List of Publications

1. Banerjee, S. & Barat, S. 2012. Effect of cow dung and stocking density on growth and production of Indian Major Carp and Ctenopharyngodon idella (Grass Carp) under integrated farming system in terrai region of West Bengal. *J. Interacad.*16 (2a):541-549.

2. Banerjee, S., Nur, R. & Barat, S. 2013. Effect of different organic manures on live weight gain of Indian Major Carp and Grass Carp *(Ctenopharyngodon idella,* Hamilton) under Integrated Fish Farming System in Terai region of West Bengal. *Environment and Ecology.* 31(2): 938-942

3. Banerjee, S. & Barat, S. 2013. Economics of different livestock-carp integrated farming systems over traditional non integrated farming system in terai region of West Bengal, India. *Society of Krishi Vigyan.* 1(2) : 20-24.

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EFFECT OF COW DUNG AND STOCKING DENSITY ON GROWTH AND PRODUCTION OF INDIAN MAJOR CARPS AND CTENOPHARYNGODON IDELLA (GRASS CARP) UNDER INTEGRATED FARMING SYSTEM IN TERAI REGION OF WEST BENGAL

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ABSTRACT

A study of six months duration from April to September was executed during the year 2010 and 2011 to observe the effect of different stocking density on fish growth rate and its production under integrated farming system in Jalpaiguri District of West Bengal, India. Three treatments namely, T_1 (Control), stocked with Indian Major Carps and Ctenopharyngodon idella (@10,000 fingerling per hectare following traditional farming system) without any integration ; T_2 (T_1+ cow dung @2600kg/ha/ 10days interval) integrated with cow dung manure ; T_3 (T_2+ increased stocking density @20,000 fingerling/ha) were considered. For all the treatments feed were given (rice bran and mustard cake @ 1:1) @2% of the body weights of the fishes and the size of the pond were average 0.01ha. The result indicated significant positive effect (P=0.05) of regular cow-dung application on the growth rate of fishes, Catla catla (41.91±35.80 g/ month, 93.08±47.85 g/month and 70.83±47.23 g/month for T_1, T_2 and T_3 respectively), Labeo rohita (30.33±20.39 g/month, 67.83±43.79 g/month and 57.41±37.99 g/month for T_1, T_2 and T_3 respectively), Cirrhina mrigala (11.50±10.31g/month, 28.17±21.66 g/month and 21.50±22.12 g/month for T_1, T_2 and T_3 respectively) and Ctenopharyngodon idella (31.50±24.16 g/month, 73.25±35.73 g/month and 62.41±44.46 g/month for T_1, T_2 and T_3 respectively) maintaining the optimum water quality. However the increased stocking density from @10,000 fingerling per hectare to @20,000 fingerling per hectare has no significant effect on growth rate of the fishes under integrated farming system and the mortality percent was also found to be significantly lower (P=0.05) in T_3 . Overall production was achieved significantly higher (P=0.05) in T_3 (36.9±2.5 kg) followed by T_2 (25.15±3.88 kg) and then T_1(9.15±1.2kg). It can be concluded that optimum production can be achieved under integrated farming system with the stocking density @20,000 fingerling per hectare when the feeding is @2% of the body weight of the fishes and can be the best treatment in respect of economic return fetched by the farmer within six month.

Key words : **Integrated farming system, Indian major carp, Production, Grass carp, Growth rate, Cow-dung, Stoking density**

INTRODUCTION

The integration of livestock-fish-crop has received considerable attention during past thouree decade with emphasis on the incorporation of animal manures as fertilizer and nutrient for promotion of natural feed in fish ponds (Wohlfarth and Schroeder, 1979; Delmendo, 1980). It stimulates the natural primary food production in ponds and its maximum utilisation by the fish (Little and Muir, 1987) thus indicating that animal waste in aquaculture plays an important role. Integrated farming system seems to be the possible solution to meet the increased demand for food, stability of income and sustainable management of the limited natural resources and thereby improving the nutrition of the small and marginal farmers. According to Schroeder (1980) and Dhawan and Toor (1989) more than 50% of the total input cost in fish culture may be contributed by recycling the animal waste. Studies of Afzal, *et al.* (2007), Sarkar, *et al.*(2011) and Bhakta, *et al.* (2004) on animal wastes revealed that fish yield in ponds fertilised with animal excreta was 5-7 times higher than normal fish pond. Again, higher fish production was recorded when the fish were stocked more densely as 32.7 kg/ha/day of fish when 18000 fish/ha were stocked compared to 31.5 kg/ha/day when only 9000 fish/ha were stocked (Little and Muir, 1987). The pond system's capacity to absorb waste is high in tropical region resulting as higher fish yields. Monthly yield of cow dung was observed to be 510 kg with moisture content 81%, nitrogen 3.86%, phosphate 0.5% and potassium 1.62% (Ravisankar and Pramanik, 2007).

