Turkish Journal of Fisheries and Aquatic Sciences 10: 47-52 (2010)

www.trjfas.org
ISSN 1303-2712
DOI: 10.4194/trjfas.2010.0107

Assessment of Vermicompost as Direct Application Manure in Fish Farming Ponds

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Received 02 July 2008
Accepted 24 Agust 2009

Abstract

Growth performance of *Oreochromis mossambicus* (Cichlidae) (Peters, 1852) as well as phyto- and zooplankton production were estimated in water filled cisterns receiving Mixed Fertilizer (MF; Single super phosphate and Urea in 1:1 ratio), Single super phosphate (SP) and Vermicompost (VC) as direct application fertilizer. Significant differences (P<0.001) were observed in the diversity and abundance of plankton in response to fertilization with MF, SP and VC. The different fertilizer and manure used can be graded in the following descending order: VC, MF and SP. The least concentration was accounted in control sets. The highest production of fish was obtained in vats treated with VC (4,000.00 $kg.ha^{-1}$ 90 day^{-1}) followed by MF (3,100.00 kg. ha^{-1} 90 day^{-1}), SP (2,030.00 kg. ha^{-1} 90 day^{-1}) and the lowest in control (CO) sets (390.00 kg. ha^{-1} 90 day^{-1}). The highest yield of fish in vats applied with VC is attributed to its highest manorial value.

Keywords: organic manure, vermicompost, mixed fertilizer, plankton, fish production.

Balık Çiftçiliği Havuzlarında Vermikompostun Doğal Gübre Olarak Doğrudan Kullanılması

Özet

Oreochromis mossambicus'un (Cichlidae) büyüme performansı (Peters, 1852), aynı şekilde fitoplankton ve zooplankton üretimi; doğrudan uygulanan suni gübre olarak Kompoze Gübre (MF; 1:1 oranında Single Sürperfosfat ve Üre), Single Süperfosfat (SP) ve Vermikompost (VC) alan, su ile doldurulmuş tanklardan tahmin edilmiştir. MF, SP ve VC ile gübrelemeye cevap olarak plankton çeşitliliği ve bolluğu bakımından anlamlı farklılar gözlendi (P<0,001). Kullanılan suni ve doğal gübre şu azalan sırayla derecelendirilebilir: VC, MF ve SP. En az konsantrasyon, kontrol setlerinde görüldü. En yüksek balık üretimi; VC (4.000,00 $kg.ha^{-1}$ 90 $gün^{-1}$) verilen tankta ve daha sonra MF (3.100,00 $kg.ha^{-1}$ 90 $gün^{-1}$) ve SP (2.030,00 $kg.ha^{-1}$ 90 $gün^{-1}$) verilen tanklarda, ve en düşük balık üretimi ise kontrol (CO) setlerinde (390,00 $kg.ha^{-1}$ 90 $gün^{-1}$) elde edildi. Verimin; VC verilen tanklarda en yüksek olması, VC'nin "manorial" değerinin en yüksek olmasına atfedilmiştir.

Anahtar Kelimeler: organik gübre, vermikompst, kompoze gübre, plankton, balık üretimi.

Introduction

The purpose of pond manuring is primarily to provide adequate amounts of essentials nutrients for phytoplankton production (Steinberg *et al.*, 2006; Wang, 2000). Fertilization or manuring is widely practiced in fishponds for natural fish production as it is important for sustainable aquaculture and to reduce expenditure on costly feeds and fertilizers which form more than 50% of the total input cost (Edwards, 1980; Oribhabor and Ansa, 2006). Wide variety of organic manures such as grass, leaves, sewage water, livestock manure, industrial wastes, night soil and dried blood meal have been used (Hickling, 1962) to improve fish production. Although organic fertilizer can be utilized as food for invertebrate fish-food organisms and fish (Taiganides, 1978), they are intended primarily to release inorganic nutrients for phytoplankton and zooplankton growth. Phytoplankton and zooplankton are rich source of protein often containing 40–60% protein on a dry matter basis and are sufficient to support excellent fish growth (Pillay, 1995; Silva and Anderson, 1995). Studies on growth performance of culturable fish in relation to feeding provide information for successful application in the management and exploitation of the resources. The present trial was undertaken to study both qualitative and quantitative characteristics of various groups of phytoplankton and zooplankton, (fish food) and to assess the growth performance of the test fish *Oreochromis mossambicus* (Peters, 1852) in cisterns receiving two fertilizers and one manure, namely; MF, SP and VC.

