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Determination of the Necessary Quantity of Supplementary Fertilization for a Duck – Fish Integrated Semi – intensive Aquaculture System

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ABSTRACT. For semi – intensive aquaculture ventures, correct level of application of fertilizer is essential for sustained optimum growth of planktons. In a duck – fish integrated pond, suitable quantities of duck litter for supplementary fertilizing was determined in this experiment.

Nile tilapia (Oreochromis niloticus) 10 per pond, bighead carp (Aristichthys nobilis) 5 per pond and common carp (Cyprinus carpio) 7 per pond were stocked randomly in four cement tanks each of 12.5 m^2 and 1.0 m depth, which were base fertilized with limed duck litter (dolomite:duck litter 01:19) at 10,000 kg/ha rate a fortnight prior to stocking of fish. Fish were not given any feed except for limed duck litter, which was applied at two levels to four tanks [1,000 (high) and 500 (low) kg/ha/wk] twice weekly. Both treatments were duplicated.

Harvesting of fish after 154 days showed that weight gain of bighead carp and common carp was significantly ($P<0.05$) high in the high fertility level. Furthermore, total production rate in the high fertility treatment (9.650 kg/ha/d) was 32.9% higher than in the low fertility level.

INTRODUCTION

Integration is an useful method of increasing profit margins in fish culture ventures. According to Edwards *et al.*, (1988), the necessity to increase the productivity and profitability of farming in developing countries is great. A solution to this is the rearing of fish using excreta.

In diverse forms of duck – fish integrated systems found in different parts of the world, various fish combinations and densities are

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being used (Woynarovich, 1980). However, the main effect of manure is to supply nutrients to different biota present in the fish pond (Schroeder, 1980). The rate of duck litter which should be used to supplement the fertility of water during the culture of fish was tested in this experiment.

MATERIALS AND METHODS

Four cement tanks at the University Farm of the Department of Animal Science, University of Peradeniya, Sri Lanka, each with an area of 12.5 m^2 and average depth of 1 m were used for this study. A fortnight prior to the stocking of fish, duck litter mixed with dolomite at a rate of 19:1 was used as a basal mixture at 10,000 kg/ha (DM basis).

Nile tilapia (*Oreochromis niloticus*) 10 per tank, bighead carp (*Aristichthys nobilis*) 5 per tank and common carp (*Cyprinus carpio*) 7 per tank were stocked randomly in the four tanks, at a stocking density of 17,000 fish/ha.

Thereafter duck litter was added at two levels as supplementary fertilizer. Duck litter was added at 1,000 kg/ha/wk (High fertilizer) and at 500 kg/ha/wk (Low fertilizer). Fertilization was carried out twice weekly in equal amounts on Mondays and Thursdays. Fish were harvested 154 days after the introduction.

Water quality parameters were determined by standard methods (A.O.A.C., 1975) between 0430 and 0530 h as referred by Edirisinghe 1988 and 1989. Complete random design was used in statistical analysis of the data.

RESULTS

The proximate composition of limed duck litter is shown in Table 1. Early morning ambient temperature ranged from 19.5 – 23.5°C. Water temperature were between 23.5 and 26.0°C and were similar in all tanks.

Table 1. Proximate analysis of duck litter.*

Parameter	Percent ($\bar{X} \pm$ S.E.)
Crude protein	13.7 ± 0.3
Ether extract	0.7 ± 0.0
Ash	26.6 ± 1.3
Crude fibre	9.4 ± 0.1
Nitrogen free extracts	45.1 ± 1.2

* Dry weight basis comprising duck litter:dolomite in a ratio of 19:01. n = 5, $\bar{X} \pm$ S.E. = Mean ± standard error.

Mean total alkalinity (167.9 and 157.9 mg/l), total nitrogen (1.1 and 0.9 mg/l), total phosphates (1.7 and 1.2 mg/l), K^+ (63.5 and 57.6 mg/l), Ca^{2+} (15.3 and 15.8 mg/l) and Mg^{2+} (13.2 and 11.7 mg/l) values (Table 2) indicated that pond water in either treatment was rich in nutrients.

Density of total particles in the high fertility treatment (151.8×10^5 per litre) was significantly different ($P<0.05$) from that in the low fertility treatment (99.1×10^5 per litre) as shown in Table 3. Even the phytoplankton (83.5×10^4 per litre) and zooplankton densities (37.7×10^3 per litre) in the high fertility treatment were different at 5% level when compared with the respective values (69.3×10^4 and 17.7×10^3 per litre) in the low fertility treatment.

Weight gain of bighead carp (116.9 and 43.2 g) and common carp (62.0 and 43.9 g) was significantly different ($P<0.05$) in the high fertility treatment, when compared with the low fertility treatment (Table 4). Even though supplementary fertility levels had no significant effect ($P>0.05$) on the weight gain of Nile tilapia (93.9 and 79.4 g) and Nile tilapia recruitment (214.1 and 210.3 g), total production rate in the high fertility level (9.650 kg/ha/d) was substancially higher than the respective value in the low fertility treatment (6.471 kg/ha/d) as shown in Table 5.

Comparatively low survival rate of bighead carp (80% in the high fertility level and 90% in the low fertility level) and common carp (90% in the high fertility level) as shown in Table 5 was due to predation by water birds. Predation was chiefly in the mornings when fish were surfacing due to low dissolved oxygen content.

