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Effect of Pond Fertilization with Vermicompost and Some Other Manures on the Growth Performance of Indian Major Carps

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ABSTRACT

Vermicompost is one of the ready to use organic fertilizers. The efficacy of vermicompost vis-a-vis other organic fertilizers for fish production has not yet been extensively explored. For this purpose, an experiment was performed on three Indian major carps viz. catla (*Catla catla* Ham.), rohu (*Labeo rohita* Ham.) and mrigal (*Cirrhinus mrigala* Ham.). The fry/fingerlings acclimated for 10 days prior to the commencement of experiment were stocked in 5.54×6.15 m size ponds with a stocking density of 30 fish per pond in a ratio of 3:4:3, respectively. Six treatments viz. a control (T_1) without any treatment, pig manure at 4,000 kg ha^{-1} $year^{-1}$ (T_2), poultry manure at 6,000 kg ha^{-1} $year^{-1}$ (T_3), cow dung at 10,000 kg ha^{-1} $year^{-1}$ (T_4), vermicompost at 10,000 kg ha^{-1} $year^{-1}$ (T_5) and vermicompost at 15,000 kg ha^{-1} $year^{-1}$ (T_6) were used and their effect on growth performance of these fishes was recorded every month for a period of one year. All the six treatments caused significant monthly increase in fish growth; the three fish species gained maximal growth (length and weight) in ponds treated with vermicompost at 10,000 kg ha^{-1} $year^{-1}$ (35.6 cm, 900.5 g; 36.8 cm, 935.0 g; 35.2 cm, 879.0 g), followed by vermicompost at 15,000 kg ha^{-1} $year^{-1}$ (31.8 cm, 880.8 g; 32.1 cm, 910.2 g; 33.2 cm, 860.2 g), cow dung at 10,000 kg ha^{-1} $year^{-1}$ (28.7 cm, 835.7 g; 29.3 cm, 850.7 g; 30.1 cm, 783.0 g), poultry manure at 6,000 kg ha^{-1} $year^{-1}$ (26.5 cm, 768.7 g; 27.4 cm, 792.2 g; 28.9 cm, 760.9 g), pig manure at 4,000 kg ha^{-1} $year^{-1}$ (25.1 cm,718.1 g; 25.9 cm, 732.9 g; 26.8 cm, 693.8 g) and the control (21.7 cm, 645.5 g; 22.0 cm, 606.2 g; 23.1 cm, 591.2 g), respectively; the differences between treatments were significant. Among the three species, *Labeo rohita* attained the maximal growth (length and weight) (36.8 cm and 935.0 g) followed by *Catla catla* (35.6 cm and 900.5 g); *Cirrhinus mrigala* showed the minimal growth (35.2 cm and 879.0 g). Pond fertilization with vermicompost at 10,000 kg ha^{-1} $year^{-1}$ (in split doses) seemed to be the optimum dose for the maximum growth of Indian major carps.

Key words: Indian major carps, growth, pond fertilization, manure

INTRODUCTION

The rapid increase in world population has presented complex challenges before the administrators, policy makers and the food producers, the most important one is malnutrition and shortage of quantity as well as quality of food. More than half of the world population depends upon fish for animal protein. Fish as a food is easily digestible and nutritionally better than beef or mutton, hence can mitigate the problem of malnutrition. More over, fish flesh contains all the essential amino acids and minerals, i.e., iodine, phosphorus, potassium, iron, copper, vitamin A and

D in desirable concentrations (Hussain, 1986; Abbas *et al*., 2010). It serves as a valuable ingredient to a healthy diet because of its low carbohydrate and unsaturated fat contents. Since the fish meat is an excellent source of Omega-3 fatty acid, it is often recommended to the heart patients. Therefore, the inclusion of fish in human diet that contains mainly cereals, starchy roots and sugar can make it nutritionally more suitable for the healthy growth (Choo and Williams, 2003; Sandhu, 2005; Salim, 2006; Yildirim, 2008). In the poor and developing countries, fisheries sector is very important not only to provide fish as a main source of animal protein to ensure food security but also to improve employment and income for poverty elimination (Sheikh and Sheikh, 2004).

Fish production can be increased by feeding and pond fertilization. Optimum fertilization rate is the amount of organic matter that should be cost effective and can be utilized in a pond ecosystem without having harmful effect on water quality as well as on fish growth (Hayat *et al*., 1996; Jha *et al*., 2004). To improve the productive efficiency of fish ponds and to have a maximum yield from the limited resources of fresh water bodies, it is necessary to fertilize the fish ponds with balanced food in sufficient quantities. Pond fertilization using both organic manure and inorganic fertilizers is the latest management protocol to enhance the biological productivity of treated waters (Bhakta *et al*., 2004). In comparison to artificial feeding, the former method should ensure maximum fish growth in shortest period under more hygienic, economic and simple conditions (Bhakta *et al*., 2004). The basic principle behind the fertilization of a fish pond with a suitable manure is to actually increase the production of beneficial phytoplanktons, the key component of aquatic food chain which are responsible for increasing the amount of harvestable fish (Garg and Bhatnagar, 2000; Terziyski *et al*., 2007). It is estimated that pond fertilization can enhance the fish harvest of the given water body up to 2.8 times of an unfertilized pond (Wurts, 2004). But, there are many kinds of organic fertilizers, the most common among these are pig excreta, poultry excreta and cow dung etc. In the application of all these fertilizers ecologically feasible and economically viable? Do all these fertilizers have same effect on the fish growth and hydro-biological parameters of the treated waters? These are some of the questions which need explanation.