Materials and Methods

Experimental Design

The present trial was conducted in private premise at Krishnagar (longitude 88º33' E, latitude 23º24' N) over a period of 90 days during May-September (average temp 34°C). The trial was repeated twice. Nine concrete vats (radius 45 cm; depth 33 cm; capacity 150 liters) were treated with two different types of inorganic fertilizer namely, MF, SP and separate sets with organic manure (VC) having three replicates of each kind. Control sets were also run simultaneously without manure. Each vat was provided with an uncontaminated soil base of 8 cm. All the cisterns were then filled exclusively with ground water [pH 7.16, temperature 34°C, Dissolved oxygen (DO) 4.0 mg L^{-1}]. The amounts of different organic manures were applied on as per the P_2O_5 content of the fertilizer and manures. All the treatment series received manure fertilizer at 15 days intervals. The first application of manure was done 15 days prior to fish introduction. The total phosphate content of the manures applied was determined prior to its use in experimental vats.

The preparation of fertilizer was as follows: (i) Urea and Single super phosphate was mixed in equal amount (1:1) and used as Mixed Fertilizer (MF); (ii) Single super phosphate (SP) alone; (iii) Vermicompost (VC) alone. The phosphorus and nitrogen concentration of the fertilizer were as follows MF (P=16%, N=46%); SP (P=16%, N=0%) and VC (P=1.5%, N=2%).

The weights of manures were ranged from (9.2, 4.6 and 510 g respectively) on 50 kg P_2O_5 content basis. No supplementary feed was applied during this period. Fry of *Oreochromis mossambicus* (average weight 3.5±0.01 g; average length 2.50±0.02 cm) (Table 1) were stocked at 12 No.$vats^{-1}$ these fry of *Oreochromis mossambicus* and fishes were acclimatized in outdoor vats prior to their release in treatment vats. A constant water level was maintained in the test vats by weekly supply of ground water to compensate the water loss due to evaporation in every vat. Water quality such as temperature, pH, dissolved oxygen, free carbon dioxide, total alkalinity, hardness, ammonia-nitrogen and phosphorous were estimated at 15−day intervals following Standard Methods (2002). Qualitative and quantitative analyses of phytoplankton and zooplankton (4% formalin preserved) from each vats were also done using Sedgewick - Rafter Counting Chamber (Glass slide with central 50x20 mm cell of 1 mm depth, base ruled in 1 mm square grid, for plankton counting, Graticules, England) at an interval of 45 days by filtering 20 liters of water through a conical plankton net of number 25 bolting silk cloth (80 mesh cm^{-2}). The plankton samples were then hot air dried for 24 hours at 100°C and after that measured for their dry weight. The total weight of the fish was determined at 45−day intervals by weighing more than 50% of fishes from each of the cisterns.

GPP (Gross Primary Production) and NPP (Net Primary Production) was measured following dark and light bottle method described by Vollenweider (1974). The result expressed in terms of $g.m^{-2}.day^{-1}$ (Boyd, 1982) and was converted into gram carbon by multiplying with a factor of 0.375 (Natarajan and Pathak 1983).

The absolute growth (AG), growth increment (GI) and the total weight gain (TW) was estimated as follows. Procurement of manure and fertilizer: Prepared VC was taken from Akshay Krishi Vikas, Karimpur, Nadia, and other fertilizer was procured from local shops.