The ponds in the study area are generally seasonal and water in the ponds is available mostly during April to October of every year hence the present experiment is for six months (April to September) of each year. The Ctenopharyngodon idella (Grass Carp) are considered along with IMC in this study as the excreta of herbivorous fish can be utilised to fertilise the water and produce plankton for filter-feeding fish to consume(Martin, *et al*. 2005) .The present study is to observe the effect of cow-dung and increased stocking density on the monthly growth rate of Catla catla ,Labeo rohita, Cirrhina mrigala and Ctenopharyngodon idella and overall pond production within six months in terrai region (Jalpaiguri District) of West Bengal.

MATERIALS AND METHODS

As experiment was carried out during April to September period of each year 2010 and 2011 at village Belacoba of Jalpaguri district, situated in the Terai region of West Bengal having a sub- tropical humid climate at 26?58'N latitude and 88?58'E longitude and 43 m above msl. The soil of the research field was sandy and loamy in texture. Nine ponds of same size (0.01 ha) were selected to carry out the three treatments T_1, T_2 and T_3 (three ponds for one treatment). The treatments were selected following the procedure mentioned by Jena, *et al.*(2007) in carp farming and Srivastava (2009) in training manual on breeding, rearing and management of Indian Major Carps (IMC), air breathing fishes and fresh water prawns. Treatment 1(T_1) (Control), was stocked with Indian Major Carps and Ctenopharyngodon idella ,an exotic carp @10,000 fingerling per hectare following traditional farming system without any integration. Treatment 2 (T_2) was integration of cow dung @2600kg/ha/ 10days interval with the aquaculture stocked with Indian Major Carps and Ctenopharyngodon idella, an exotic carp, @10,000 fingerling per hectare. Treatment

3 (T_3) was integration of cow dung @2600kg/ha/10days interval with the aquaculture stocked with Indian Major Carps and Ctenopharyngodon idella , an exotic carp ,with stocking density @20,000 fingerling/ha.Table-1 shows the details of the three treatments. The stocking ratio followed was. 1:1:1 with IMC and 10% Ctenopharyngodon idella (Srivastava, 2009) considering the market preferences of fishes with average weight 14.0-15.0 g.

All the ponds under the experiment were seasonal with an average size of 0.01 ha and depth of 1.5 to 2 m. During March, ponds were dried and the bottom soil along with aquatic weeds was removed. Raw cow-dung at the rate of 3 tonnes per ha was applied as the basal dose 15 days prior to stocking. Lime was applied @250 kg per ha three to four days prior to stocking (Jena, *et al.* 2007). The fingerlings of IMC and Grass Carp were stocked in the month of April @ 10,000 fingerlings/ha in the pond

Table 1. Detail of the three treatments followed in the experiment

Treatments	T1(control)	T_2	T_3
Farming system	Non integrated	Integrated	Integrated
No. of ponds	3	3	3
Period of study	Six month (April to September)	Six month (April to September)	Six month (April to September)
Year of study	2010 and 2011	2010 and 2011	2010 and 2011
Size of ponds	0.01ha	0.01ha	0.01ha
Stocking density	10,000/ha	10,000/ha	20,000/ha
Stocking ratio (C:R:M:GC)	3:3:3:1	3:3:3:1	3:3:3:1
Aquaculture	Composite aquaculture (IMC+GrassCarp)	Composite aquaculture (IMC+GrassCarp)	Composite aquaculture (IMC+GrassCarp)
Avg fingerling size(g)	14-15	14-15	14-15
Cow dung application	No manuring	Manuring @2600kg/ha/10days	Manuring @2600kg/ha/10days
Fish feed (Rice Bran: Mustard oil cake, 1:1)	@2% of the total fish weight	@2% of the total fish weight	@2% of the total fish weight