For increasing the fish production for better economic returns, one alternative is to fertilize the pond with cheap, easily available and suitable organic manures; vermicompost is one of these. The known usefulness of vermicompost in agriculture not withstanding (Meena, 2003; Saini *et al*., 2008a,b, 2010), its usefulness in aquaculture as an organic manure for augmentation of fish production has not yet been extensively explored and only a few reports on this subject are available where efficacy of vermicompost with other commercial manures in enhancing the fish production has been compared (Deolalikar and Mitra, 2004; Kumar *et al*., 2007; Chakrabarty *et al*., 2009; Kaur and Ansal, 2010). Our earlier study revealed higher survival rate of Indian major carps in ponds fertilized with vermicompost over those treated with other manures (Godara *et al*., 2015a), without adversely affecting the water quality parameters (Godara *et al*., 2015b). Vermicompost is a product of vermi-biotechnology that is frequently used in agro-ecosystems as organic fertilizer (Saini *et al*., 2008a,b, 2010). The advantage of use of vermicompost as organic fertilizer is the quick availability of nutrients in 'ready-to-uptake' forms (Kaur and Ansal, 2010). Indian major carps, catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) are the most important freshwater cultivable fishes of India which together make a suitable and common combination for composite fish culture system (Deolalikar and Mitra, 2004; Kumar *et al.,* 2007; Chakrabarty *et al*., 2009; Kaur and Ansal, 2010). Some researchers have already attempted to culture these three fish species under different treatments of organic fertilizers (Dhawan and Kaur, 2002a, b; Hossain *et al*., 2003). However, the information regarding efficacy of vermicompost as manure in aquaculture pond is scanty. In view of these points, the present investigation was proposed.

MATERIALS AND METHODS

Experimental set up/design: This study was carried out at the Fish Farm and Fisheries Biology Laboratory of Department of Zoology in Chaudhary Charan Singh Haryana Agricultural University, Hisar, India. The experiment was performed in the fish ponds each with a size of 5.54×6.15 m from August, 2011 to August, 2012 (Fig. 1). The ponds were cleaned and the lime was applied at 200 kg ha^{-1} $year^{-1}$. These ponds were filled with inland ground water obtained from the deep tube wells and were allowed to stabilize for about 15 days. Three fish species of Indian major carps commonly used for composite fish culture in India, viz. catla (*Catla catla* Ham.)-a surface feeder, rohu (*Labeo rohita* Ham.)-a column feeder and mrigal (*Cirrhinus mrigala* Ham.)-a bottom feeder, were used for this experiment. The water level throughout the experiment was maintained at 1.54 m.

Treatments and pond fertilization: In this experiment, there were six different treatments each with four replications; the ponds devoid of any fertilizer acted as the control (T_1). To fertilize the ponds, other five treatments included semi dried pig manure at 4,000 kg ha^{-1} $year^{-1}$ (T_2) (Fig. 2a), poultry manure at 6,000 kg ha^{-1} $year^{-1}$ (T_3) (Fig. 2b), cowdung at 10,000 kg ha^{-1} $year^{-1}$ (T_4) (Fig. 2c), vermicompost at10,000 kg ha^{-1} $year^{-1}$ (T_5) and vermicompost at 15,000 kg ha^{-1} $year^{-1}$ (T_6) (Fig. 2d). In the beginning of the experiment, initial dose equal to 25% of the total amount of the manure type was applied and remaining amount was given in equal split doses at fortnightly intervals. However, the supplementary diet made by recommended procedure and the ingredients and methods of administration was also given at fortnightly intervals.