DISCUSSION

Total alkalinity, mineral iron concentrations and plankton density in the treatments which received supplementary fertilizer at 1,000 kg/ha were significantly high ($P<0.05$). This was reflected by the higher production obtained in the treatment which received supplementary fertilizer at 1,000 kg/ha rate (Table 5).

The difference in the increased weights of bighead carp in the two treatments was very prominent. This could be due to the availability of

Table 2. Physico-chemical parameters ($\bar{X} \pm$ S.E.) of pond water.

Parameter	Unit	Fertility level: High[a] (1,000 kg/ha/wk)	Low[a] (500 kg/ha/wk)
Temp. (water)	^{0}C	24.7 ± 0.2	24.7 ± 0.2
Temp. (ambient)	^{0}C	21.8 ± 0.3	21.8 ± 0.3
Total Alkalinity	mg/l	167.9 ± 1.2	157.9 ± 3.4
Do	mg/l	1.9 ± 0.0	2.0 ± 0.0
pH[b]	–	8.0 ± 0.0	8.0 ± 0.0
Total Nitrogen	mg/l	1.1 ± 0.0	0.9 ± 0.0
Soluble Phosphates	mg/l	1.7 ± 0.0	1.2 ± 0.0
K^+	mg/l	63.5 ± 0.9	57.6 ± 1.9
Na^+	mg/l	11.9 ± 0.4	8.2 ± 0.7
Ca^{2+}	mg/l	15.3 ± 0.7	15.8 ± 0.7
Mg^{2+}	mg/l	13.2 ± 0.3	11.7 ± 0.4

$\bar{X} \pm$ S.E. = Mean ± Standard error; [b]Geometric mean

[a]Within comparisons, means across columns were not statistically different ($P > 0.05$).

Table 3. Plankton density ($\bar{X} \pm$ S.E.) of pond water.

Particle Type (per litre)	Fertility level: High[a] (1,000 kg/ha/wk)	Low[b] (500 kg/ha/wk)
Total Particles x 10^5	151.8[a] ± 4.7	99.1[b] ± 4.1
Phytoplanktons x 10^4	83.5[a] ± 2.5	69.3[b] ± 2.9
Zooplanktons x 10^3	37.7[a] ± 2.2	17.7[b] ± 2.9

$\bar{X} \pm$ S.E. = Mean ± Standard error.

[a, b]Within comparisons, means with different superscripts across columns differ significantly ($P < 0.05$).

Table 4. Weight gain of fish ($\bar{X} \pm$ S.E.) during the culture period (154 days).

Fish Type	Weight Gain (g): High Fertility Level (1,000 kg/ha/wk)	Low Fertility Level (500 kg/ha/wk)
Bighead Carp	116.9[a] ± 26.1	43.2[b] ± 30.8
Tilapia	93.9[c] ± 25.2	79.4[c] ± 26.4
T. Rec.	214.1 ± 40.2	210.3 ± 12.2
Common Carp	62.0[a] ± 11.9	43.9[b] ± 12.2

T. Rec. = Total weight of tilapia recruits.

[a, b] Within comparisons, values with different superscripts across columns differ significantly ($P < 0.05$).

[c] Within comparisons, values with the same superscript across columns do not differ significantly ($P > 0.05$).

Table 5. Production details and survival rates at harvesting.

	High Fertility Level (1,000 kg/ha/wk)		Low Fertility Level (500 kg/ha/wk)	
Fish Type	Production kg/ha/d	Survival Rate %	Production kg/ha/d	Survival Rate %
Bighead Carp	3.076	80	1.137	90
Tilapia	4.942	90	4.179	95
T. Rec.	1.127	-	1.107	-
Common Carp	1.632	90	1.555	100
Total	9.650	-	6.471	-

T. Rec. = Tilapia recruits.

more suspended detritus and feed in the high fertility treatments. It has been shown that bighead carp grow very fast when feed is sufficiently rich in zooplankton (Woynarovich, 1975). Even common carp showed numerically higher growth at high fertility level indicating the necessity of supplementary fertilization at 1,000 kg/ha/wk rate. Very low early morning dissolved oxygen content experienced in the high fertility treatment indicated that a further increase in the supplementary fertilizing level would not be feasible in this type of culture system.

In addition to the considerable elasticity in the choice of food, Nile tilapia has tolerated the adverse conditions such as low dissolved oxygen concentration satisfactorily. Production of significant number of Nile tilapia recruits, where low dissolved oxygen concentration prevailed, proves their ability to manipulate ontogeny according to physicochemical and biocenotic factors as reported by Pullin and Lowe-McConnell (1982).

The increase in weight of Nile tilapia (both adult and recruits) was least affected indicating their trophic plasticity and adaptability. This is also exemplified by the practically the same production obtained, irrespective of the supplementary fertilizing level (Table 5).

An important reason for the low overall production was the low increase in weight of bighead carp and common carp, perhaps due to non-availability of sufficient feed due to excessive proliferation of Nile tilapia.

Comparatively higher variation in the growth rate of Nile tilapia was observed especially due to the presence of female Nile tilapia. Male Nile tilapia exhibit growth superiority when grown in ponds (Edirisinghe, 1986) and lakes (Balarin and Hatton, 1979). Nile tilapia used might have had a wide genetic variation due to non-selective breeding and nursing.

Edirisinghe (1988) has reported that a production of around 21 kg/ha/d was obtained when Nile tilapia males were introduced to the same polyculture system. Therefore, the observed low production of marketable sized fish (8.018 kg/ha/d) would not have been due to limitations in the supplementation of the nutrients as shown by the rather constant plankton numbers (Tables 2 and 3).

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