C= Catla catla,

R=Labeo rohita,

M=Cirrhina mrigala

GC= Ctenopharyngodon idella

under T_1, T_2 and @ 20,000 fingerlings/ha for T_3. Application of cow dung @ 2600kg per ha once in ten days (Jha, *et al.* 2004) was followed for the ponds under T_1 and T_3. The cow-dung was collected everyday and stored for application in the pond after each 10 days. The cow-dung were spread equally covering the whole pond. Starting application was 10days after stocking of fish fingerlings.

Optional application of lime @ 200kg per ha was done when the pH of pond water was found to be slightly acidic during the experiment. Supplementary feed (Mustard Oil Cake and Rice Bran @1:1) was given from the day of stocking @ 2% of total body weight once daily (R.C. Srivastava, 2009). The feeds were supplied in the pond in powdered form at the beginning and then in a dough form after 2 months of stocking.

Samples of water were collected bimonthly at a fixed hour of the day (9:00 am), using the standard water samplers. Samples were collected from different sites of each pond then pooled into one for each pond before final analysis. Water quality parameters were examined following the standard methods described by APHA (2005). Samples of zooplankton were collected from each ponds using plankton net made of standard bolting silk cloth (60ìm) and the samples were concentrated to a suitable volume for quantitative determinations following the methods described in APHA (2005).

Before sampling of fish, fishes were starved for 24 hr to avoid stressful effect of netting and handling, 0.5% of the fishes were netted from each of the pond at monthly (Goddard, 1996) and data relating to fish absolute growth rate were collected. The absolute fish growth rate was observed monthly during the study period and calculated according to Wootton (1989) as follows:

Absolute growth rate(g) = (W1-W0)/ (t1-t0)

Where

W0=mean body weight at time t0 and W1=mean body weight at time t1

Overall production of fishes and their survival were recorded at the time of harvest after the end of study period (September).

Cost – benefit analysis :

On the basis of current market prices for the procurement of advanced fry of fish and returns of fish species,the cost-benefit analysis of data was carried out following the simple procedure as (Jolly and Clonts 1993):

Profit= Gross output- Total cost.

Statistical analysis:

One –way ANOVA (Gomez and Gomez 1984) was used for the analysis of data. If the main effect was found significant, the ANOVA was followed by least significant difference (LSD) test. Statistical analysis was made by using SPSS (Version 18) software. All statistical tests were performed at a 5% probability level.

RESULTS AND DISCUSSION

During the study period the mean±SD of pond water quality of the three treatments were observed and summarized in Table 2 which shows that within T_1, T_2 and T_3 the Dissolved oxygen (mg l^{-1}) (5.39±0.42 , 5.12±0.36 and 5.02±0.49 respectively), Free carbon dioxide (mg l^{-1}) (11.38±0.93, 11.70±0.68 and 14.00±0.85

Table 2. Mean±SD of the Water Quality of pond under different Treatment (N=36) during the experiment