Fig. 1: Fish ponds where experiment was performed

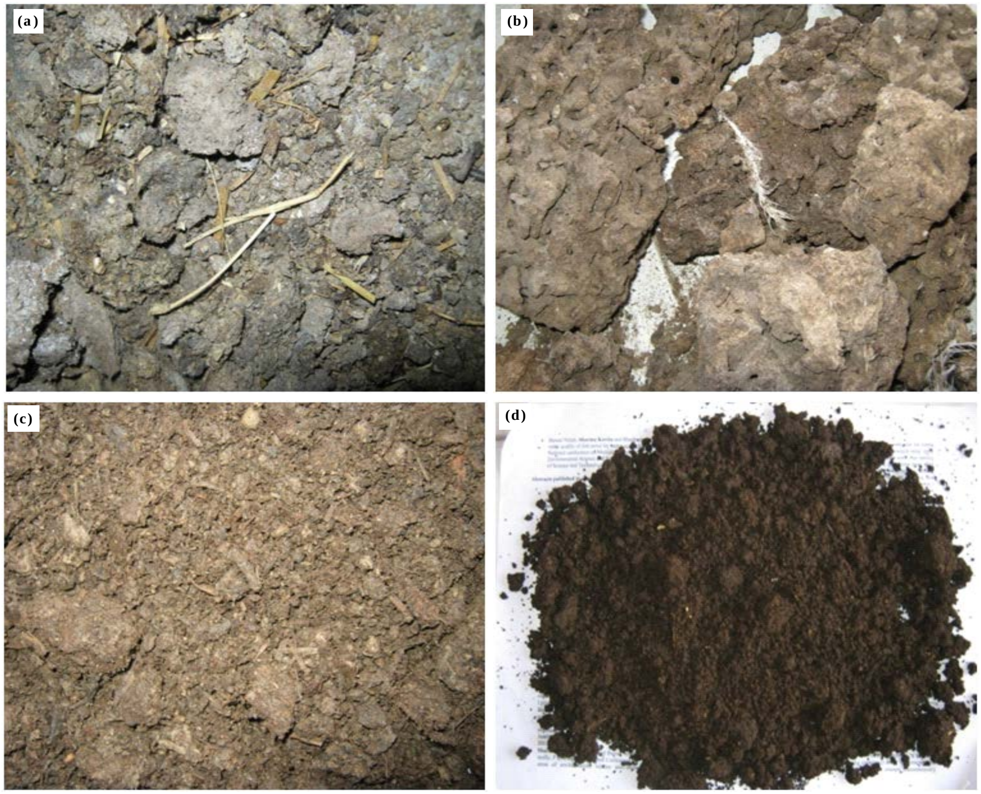

Fig. 2(a-d): Different kinds of manure used for fish culture (a) Piggery dung, (b) Poultry dung, (c) Cow dung and (d) Vermicompost

Supplementary diet, its ingredients and method of preparation: The various feed ingredients used in the present study were fish meal (in 35 parts contributing 18% protein), soybean (in 30 parts contributing 12.6% protein), mustard oil cake (in 18 parts contributing 5.4% protein), rice bran (in 10 parts contributing 1.3% protein), wheat flour (in 6 parts contributing 0.6% protein) and salt+vitamins and mineral premix (1 part). Thus the artificial diet contained about 38% (37.9%) protein which were procured locally. All the ingredients were ground and powdered prior to the preparation of supplementary diet (Fig. 3). Wheat flour was used as binder to make the diets water stable.

Soybean seed were cleaned, autoclaved for half an hour at 121°C at 15 lb pressure to remove Antinutritional Factors (ANFs) such as trypsin inhibitors, haemoglutinins, lectins and phytic acid. After oven drying at 60°C, it was ground into fine powder. Mustard oil cake, rice bran and processed soybean were finely ground to pass through 0.5 mm sieve prior to the analysis of proximate composition. Wheat flour was used as binder. All the ingredients were mixed in different proportion (as given above) and a thick dough was prepared by using distilled water. The dough was then passed through a mechanical pelletizer and thick (0.5 mm) pellets were obtained. Before using in feeding trials, the latter were dried in oven at 60-62°C (Fig. 3).

Collection and maintenance of the experimental fishes: The fingerlings of three Indian major carp (i.e., *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) were procured from the Satroad Fish Farm (Hisar) and were stocked in plastic tubs in the aquarium room and acclimated there for

Fig. 3: Supplementary feed given to the Indian major carps

Fig. 4: Aquarium room where experimental fishes were acclimated

10 days prior to the commencement of experiment (Fig. 4). During the acclimation period, the fry were fed on supplementary diet. Fry of three fish species with mean body weight ranging between 0.82-1.42 g were selected and randomly stocked at 30 fish per pond in 3:4:3 (catla: rohu: mrigal) ratios. Fish were fed daily at 2% b.wt. day^{-1} for the whole experimental duration of 12 months. Monthly data on length and weight of 10 fishes sampled randomly from each pond (thus 40 for each treatment) were recorded without sacrificing the sampled fishes from the commencement to the cessation of this experiment stretched over 12 months.

Growth parameters of experimental fish: The observations on the growth parameters were recorded in the first week of each month from the beginning till the end of the experiment. Following parameters were recorded:

$$\text{Live length gain (cm)} = (L_2\text{-}L_1)$$

Where:
L_1 = Initial length (cm)
L_2 = Final length (cm)

$$\text{Live weight gain (g)} = (W_2\text{-}W_1)$$

Where:
W_1 = Initial weight (g)
W_2 = Final weight (g)

Statistical analysis: The experiments were laid down in two factor Completely Randomized Design for Analysis of Variance (ANOVA). The values of Least Significant Differences (LSD) were derived and the treatment means were compared at 5% level of significance (Snedecor and Cochran, 1989).