Absolute growth (AG) = Final body weight − Initial body weight

Growth increment (GI) = (Final body weight − Initial body weight) / Number of culture days

Table 1. Details of fish production *Oreochromis mossambicus* (Cichlidae) in the experiment

Parameters	CO	SP	MF	VC
Fertilizer / Manure added (g)	0	4.6	9.2	510
Stocking density	10.00	10.00	10.00	10.00
Initial average individual length (cm)	2.5± 0.02	2.5±0.02	2.5±0.02	2.5±0.02
Initial average individual weight (g)	3.50± 0.01	3.50±0.03	3.50±0.05	3.50±0.02
Final average individual length (cm)	4.44±0.03	5.86±0.05	6.80±0.02	7.96±0.04
Final average individual weight (g)	4.60±0.01	7.14±0.05	10.22±0.03	14.54±0.06
Growth increment (g $fish^{-1}$ day^{-1})	0.0222	0.0404	0.0746	0.1226
Total weight gain (TWG) (g $fish^{-1}$)	0.60	1.04	1.92	3.15
Survival (%)	85	88	86	95

Note. CO − Control, SP − Single super phosphate, MF − Mixed Fertilizer, VC − Vermicompost ± − Standard deviation

Total weight gain (TW) = (Final body weight − Initial body weight) / Initial body weight

The result was evaluated calculating ANOVA (One way) correlation coefficient and regression analysis, using appropriate software [SPSS software (See Ref.)].

Results and Discussion

Water Quality

The average water temperature was remained almost similar (≥ 30.0±6.5°C) in all the experimental sets and but there was a marked difference of temperature (30.0-30.6°C) during the tenure of the experimental period; variation was also found in, pH (7.10-7.30) and dissolved oxygen content of water (5.01-7.02 mg L^{-1}) among the treatments (Table 2). The orthophosphate concentrations were the highest in MF and SP treated cistern in the mixed fertilizer (0.19 mg L^{-1}) treatment and the lowest in control (0.06 mg L^{-1}). The amount of organic phosphate, on the other hand was the highest (0.44 mg L^{-1}) in the VC treatment. The concentration of total P was higher in VC (0.58 mg L^{-1}) than in the SP and MF treatment (0.46 and 0.49 mg L^{-1}). There were no significant differences ($P<0.05$) in the concentration of total P among treatments (MF, SP, VC), and in available P concentration of treatments received MF, SP and VC. However, as expected control series showed always- the lowest concentration of total and available P among the all test combinations. But the total nitrogen concentration showed significant differences among different test combinations. The sets designated as CO, SP showed no significant difference in their available N concentration as well as MF and VC showed no significant difference in the concentration of available-N in water.

Soil Analysis

The soil pH remained similar in all experimental sets and there was no marked variation in pH (7.05─7.10). The available phosphate was similar in MF, SP and VC series (15–17 mg kg^{-1}) and the available nitrogen was the highest in VC, followed by MF and SP. In all the cases control set showed the lowest concentration and varied significantly ($P>0.001$) from treatment series.

Plankton Analysis

Initially the plankton count was nil up to 5 days in every experimental cistern. Phytoplankton started appearing on day 6 and zooplankton appeared on day 12 in each cistern. In all the treatments dry weight and population (no L^{-1}) of the both phytoplankton and zooplankton population were significantly ($P<0.001$) higher than control.

Phytoplankton composition was represented by four groups, namely Myxophyceae, Chlorophyceae, Cyanophyceae and Bacillariophyceae in all the experiment series. Among the four-phytoplankton groups Bacillariophyceae exhibited the highest percentage composition (72.8-79.50%) in all the four treatments on various sampling days, whereas Cyanophyceae exhibited the lowest (5.83-13.42%) trend in all the treatments. The phytoplankton population was found in increasing order in vats treated with VC (3,034 L^{-1}) followed by MF (2,685 L^{-1}) than by SP (2,100 L^{-1}). Also, overall observation revealed an increasing trend of phytoplankton population in various sampling days of the experimental period in all the treatments. Significant differences ($P>0.005$) were also found among the series treated with VC, MF and SP.

