeding, starvation and reduced growth rates in fishes and may result in fish mortality, either directly or indirectly [44]. Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter. Ammonia concentration above 0.1 mg/L causes stress to fish and results in poor feeding, reduced growth rates, reduced disease resistance which results in reduced survival rates [45].

5. Conclusion

The results of the study clearly indicate that in the indirect integration system of pig-fish farming, where fresh pig dung contains 0.61% nitrogen, 0.50% phosphate-phosphorus (PO_4-P), the dung load of 8000 kg ha^{-1} for the three months of experimental period is optimum for satisfactory growth of Indian major carps, which yield on average production of 5354.0±167.37 kg $ha^{-1}yr^{-1}$. The study also indicates that under eco-climatic conditions of Raha locality of Assam in India more than 8000 kg ha^{-1} organic load in the form of fresh pig dung for three months culture period, deteriorate water quality, which will have negative effects on final production profile.

Table 1: Mean values (±SE) of water quality parameters of 15 day samples over the 3 month culture period

Treatment	Temperature (^{0}C)	Turbidity (NTU)	pH	Morning DO (mg l^{-1})	Evening DO (mg l^{-1})	CO_2 (mg l^{-1})	Alkalinity (mg l^{-1})	BOD (mgl^{-1})	Ammonia-nitrogen (mg l^{-1})	Nitrate-nitrogen (mg l^{-1})	Phosphate-Phosphorus (mg l^{-1})
Control	30.87±0.31^{a}	19.87±0.32^{a}	6.48±0.03^{a}	2.94±0.02^{e}	4.76±0.04^{a}	3.12±0.03^{c}	65.50±1.42^{a}	2.17±0.10^{a}	0.02±.003^{a}	0.02±0.002^{a}	0.02±0.002^{a}
T_1	30.86±0.32^{a}	47.58±0.91^{b}	7.22±.05^{d}	2.74±0.06^{d}	5.54±0.08^{b}	2.10±0.10^{b}	124.02±2.98^{b}	3.43±0.06^{b}	0.65±0.062^{b}	0.17±0.016^{b}	0.20±0.008^{b}
T_2	30.86±0.32^{a}	63.08±.99^{c}	7.38±0.06^{e}	2.44±0.06^{c}	5.96±0.10^{c}	2.22±0.14^{b}	125.97±3.32^{b}	3.70±0.12^{c}	0.69±0.066^{b}	0.20±0.015c	0.21±0.007^{b}
T_3	30.87±0.32^{a}	71.59±1.27^{d}	7.07±0.05^{c}	2.22±0.07^{b}	7.16±0.15^{d}	1.76±0.02^{a}	127.07±3.57^{b}	5.50±0.14^{d}	0.78±0.67^{c}	0.31±0.018^{d}	0.26±0.012^{c}
T_4	30.86±0.32^{a}	76.67±1.17^{e}	6.84±0.05^{b}	2.08±0.03^{a}	7.36±0.13^{e}	1.57±0.04^{a}	129.81±3.48^{b}	5.99±0.18^{e}	0.80±0.062^{d}	0.35±0.021^{e}	0.29±0.017^{d}
SEm(±)	0.99	0.89	0.04	0.04	0.09	0.07	2.75	0.11	0.05	0.02	0.01
CD%	NS	2.51	0.11	0.11	0.25	0.19	7.78	0.31	0.14	0.05	0.03

Values are mean (±SE); values in different superscript were significantly different (p<0.05)

Table 2: Mean values (±SD) of plankton abundance of pond water of fortnightly samples over the 3-month culture experiment