RESULTS

Gain in body length: The body length of three fish species increased tremendously under all the six treatments. However, vermicompost at 10,000 kg ha^{-1} $year^{-1}$ was found to be the best among the six treatments, followed by vermicompost at 15,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$ and pig manure at 4,000 kg ha^{-1} $year^{-1}$; the control treatment was least effective (Table 1). In *C. catla*, under vermicompost at 15,000 kg ha^{-1} $year^{-1}$, vermicompost at 10,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and control, the body length increased from 2.4±0.0-31.8±0.9, 1.7±0.2-35.6±0.8, 2.8±0.0-28.7±1.2, 2.4±0.1-26.5±0.9, 2.8±0.1-25.1±0.9 and 2.3±0.0-21.7±0.6 cm, respectively. In *L. rohita*, under vermicompost at 15,000 kg ha^{-1} $year^{-1}$, vermicompost at 10,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and control, the body length increased from 2.4±0.2-32.1±0.9, 1.9±0.1-36.8±1.6, 2.3±0.1-29.3±1.1, 2.6±0.1-27.4±1.0, 2.7±0.0-25.9±0.8 and 2.1±0.0-22.0±0.5 cm, respectively. Likewise, in *Cirrhinus mrigala*, under vermicompost at 15,000 kg ha^{-1} $year^{-1}$, vermicompost at 10,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and control, the body length increased from 2.7±0.0-33.2±0.9, 2.4±0.1-35.2±1.5, 2.5±0.2-30.1±1.0, 2.3±0.1-28.9±0.7, 2.3±0.0-26.8±1.0 and 2.1±0.1-23.1±0.9 cm, respectively (Table 1).

Experimental fishes of three species attained different body length under all the six treatments and the differences between the treatments were significant ($p<0.05$; ANOVA, LSD (*catla*) = 0.91, LSD (*rohita*) = 0.82, LSD (*mrigala*) = 0.86, Table 1). Fishes kept in water treated with vermicompost at 10,000 kg ha^{-1} $year^{-1}$ showed maximal gain in length; minimal gain in length was observed under the control treatment. Among the three species, *Labeo rohita* attained the maximal length (36.8 cm) followed by *Catla catla* (35.6 cm); *Cirrhinus mrigala* showed the minimal length (35.2 cm) (Table 1).

Table 1: Body length of *Catla catla, Labeo rohita* and *Cirrhinus mrigala* in pond waters treated with different manures from August, 2011 to August, 2012