The zooplankton composition was represented by three groups, namely, Rotifera, Cladocera and

Table 2. Mean values (± SD) of physico-chemical parameters of water and soil, primary productivity of phytoplankton in various treatments. Each mean value applies to three months samples

	Fertilizer	CO	SP	MF	VC
Water regime	Temp (°C)	30.5±6.0	30.0±6.5	30.60±6.5	30.50±6.0
	pH	7.20±1.3	7.10±1.6	7.20±1.1	7.30±0.9
	Dissolved Oxygen (mg L^{-1})	5.01±0.9	6.21±1.1	6.74±1.0	7.02±1.2
	Ortho phosphate (mg L^{-1})	0.06±0.09	0.19±0.06	0.19±0.10	0.14±0.05
	Organic phosphate (mg L^{-1})	0.07±0.19	0.26±0.15	0.30±0.14	0.44±0.21
	Total phosphate (mg L^{-1})	0.13±0.10	0.46±0.16	0.49±0.25	0.58±0.21
	No_3-N (mg L^{-1})	0.01±0.008	0.03±0.001	0.15±0.03	0.16±0.04
	Total inorganic N (mg L^{-1})	0.04±0.24	0.20±0.22	0.40±0.19	0.58±0.23
	Total phosphate / Total inorganic N (P/N)	3.25	2.30	1.02	1.0
Soil Regime	pH	7.05±0.1	7.05±0.13	7.05±0.16	7.05±0.12
	rH (mv)	180±20	190±15	190±13	210±16
	Available N (mg kg^{-1})	6±0.15	17±0.35	17±0.30	18±0.40
	Available P (mg kg^{-1})	5±0.10	5±0.11	15±0.26	17±0.28

Note. CO − Control, SP − Single super phosphate, MF − Mixed Fertilizer, VC − Vermicompost ± − Standard deviation

Copepoda. The contribution of different zooplankton groups showed similar trend in the entire treatment group. The zooplankton population were represented by three major groups; the order of dominance was Cladocera (38.74−46.94) > Copepoda (40.23−54.81) > Rotifera (8.98−25.54). All the groups were significantly (P<0.001) different from each other in their abundance. Among the various treatments, the highest zooplankton population was observed in the cisterns treated with VC (780 L^{-1}) followed by MF (450 L^{-1}), SP (306 L^{-1}) and CO (40 L^{-1}). Moreover, the zooplankton count was increased with days of sampling in all treatments except in the control sets where a declining trend of zooplankton count was observed.

Fish Growth and Production

There was regular increase in weight of fish in all the treatments; however, the growth was much greater in the treated ponds than in the control. Among the various treatments, maximum growth increment, total gains were recorded with VC followed by MF and SP. Minimum growth rate was recorded in CO.

The average growth of individual fishes (Figure 1) among treatment varied significant (P>0.05) and a step wise multiple regression analysis also attested the findings (Figure 2). The total yield of fish was higher in the system with high plankton count as revealed from the vats treated with VC (4,000.00 kg ha^{-1} 90

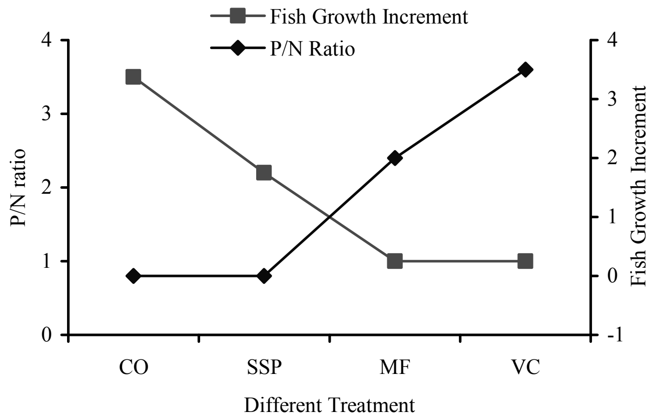

Figure 1. P / N ratio ploted against fish growth increment, among different manures.
Note. CO - Control, SP - Single super phosphate, MF - Mixed Fertilizer, VC – Vermicompost.