Plankton group	T_1	T_2	T_3	T_4	C
Phytoplankton (Nos. x 10^6/l)					
Cyanophyceae	21.72 ± 4.43^{b}	28.52 ± 5.36^{b}	37.40 ± 6.29^{ab}	41.99 ± 5.43^{a}	13.47 ± 4.31^{c}
Chlorophyceae	6.62 ± 2.63^{a}	6.42 ± 1.96^{a}	6.86 ± 2.59^{a}	6.18 ± 1.48^{a}	4.74 ± 1.24^{a}
Bacillariophyceae	0.22 ± 0.05^{a}	0.18 ± 0.04^{ab}	0.20 ± 0.07^{a}	0.14 ± 0.03^{b}	0.12 ± 0.03^{b}
Total	28.54 ± 7.13^{b}	35.13 ± 7.34^{ab}	44.45 ± 7.94^{a}	48.32 ± 6.32^{a}	18.34 ± 4.56^{c}
Zooplankton (Nos./l)					
Copepoda	224.35± 32.48^{b}	304.37±45.26^{ab}	373.83± 65.92^{a}	434.59± 88.99^{a}	135.25± 27.32^{c}
Cladocera	122.05± 14.60^{b}	145.26± 46.57^{b}	263.26± 55.82^{a}	254.23± 47.62^{a}	97.84± 12.74^{b}
Total	346.40± 37.07^{b}	449.61± 46.35^{ab}	637.10± 62.34^{a}	688.81± 75.47^{a}	233.08±22.64^{bb}

Table 3: Growth performance, SGR%, survival and production of Indian major carps in different treatments after 3 month culture period

Treatment	Fish species																		Total Production (kg $ha^{-1}yr^{-1}$)
	Catla						Rohu						Mrigal						
	Initial weight (g)	Final weight (g)	Weight gain (g)	SGR%	Survival%	Production (kg ha^{-1})	Initial weight (g)	Final weight (g)	Weight gain (g)	SGR%	Survival%	Production (kg ha^{-1})	Initial weight (g)	Final weight (g)	Weight gain (g)	SGR%	Survival%	Production (kg ha^{-1})	
Control	55±0.71	127.92±7.08^{a}	72.92±6.59^{a}	0.84± 0.06^{a}	74.06(59.38)± 0.95^{b}	30.33±2.29^{a}	40.0±0.71	93.75±4.09^{a}	53.75±3.80^{a}	0.77 ± 0.01^{a}	65(53.73) ± 1.22^{b}	14.66±3.47^{a}	40.0±0.75	87.58±8.54^{a}	47.58±5.15^{a}	0.68 ± 0.03^{a}	44.14(41.63) ± 1.32^{a}	9.32±2.68^{a}	2172.4±108.61^{a}
T_1	55±0.41	244.2±2.12^{bc}	189.2±2.08^{bc}	1.62± 0.01^{b}	75(60.00) ± 1.12^{b}	58.56±1.91^{c}	40.0±0.71	218.4±1.20^{bc}	178.4±0.49^{b}	1.84 ± 0.01^{b}	65.83(54.22)± 1.23^{b}	34.44±1.69^{c}	40.0±1.15	179.5±0.91^{b}	139.5±0.40^{b}	1.63 ± 0.02b	71.66(57.83) ± 1.54^{c}	30.78±1.21^{c}	4951.2±125.1^{c}
T_2	55±1.08	253.1±0.78^{c}	198.1±1.84^{c}	1.65±0.03^{b}	72.81(57.83) ± 1.31^{b}	59.49±1.42^{cd}	40.0±1.29	220.5±0.4^{c}	180.5±1.68^{b}	1.86 ± 0.04^{b}	65.41(53.97) ± 1.54^{b}	34.61±1.53^{c}	40.0±1.77	183.2±2.29^{c}	143.2±2.75^{b}	1.66 ± 0.06^{b}	70.40(57.03) ± 1.45^{c}	30.96±1.34^{c}	5002.4±37.29^{c}
T_3	55±0.71	280.2±0.65^{d}	225.2±1.36^{d}	1.77± 0.02^{c}	71(57.42) ± 1.62^{b}	62.76±1.25^{d}	40.0±0.91	245.8±0.58^{b}	205.8±1.48^{c}	1.97 ± 0.03^{c}	63.75(52.98) ± 1.32^{b}	37.6±1.01^{dc}	40.0±1.08	203±1.51^{d}	163±1.43^{c}	1.76 ± 0.03^{b}	68.75(56.01) ± 1.32^{c}	33.49±2.14^{c}	5354.0±167.37^{d}
T_4	55±0.41	239.0±1.29^{b}	184.0±1.68^{b}	1.59± 0.01^{b}	61.87(51.87) ± 1.54^{a}	47.32±0.83^{b}	40.0±0.41	214.2±0.41^{b}	174.2±0.82^{b}	1.82 ± 0.06^{b}	55.00(47.87) ± 1.32^{a}	28.27±1.52^{b}	40.0±0.85	177.0±1.08^{b}	137±2.28^{b}	1.62 ± 0.03^{b}	58.33(49.79) ± 1.21^{b}	24.78±1.93^{b}	4014.8±148.38^{b}
SEm(±)	0.28	12.85	12.85	0.07	1.02	2.81	0.34	12.31	12.31	0.08	1.06	1.97	0.46	10.46	10.46	0.09	1.04	2.09	268.85

Values are mean (±SE), values in different superscript are significantly different (p<0.05), and Values in parenthesis are angular value.