	Body length under different treatments (cm)																	
	C. catla						*L. rohita*						*C. mrigala*					
Months	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
Aug.	2.3±0.0	2.8±0.1	2.4±0.1	2.8±0.0	1.7±0.2	2.4±0.0	2.1±0.0	2.7±0.0	2.6±0.1	2.3±0.1	1.9±0.1	2.4±0.2	2.1±0.1	2.3±0.0	2.3±0.1	2.5±0.2	2.4±0.1	2.7±0.0
Sep.	4.9±0.3	5.1±0.2	5.4±0.3	6.2±0.3	6.1±0.3	5.8±0.4	4.6±0.4	5.3±0.5	5.8±0.4	4.8±0.4	3.9±0.3	4.8±0.3	4.4±0.2	4.6±0.4	4.8±0.4	5.0±0.3	4.9±0.3	5.5±0.4
Oct.	9.4±0.4	10.8±0.4	11.5±0.4	11.9±0.4	15.2±0.3	13.6±0.5	8.8±0.4	11.4±0.4	12.1±0.5	13.1±0.4	15.4±0.5	9.4±0.4	8.8±0.4	9.1±0.5	9.4±0.5	13.2±0.3	15.0±0.5	13.4±0.4
Nov.	13.2±0.5	15.9±0.4	18.3±0.5	19.9±0.5	24.0±0.5	22.5±0.5	12.9±0.5	15.0±0.4	17.9±0.3	20.0±0.5	24.1±0.6	22.9±0.5	12.1±0.4	15.2±0.4	17.3±0.6	19.3±0.4	25.2±0.6	23.0±0.6
Dec.	14.0±0.5	17.0±0.4	19.2±0.5	21.0±0.4	25.0±0.5	23.0±0.7	16.1±0.5	20.3±0.4	18.9±0.5	20.1±0.5	25.4±0.6	24.0±0.5	14.0±0.4	17.5±0.7	19.0±0.6	21.2±0.6	26.6±0.6	23.7±0.7
Jan.	14.2±0.5	17.1±0.4	19.8±0.5	22.1±0.7	26.0±0.6	23.5±0.5	16.2±0.6	21.0±0.5	19.5±0.6	20.4±0.7	26.5±0.8	24.6±0.4	14.4±0.4	17.8±0.7	19.9±0.7	22.0±0.6	27.3±0.7	24.1±0.7
Feb.	15.6±0.4	17.7±0.6	20.3±0.6	22.9±0.8	26.3±0.6	24.0±0.9	16.9±0.7	21.5±0.5	21.6±0.6	22.9±0.7	27.7±0.8	25.0±0.6	15.6±0.4	18.3±0.8	20.2±0.7	22.3±0.6	28.1±0.8	25.0±0.7
Mar.	16.9±0.4	20.5±0.6	21.0±0.6	23.5±0.7	27.7±0.7	25.4±0.8	17.3±0.6	22.4±0.5	24.0±0.5	25.0±0.9	29.0±0.9	27.0±0.6	17.3±0.7	20.8±0.8	21.8±0.9	23.7±0.6	29.6±0.7	26.3±0.9
Apr.	17.4±0.4	22.9±0.7	23.3±0.4	24.6±0.8	29.0±0.7	26.6±0.9	18.8±0.8	23.0±0.5	25.0±0.9	25.8±0.9	30.1±0.7	28.9±0.7	18.0±0.6	21.9±0.7	23.3±0.9	25.0±0.7	31.0±0.8	27.1±0.9
May	18.5±0.5	23.4±0.7	24.9±0.7	25.3±0.6	31.4±0.8	28.1±0.9	19.4±0.7	23.7 0.7	25.6±0.8	26.4±0.8	31.8±0.9	29.6±0.8	19.1±0.8	23.0±0.8	24.6±1.1	26.1±0.7	32.4±0.9	28.5±1.0
Jun.	19.8±0.6	23.9±0.8	25.5±0.8	27.4±0.7	32.0±0.9	29.8±0.8	20.9±0.9	24.1±0.7	26.9±0.8	27.0±0.9	32.6±1.3	30.1±0.8	20.0±0.7	24.0±1.0	25.7±0.8	27.0±0.8	33.2±0.9	31.0±0.9
Jul.	20.9±0.9	24.3±0.9	25.8±0.9	28.1±0.9	33.6±0.9	30.4±1.0	21.2±0.5	24.4±0.8	27.1±0.9	28.0±0.9	34.0±1.3	31.0±0.8	21.6±0.8	25.3±0.6	27.8±0.8	28.8±0.9	34.0±1.0	32.4±1.4
Aug.	21.7±0.6	25.1±0.9	26.5±0.9	28.7±1.2	35.6±0.8	31.8±0.9	22.0±0.5	25.9±0.8	27.4±1.0	29.3±1.1	36.8±1.6	32.1±0.9	23.1±0.9	26.8±1.0	28.9±0.7	30.1±1.0	35.2±1.5	33.2±0.9

T_1: Control, T_2: Pig manure at 4,000 kg ha^{-1} year^{-1}, T_3: Poultrymanure at 6,000 kg ha^{-1} year^{-1}, T_4: Cow dung at 10,000 kg ha^{-1} year^{-1}, T_5: Vermicompost at 10,000 kg ha^{-1} year^{-1} and T_6: Vermicompost at 15, 000 kg ha^{-1} year^{-1}, values are Mean±S.E. of 40 observations, LSD catla for months: 0.91 ($p \leq 0.05$), LSD rohita for months: 0.82 ($p \leq 0.05$), LSD mrigala for months: 0.86 ($p \leq 0.05$), LSD catla for treatments: 1.32 ($p \leq 0.05$), LSD rohita for treatments: 1.56 ($p \leq 0.05$), LSD mrigala for treatments: 1.12 ($p \leq 0.05$)

Likewise, under all the six treatments, individuals of all the three species showed significant difference in monthly gain in body length, as the differences between the months were significant ($p<0.05$, ANOVA, LSD (*catla*) = 1.32, LSD (*rohita*) = 1.56, LSD (*mrigala*) = 1.12, Table 1). The individuals of three species showed significant increase in body length from August-Novenber. However, the fish growth seemed to almost reach a stagnation stage in December and continued in this stage during the winter months of December, January, February and even in March (Table 1). The fishes regained the growth in April and continued to do so till the end of the experiment in August. The retardation of growth seemed to be related with very low temperature of this region during winter months.