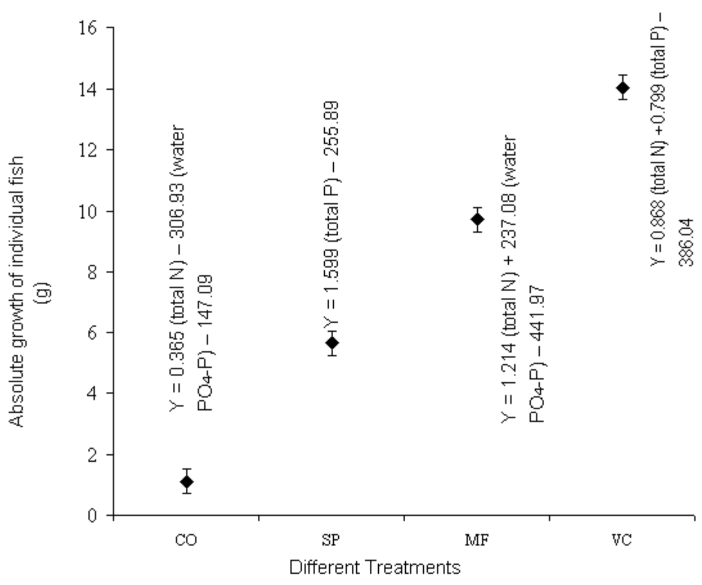

Figure 2. Absolute growth of individual fish.
Note. CO − Control, SP − Single super phosphate, MF − Mixed Fertilizer, VC − Vermicompost

day^{-1}) as compared to low plankton count in CO sets (390.00 kg ha^{-1} 90 day^{-1}). The net production of fish from the cisterns manured with MF was 3,100.00 kg ha^{-1} 90 day^{-1} and with SP was 2,030.00 kg ha^{-1} 90 day^{-1} (Figure 3).

High rates of fish yield and excellent growth in the present experiment can largely be attributed due to higher availability of natural food of high nutritional value in the treatments. Smith and Swingle (1939) established a direct relationship between average plankton and fish production. Similar results were observed in the present experiment where the absolute growth of fish in all the treatments exhibited a highly predictive correlation with the primary productivity of water.

A positive correlation (r = 0.99) observed between absolute growth of test fish, *Oreochromis mossambicus* and dry weight of plankton (Figure 3) signifies that natural food (plankton) alone offers all the constituents of a complete and balance diet more essentially the amino acids, required for fish growth. Moreover, some carps even feed upon the undigested fraction of these manures directly, which may be low in nutrient value but the microorganisms adhering to them are of high protein value (Schroeder, 1980; Ansa and Jiya, 2002).

Because the average weight and total fish yield achieved in any treatment charged with VC were essentially higher than that of the SP treatment, it is apparent that VC might be a cost-effective fertilizer in carp culture, replacing the expensive chemical fertilizer SP. This is particularly significant in developing nations, where the purchasing power of fish farmers for chemical fertilizer is very low, and VC forms an abundant alternative natural resource for inexpensive P fertilizer.

Large variation of fish yield (>10.25 times) among four experimental sets might be explained in terms of P/N ratio of water. The lowest and the highest production of fish in CO and VC (set) was related to the lowest and the highest P/N (Figure 1) ratio of the vats. There was direct relationship between dry weight of plankton and fish yield (r = 0.87) in all the treatment series.

The present study thus demonstrates that carp production under similar culture conditions can be greatly enhanced using VC, in place of MF or SP. Higher rates of nutrient, increased plankton production of high nutritional value and optimum water quality conditions in the VC applied vats accounts for the increased growth rate of fish as compared to control sets without manure.