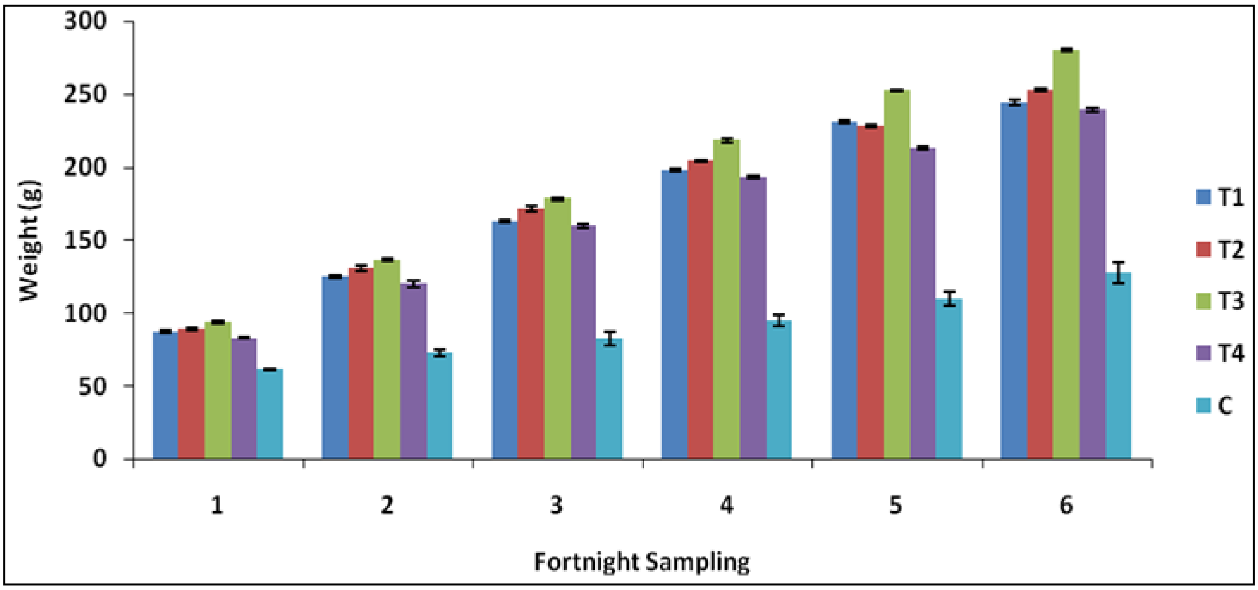

Fig 1: Effect of different treatments on fortnightly weight increments in Catla

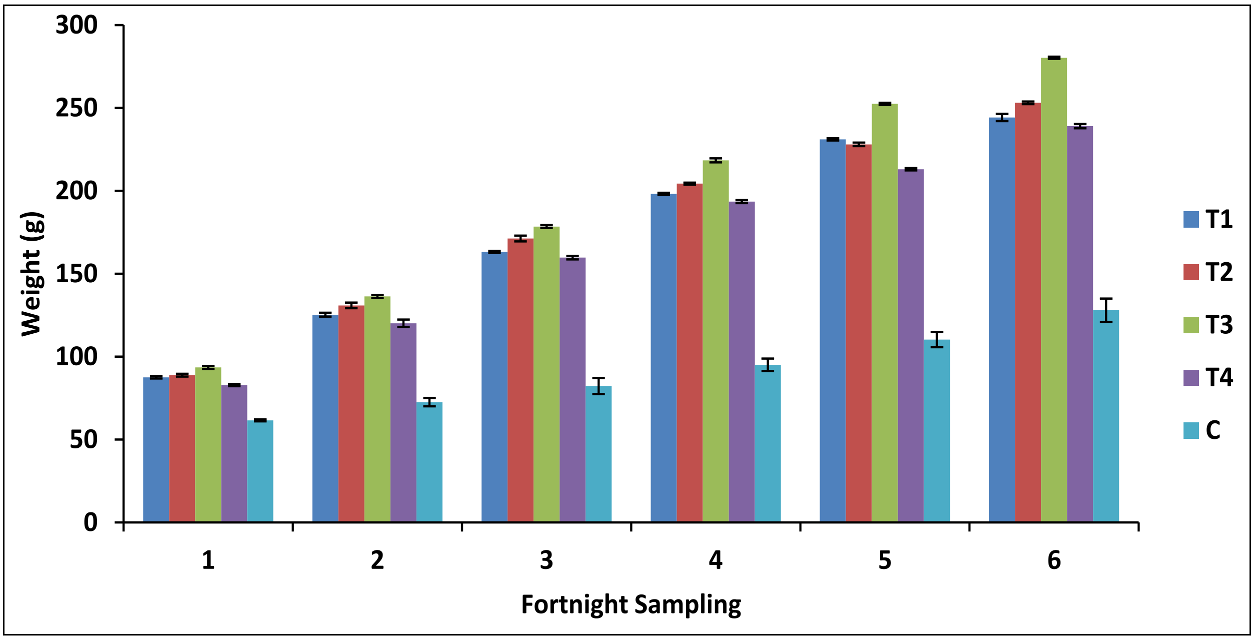

Fig 2: Effect of different treatments on fortnightly weight increments in Rohu

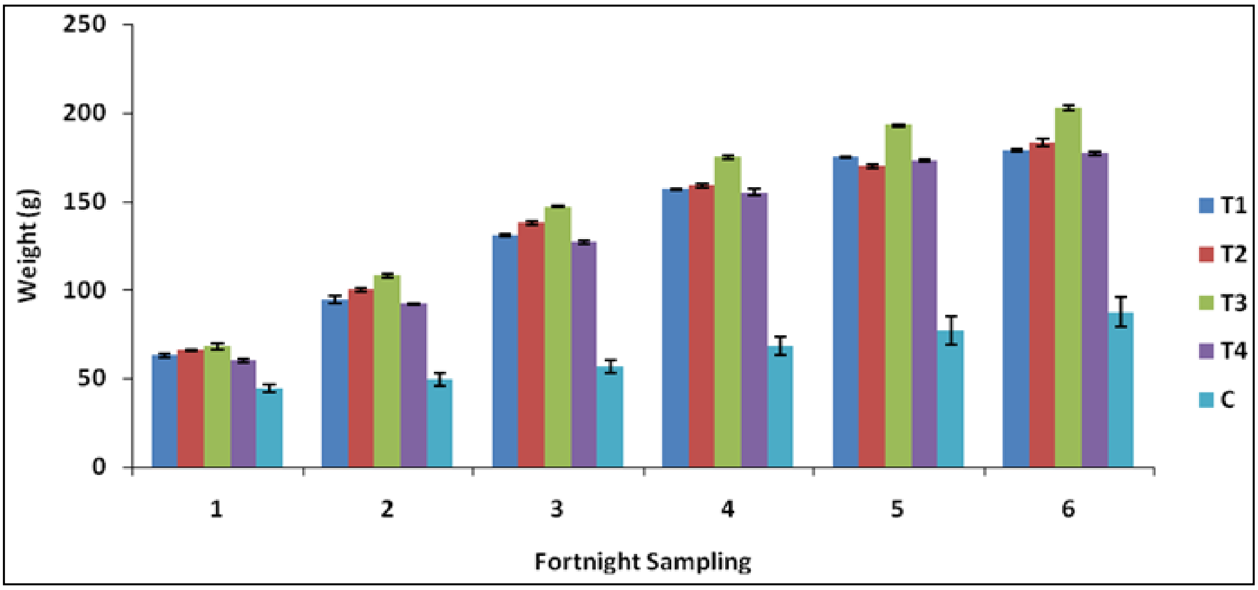

Fig 3: Effect of different treatments on fortnightly weight increments in Mrigal

6. Acknowledgement

The authors are thankful to Dr. K.M. Bujarbaruah, Vice-Chancellor, Assam Agricultural University, Dr. A. Chakraborty, Director of Research (Veterinary), Assam Agricultural University and Faculty of College of Fisheries, Raha, Assam in providing the necessary facilities to carry out the research work. The authors also thank the M.F.Sc and PhD scholars of College of Fisheries, Raha, Assam for their timely support during various stages of the study.