Gain in body weight: The body weight of three fish species also increased tremendously under all the six treatments. However, vermicompost at 10,000 kg ha^{-1} $year^{-1}$ was found to be the best among the six treatments, followed by vermicompost at 15,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and the control treatment was least effective (Table 2). In *C. catla*, under vermicompost at 15,000 kg ha^{-1} $year^{-1}$, vermicompost at 10,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and control, the body weight increased from 1.5±0.0-880.7±3.6, 1.4±0.1-900.5±2.8, 1.2±0.0-835.7±2.9, 1.4±0.1-768.5±2.6, 1.2±0.2-718.1±3.3 and 1.3±0.1-645.5±3.3 g, respectively. In *L. rohita*, under vermicompost at 15,000 kg ha^{-1} $year^{-1}$, vermicompost at 10,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and control, the body weight increased from 1.4±0.3-910.2±4.1, 1.7±0.1-935.0±3.8, 1.3±0.1-850.7±3.6, 1.2±0.1-792.2±3.2, 1.5±0.2-732.9±3.2 and 1.4±0.1-660.2±2.9 g, respectively. Likewise, in *Cirrhinus mrigala*, under vermicompost at 15,000 kg ha^{-1} $year^{-1}$, vermicompost at 10,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and control, the body weight increased from 1.4±0.1-860.2±4.0, 1.3±0.0-879.00±3.4, 1.5±0.0-783.0±3.1, 1.4±0.1-760.9±2.6, 1.3±0.1-693.8±3.0 and 1.6±0.1-591.2±2.9 g, respectively (Table 2).

Experimental fishes of three species attained different body weight under all the six treatments and the differences between the treatments were significant ($p<0.05$, ANOVA, LSD (*catla*) = 25.7, LSD (*rohita*) = 31.6 and LSD (*mrigala*) = 21.8, Table 1). Fishes kept in water treated with vermicompost at 10,000 kg ha^{-1} $year^{-1}$ showed maximal gain in weight; minimal gain in weight was observed under the control treatment. Among the three species, *Labeo rohita* attained the maximal weight (935.0 g) followed by *Catla catla* (900.5 g) and *Cirrhinus mrigala* showed the minimal weight (879.0 g) (Table 2).

Likewise, under all the six treatments, individuals of all the three species showed significant difference in monthly gain in body weight, as the differences between the months were significant ($p<0.05$ ANOVA, LSD (*catla*) = 18.2, LSD (*rohita*) = 16.8 and LSD (*mrigala*) = 17.3, Table 1). The individuals of three species showed same pattern of gain in weight as they did for length. There was significant increase in body weight from August-Novenber. However, the fish weight almost reached a stagnation stage in December and continued in this stage during the winter months of December, January, February and even in March (Table 1). The increase in fish weight started in April and continued to do so till the end of the experiment in August. The retardation of gain in fish weight From December to March seemed to be related with very low temperature of this region during winter months.

The foregoing account clearly reveals that order of efficacy of different manures used in this study in enhancing the growth parameters (length and weight) of three fish species of Indian major

Table 2: Body weight of *Catla catla, Labeo rohita* and *Cirrhinus mrigala* in pond waters treated with different manures from August, 2011 to August, 2012