The results of multiple regression analysis (Figure 2) were highly significant ($P<0.05$) in each case. It is evident that both total P and total N of surface sediments exerted considerable influence in the VC treatment. Total P of surface sediments and orthophosphate of water, on the other hand, were the major determinants in SSP treatment.

Conclusion

Superiority of VC was well pronounced as it served the double role as direct feed to growing fishes and as direct manure for increasing growth of fish food. In view of the need of the organic aquaculture vermicompost could serve as a direct application feed and fertilizer for the fish farming ponds.

The vermicompost applied to the culture waters served as a direct feed for the fish and also acted as

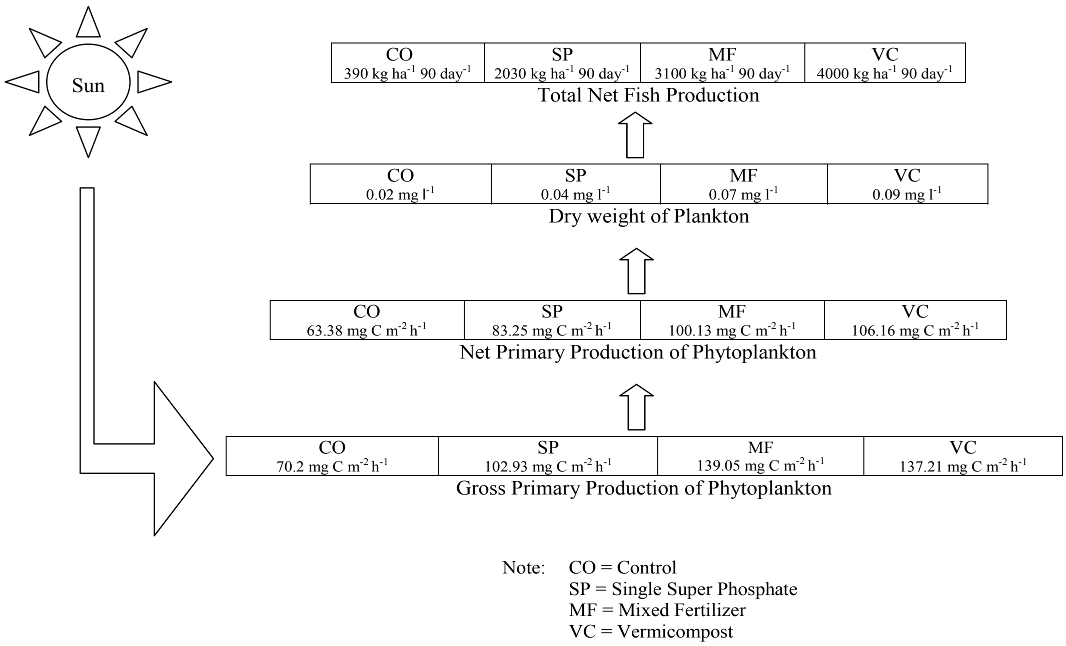

Figure 3. Diagrammatic Model of Fish Production through ecological chain.

pond fertilizer for autotrophic and heterotrophic production of natural fish food organisms (Chakrabarty, 2008; Muendo *et al*., 2006). the average weight and total fish yield achieved in the vermicompost treatment were higher than those of the MF and SSP treatment, vermicompost contains body remains and cocoon of earthworm, which provides Iron (as earthworms contain hemoglobin in their blood serum), protein, growth hormones etc. for developing fishes (Chakrabarty, 2008). It is apparent that vermicompost might be cost-effective manure in carp culture, replacing the expensive chemical fertilizers. This is particularly significant in developing nations, where fish farmers are unable to buy costly fish feed and chemical fertilizer vermicompost forms an abundant alternative natural resource for less expensive manure and fish feed for higher fish yield.

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