7. References

1. Baluyut EA. Aquaculture Systems and Practices: A Selected Review. ADCP/REP/89/43. FAO, Rome, 1989.
2. Welcomme RL. International Introduction of Inland Aquatic Species. FAO Fisheries Technical Paper, FAO, Rome, 1988, 294-318.
3. Ayyappan S, Sugunan VV, Jena JK, Gopalakrishnan A. Indian Fisheries. In: Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 2015, 1051.
4. Jena JK, Das PC. Carp Culture. In: Handbook of Fisheries and Aquaculture. ICAR, New Delhi, 2015, 1051.
5. Katiha PK, Jena JK, Pillai NGK, Chakraborty C, Dey MM. Inland Aquaculture in India: Past trend, present status and future prospects. Aquaculture Economics and Management. 2005; 9(1-2):237-264.
6. Anon. Lecture Notes on Composite Fish Culture and its Extension in India. NACA/TR/85/15. NACA, Bangkok, 1985.
7. Dhawan A, Kaur S. Pig dung as pond manure: Effect on water quality, pond productivity and growth of carps in polyculture system. Naga. 2002; 25(1):11-14.
8. Schroeder GL. Fish farming in manure loaded ponds. ICLARM- SEARCA Conf. Agriculture-Aquaculture Farming Systems, Manila, Philippines, 1980, 73-86.
9. Dhawan A, Toor HS. Impact of organic manure and supplementary diet on plankton production and fish growth and fecundity of an Indian major carp, *Cirrhinus mrigala* (Ham.) in fish ponds. Biological Waste. 1989; 29(4):289-297.
10. Sharma BK, Das MK, Das SR. Carp farming integrated with pig raising in India. Environment and Ecology. 1988; 6(1):159-168.
11. Bhattacharjya BK, Barman K, Yengkokpam S, Debnath D, Das P, Sharma N *et al*. Recycling of commercial piggery wastes in semi-intensive carp polyculture under rain-fed pond environment in Assam: An economic analysis. Journal of the Inland Fisheries Society of India. 2017; 49(1):35-45.
12. Dhawan A, Kaur S. Effect of pig dung on growth and reproductive potential of *Cyprinus carpio.* Indian Journal of Fisheries. 2002; 49(1):103-106.
13. Borah S, Bhattacharjya BK, Sarma KK, Meena DK, Das, UK. Some Innovative Techniques Practiced by Fish Farmers of Northeastern India. World Aquaculture. 2016; 47(4) 61-63.
14. Saud BJ, Chetia M, Borah S, Ramteke KK, Kashyap D, Sharma P. Growth surveillance of *Labeo rohita* (Hamilton, 1822) fingerlings fed on two formulated feeds. Ecology, Environment and Conservation. 2013; 19(04):1085-1088.
15. APHA. Standard method for examination of water and wastewater. American Public Health Association, 1998.
16. Pillay TVR. Aquaculture-Principles and Practices. Fishing News Books, Cambridge, England, 1986, 575.
17. Needham GJ, Needham PR. A guide to fresh water biology. 5th edition, Holdon Day Inc., San Francisco, 1966.
18. Duncan DB. Multiple range and multiple ‘F’ tests. Biometrics. 1955; 11:1-42.
19. Bhatnagar A, Jana SN, Garg SK, Patra BC, Singh G, Barman UK. Manual on water quality management in aquaculture. CCS Haryana Agricultural University, Hisar (India), 2004, 203-210.
20. Santhosh B, Singh NP. Guidelines for water quality management for fish culture in Tripura. ICAR, Tripura, 2007.
21. Green JD. Ecological studies on crater lakes in West Cameroon, Debunshalake. Journal of Zoology. 1974; 17:199-223.
22. Ellis MM. Bulletin on detection and measurement of stream pollution, Washington. 1937; 48(22):365-437.
23. Das SM. Hydrogen ion concentration, plankton and fish in fresh water eutrophic lakes of India. Nature. 1961; 191:511-512.
24. Banerjee SN. Water quality and soil condition of fish ponds in some states of India in relation to fish production. Indian Journal of Fisheries. 1967; 14(1&2):115-144.
25. Cruz EM, Shehadeh ZH. Preliminary results of integrated pig fish and duck-fish production tests. Pullin RSV, Shehadeh ZH. (Ed), Integrated agri-aqua, farming system, ICLARM SEARCA, Manilla, Philippines, 225-238.
26. Bwala RL, Omoregie E. Organic enrichment of fish pond: Application of pig dung vs. Tilapia yield. Pakistan Journal of Nutrition. 2009; 8(9):1373-1379.
27. Pahwa DV, Mahrotra SN. Observation on fluctuations in abundance of plankton in relation to certain hydrobiological condition of river Ganga. Proceeding of the National Academy of Sciences, Section B. 1966; 36(2):157-189.
28. Gautam A. Ecology and pollution of mountain waters. Ashish Publishing House, New Delhi, 1990.
29. Ray P, David A. Effects of industrial wastes and sewage upon the chemical and biological composition of fisheries of river Ganga at Kanpur. Environmental Health. 1966; 8(4):307-339.
30. Munawar M. Limnological studies on fresh water ponds of Hyderabad-1 Biotype. Hydrobiology. 1970; 35:137-162.
31. Seenayya G. Ecological studies of plankton of certain fresh water ponds of Hyderabad-1. Physio-chemical complexes. Hydrobiology. 1971; 37:7-31
32. Kumar A, Singh DK, Gupta HP. Impact of sewage on chemistry and primary productivity of two freshwater bodies in Santhal Paragana (Bihar). Indian Journal of Ecology. 1996; 23:110-116.
33. Bath KS, Singh JP. Limnology of polluted urban ponds. Environment and Ecology. 1998; 16(4):776-779.
34. Fang YX, Guo XZ, Wang JK, Fang XZ, Hill ZY. Effects of different animal manure on fish farming. Maclean JI, Dizon LB, Hosillos LV. (Ed), The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Phillipine, 1986, 117-120.
35. Sharma BK, Olah J. Integrated fish pig farming in India and Hungary. Aquaculture. 1986; 54:135-139.
36. Sharma OP, Saini VP. Evaluation of pig manure fertilization in relation to zooplankton production and water quality. Journal of Ecobiology. 1992; 4:27-31.