	Body weight (g)																	
	C. catla						*L. rohita*						*C. mrigala*					
Months	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6	T_1	T_2	T_3	T_4	T_5	T_6
Aug.	1.3±0.1	1.2±0.2	1.4±0.1	1.2±0.0	1.4±0.1	1.5±0.0	1.4±0.1	1.5±0.2	1.2±0.1	1.3±0.1	1.7±0.1	1.4±0.3	1.6±0.1	1.3±0.1	1.4±0.1	1.5±0.0	1.3±0.0	1.4±0.1
Sep.	7.6±0.6	7.3±0.9	8.7±0.8	7.23±0.9	8.6±0.7	9.2±1.1	8.3±0.7	9.2±0.9	7.3±0.9	7.9±1.0	9.4±1.0	8.9±0.7	9.7±0.9	8.3±0.7	8.0±0.9	9.3±0.9	8.2±0.9	8.7±1.1
Oct.	38.2±0.9	36.4±1.0	44.0±0.9	42.0±0.9	64.1±1.0	47.1±0.9	41.1±0.7	43.2±1.0	38.0±1.1	42.0±0.9	68.1±0.9	52.2±1.2	45.3±0.9	42.4±0.9	40.3±0.9	48.3±0.9	65.1±0.9	52.1±1.1
Nov.	115.0±1.1	118.3±1.1	118.8±1.0	122.2±1.0	167.3±1.3	140.0±1.1	113.0±0.9	115.3±0.9	122.0±1.0	135.2±0.7	169.1±1.2	143.0±1.3	120.2±0.9	127.0±0.9	130.0±1.1	135..3±1.4	165.4±1.1	146.2±1.1
Dec.	155.2±1.1	158.4±1.1	176.2±1.0	185.2±1.5	279.2±1.4	197.2±1.4	162.4±0.9	170.0±0.8	180.3±1.3	199.1±1.2	298.6±1.1	230.7±2.1	156.2±1.0	165.8±1.1	174.3±1.2	185.4±1.2	287.2±1.2	250.2±1.3
Jan.	153.2±1.7	159.1±1.2	177.3±1.3	190.0±1.5	280.3±2.0	199.8±1.1	171.2±1.0	182.4±0.9	179.1±1.2	198.0±1.2	295.3±2.0	235.2±2.7	160.5±0.9	164.5±1.3	170.2±1.4	188.0±1.4	289.4±1.2	255.2±1.5
Feb.	157.6±1.4	163.8±1.2	178.7±1.0	187.8±1.1	278.9±1.8	201.7±2.4	169.3±1.1	177.0±2.1	179.0±2.0	194.3±1.7	296.1±2.5	236.1±2.5	158.6±1.3	169.0±1.2	172.0±1.2	189.8±1.5	290.2±1.8	255.4±1.5
Mar.	168.3±1.3	165.5±1.3	190.7±2.0	199.6±1.7	292.6±2.0	216.3±2.0	180.5±1.9	188.2±1.8	188.8±1.6	203.2±2.1	308.2±2.6	252.1±3.0	168.9±2.5	183.1±2.1	185.4±2.1	198.7±1.5	298.0±2.1	263.0±1.5
Apr.	185.6±2.2	186.3±2.2	209.6±1.9	220.2±2.0	328.9±3.1	243.7±2.2	200.2±2.2	208.7±2.6	212.5±2.1	225.1±2.9	342.5±2.4	273.6±2.2	189.2±1.8	205.9±2.0	207.6±2.0	221.9±2.0	336.2±2.1	396.1±1.7
May	212.6±2.2	218.6±1.9	280.6±3.0	578.6±2.4	633.7±2.5	597.1±2.6	222.8±2.2	223.6±2.5	305.4±1.8	589.6±2.2	644.0±2.9	616.3±3.2	180.2±1.9	218.8±2.0	231.9±2.3	366.5±2.3	578.3±2.1	551.3±3.1
Jun.	304.9±2.2	320.6±2.7	378.6±2.7	688.1±2.9	710.6±2.3	680.0±2.7	280.6±2.4	322.6±2.7	419.5±2.2	692.1±2.9	734.5±3.4	704.1±3.0	246.9±2.1	342.9±2.8	366.0±3.1	486.2±2.2	704.1±2.9	672.8±3.1
Jul.	539.8±2.8	619.4±3.3	660.9±3.5	773.2±2.2	821.2±2.5	783.3±2.9	510.0±2.6	621.4±2.7	680.6±2.1	754.5±3.1	838.0±2.7	811.5±3.5	490.2±2.7	597.6±2.7	613.5±3.1	664.3±2.7	785.5±3.7	769.0±2.6
Aug.	645.5±3.3	718.1±3.3	768.5±2.6	835.7±2.9	900.5±2.8	880.7±3.6	606.2±2.9	732.9±3.2	792.2±3.2	850.7±3.6	935.0±3.8	910.2±4.1	591.2±2.9	693.8±3.0	760.9±2.6	783.0±3.1	879.0±3.4	860.2±4.0

T_1: Control, T_2: Pig manure at 4,000 kg ha^{-1} year^{-1}, T_3: Poultry manure at 6,000 kg ha^{-1} year^{-1}, T_4: Cow dung at 10,000 kg ha^{-1} year^{-1}, T_5: Vermicompost at 10,000 kg ha^{-1} year^{-1} and T_6: Vermicompost at 15, 000 kg ha^{-1} year^{-1}, Values are Mean±S.E. of 40 observations, LSD (catla) for months: 18.2 ($p \leq 0.05$), LSD (rohita) for months: 16.8 ($p \leq 0.05$), LSD (mrigala) for months: 17.3 ($p \leq 0.05$), LSD (catla) for treatments: 25.7 ($p \leq 0.05$), LSD (rohita) for treatments: 31.6 ($p \leq 0.05$), LSD (mrigala) for treatments: 21.8 ($p \leq 0.05$)

carps was: vermicompost at 10,000 kg ha^{-1} $year^{-1}$ > vermicompost at 15,000 kg ha^{-1} $year^{-1}$ > cow dung at 10,000 kg ha^{-1} $year^{-1}$ > poultry manure at 6,000 kg ha^{-1} $year^{-1}$ > pig manure at 4,000 kg ha^{-1} $year^{-1}$; the efficacy of control treatment was minimal.

DISCUSSION

Ambient air and water temperatures play an important role in the diurnal activity as well as development and growth of the poikilothermic organisms; the fish are no exception. Goolish and Adelman (1984) reported that temperature and quantity of feed have distinct effect on the fish growth. This contention fits well on our study too. The slow growth rate of *C. catla*, *L. rohita* and *C. mrigala* during November-February under the enrichment of all the treatments was because of low water temperature during these months in this region. Subsequently, the ambient temperature increases after February and so also the water temperature. This increase in water temperature seemed to be responsible to accelerate decomposition of organic inputs (poultry, pig manure and cowdung). During these warm months the release of CO_2 for photosynthesis should be maximum, which perhaps enhanced the plankton biomass and consequently the fish growth.

Pond fertilization has become an important practice in modern aquaculture, organic fertilization has replaced the inorganic fertilization (Wurts, 2004). Hence, several kinds of animal excreta and wastes, like cow dung, poultry dung and piggery dung, have been used (Natarajan and Varghese, 1980; Chakrabarty *et al*., 2008; Kaur and Ansal, 2010). However, the basic concept behind all these practices is an early availability of nutrients for primary and secondary productivity. For this purpose, the pH should be in the optimum range and the nutrients should also be available in optimum quantity without eutrophication of the treated water (Britz *et al*., 1997; Sheikh and Sheikh, 2004; Sandhu, 2005). But, each one of these manures has a specific decomposition process. Sooner the decomposition of the fertilizer, earlier are the chances of release of its nutrients in the aquatic medium followed by their early availability for primary production. Our study reveals that for the culture and growth of three species of Indian major carps, vermicompost at 10,000 kg ha^{-1} $year^{-1}$ gave the best results followed by vermicompost at 15,000 kg ha^{-1} $year^{-1}$, cow dung at 10,000 kg ha^{-1} $year^{-1}$, poultry manure at 6,000 kg ha^{-1} $year^{-1}$, pig manure at 4,000 kg ha^{-1} $year^{-1}$ and the efficacy of the control treatment was at the bottom. Here, the treatment vermicompost at 10,000 kg ha^{-1} $year^{-1}$ perhaps fulfilled the above requirements of a good fertilizer and made the optimum dose; other fertilizers seemed to lag behind in this process. These results are in agreement with many earlier studies but in disagreement with some of these. For example, Rappaport and Sarig (1978) reported that the feed of cowdung for fish culture produced highly positive results compared to poultry droppings. Javed *et al*. (1993a, b) reported that manure increased the weight, fork length and total length of *C. catla*, *L. rohita* and *C. mrigala*. Kaur and Ansal (2010) conducted experiment in cemented tanks (0.002 ha) for 120 days to assess the efficacy of vermicompost as fish pond manure at doses of 10,000 kg ha^{-1} $year^{-1}$ (VC_{10}), 15,000 kg ha^{-1} $year^{-1}$ (VC_{15}) and 20,000 (VC_{20}) kg ha^{-1} $year^{-1}$ in comparison to semi-digested cow dung (8-10 days old), which was utilized at a dose of 20,000 kg ha^{-1} $year^{-1}$ (CD_{20}). One fourth of the dose was applied 15 days prior to fish stocking and rest in equal weekly installments. Twenty fingerlings of common carp, *C. carpio* (Linn.) were stocked (10,000 ha^{-1}) and fed with supplementary diet at 2% of their body weight daily. Water quality parameters were found to be within the optimum limits for carp culture in all the treatments. Zooplankton production in all the treatments did not differ significantly. Fish growth in terms of weight gain, percent weight gain, specific growth rate and yield was maximal in VC_{15} followed by VC_{20}, VC_{10} and CD_{20}.

Banergee *et al*. (1979) reported that poultry manure can maximize fish production as it can provide nitrogen and phosphorous adequately for phytoplankton and zooplankton which in turn serve as food items for fish. Kang'ombe *et al.* (2006) argued that the use of chicken manure produced better results than cattle and pig manure treatments in unfertilized ponds. They obtained significantly higher yield of *Tilapia rendalli* along with large amount of chlorophyll and large number of zooplanktons in chicken manure treatment than those of cattle manure and pig manure. However, Rappaport and Sarig (1978) claimed that the feed of cow dung for fish culture produced better results than poultry droppings, which confirms the present finding. In enriched fish ponds with cow dung, carps fingerlings grow much better than fish ponds enriched with inorganic fertilizers (Machado and Castagnolli, 1976).

It is, therefore, not that other fertilizers can not be used for pond fertilization. Only difference is of their decomposition period and the availability of the nutrients. That is why, there is difference in the rate of fish growth under different treatments. For a faster and healthier fish growth, our study recommends vermicompost at 10,000 kg ha^{-1} $year^{-1}$ as a potential manure for the fertilization of fish ponds for the culture of Indian major carps.

CONCLUSION

Vermicompost was found to be the best among the six treatments tested in this study as all the three fish species (catla, rohu and mrigal) attained the maximal body weight in the former treatment; among these three fish species, rohu (*L. rohita*) gained maximal body weight (935.0 g), followed by catla (*C. catla*) (900.5 g) and mrigal (*C. mrigala*) (879.0 g). This study, therefore, recommends utilization of vermicompost as pond fertilizer instead of cow dung, poultry and pig manure. However, detailed study on the effect of vermicompost vis-à-vis other fertilizers on the hydro biological parameters and bacterial diversity of the treated ponds need to be investigated for the fool-proof safety of the system and the end product.

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