37. Ahmed SH, Singh AK. Correlation between antibiotic factors of water and zooplanktonic communities of a tank in Patna, Bihar. Proc. Nat. Sem. On Forty Years of Freshwater Aquaculture in India. Central Institute of Freshwater Aquaculture, Bhubaneswar, 1989, 119-121.
38. Sharma BK, Das MK, Das SR, Chakrabatty DP. Symposium on Observation of swine dung recycling in composite fish culture. CIFRI, Barrackpore, India. 1979, 99p.
39. Bora BC, Bhagawati AK, Baruah UK, Gogoi HK, Nath S. Integrated poultry-pig fish farming. Journal of the Inland Fisheries Society of India. 1998; 30(1):39-46.
40. Newell RC. The role of detritus in the nutrition of two marine deposit-feeders, the prosobranch Hydrobia ulvae and the bivalve Macoma balthica. Proceedings of the Zoological Society of London. 1965; 144:25-45.
41. Ahmed SH, Singh AK. Correlation between antibiotic factors of water and zooplanktonic communities of a tank in Patna, Bihar. In: Proceedings of the National Seminar on Forty Years of Freshwater Aquaculture in India. Central Institute of Freshwater Aquaculture, Bhubaneswar, 1989, 119-121.
42. Sharma BK. Fish culture integrated with various systems of livestock farming. I. Fish-cum-pig, II. Fish-cum duck, III. Fish-cum-poultry, IV. Fish cum-cattle, Compendium of Lecture No. 2 of Training programme on Integrated Fish Farming. CIFA (ICAR), Bhubaneswar, 1989.
43. Le Mare DW. Pig rearing, fish-farming and vegetable growing. Malaysian Agric. J. 1952; 35(3):156-166.
44. Bhatnagar A, Garg SK. Causative factors of fish mortality in still water fish ponds under sub-tropical conditions. Aquaculture. 2000; 1(2):91-96.
45. Bhatnagar A, Devi P. Water quality guidelines for the management of pond fish culture. International Journal of Environmental Sciences. 2013; 3(6):1980-2009.