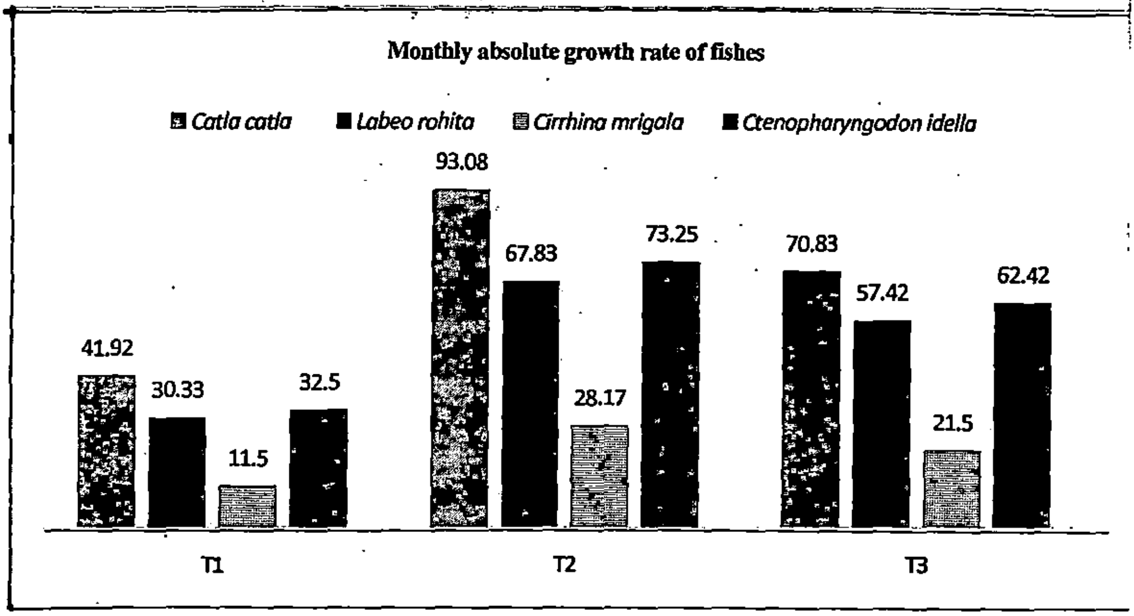
Water parameters	Treatment - 1	Treatment - 2	Treatment - 3
Temperature (°C)	29.12±1.64^{a}	26.08±1.88^{a}	28.81±1.36^{a}
pH	7.94±0.60^{a}	7.96±0.44^{a}	7.65±0.57^{a}
Dissolved oxygen (mg l^{-1})	5.39±0.42^{b}	5.12±0.36^{ab}	5.02±0.49^{a}
Free carbondioxide (mg l^{-1})	11.38±0.93^{a}	11.70±0.68^{a}	14.00±0.85^{b}
Total alkalinity (mg l^{-1})	23.81±2.09^{a}	26.61±1.47^{b}	27.46±1.40^{b}
Total hardness (mg l^{-1})	43.67±5.02^{a}	44.58±5.52^{a}	45.00±5.54^{a}
Chloride (mg l^{-1})	18.08±4.12^{a}	22.92±3.75^{b}	24.58±2.94^{b}
Ammonium-N (mg l^{-1})	0.04±0.03^{a}	0.06±0.02^{b}	0.07±0.02^{b}
Nitrite-N (mg l^{-1})	0.06±0.03^{a}	0.32±0.10^{b}	0.46±0.26^{c}
Nitrate-N (mg l^{-1})	0.23±0.14^{a}	0.38±0.31^{ab}	0.53±0.21^{b}
Phosphate (mg l^{-1})	0.03±0.02^{a}	0.29±0.10^{b}	0.33±0.14^{b}
Zooplankton (no.l^{-1})	42.08±29.61^{a}	146.67±104.37^{b}	130.08±82.07^{b}

Different superscript (a, b and c) bears significant difference (P=0.05) in the mean value

respectively), Total alkalinity (mg l^{-1}) (23.81±2.09, 26.61±1.47 and 27.46±1.40 respectively),Chloride (mg l^{-1}) (18.08±4.12, 22.92±3.75 and 24.58±2.94 respectively), Ammonium-N (mg l^{-1}) (0.04±0.03, 0.06±0.02 and 0.07±0.02 respectively), Nitrite-N (mg l^{-1}) (0.06±0.03, 0.32±0.10 and 0.46±0.26 respectively), Nitrate-N (mg l^{-1}) (0.23±0.14, 0.38±0.31and 0.53±0.21 respectively), Phosphate (mg l^{-1}) (0.03±0.02 , 0.29±0.10 and 0.33±0.14 respectively) are significantly different (p=0.05) whereas the Temperature (°C) (29.12±1.64, 26.08± 1.88 and 28.81±1.36 respectively), pH (7.94±0.60, 7.96±0.44 and 7.65±0.57 respectively) and Total hardness (mg l^{-1})(43.67±5.02, 44.58±5.52 and 45.00±5.54 respectively) are none significantly different.

It has been observed that though in T3 the Free carbon dioxide (mg l^{-1}),Total alkalinity (mg l^{-1}),Chloride (mg l^{-1}), Ammonium-N (mg l^{-1}), Nitrite-N (mg l^{-1}), Nitrate-N (mg l^{-1}) and Phosphate (mg l^{-1}) were found to be significantly higher than control(T_1) but the pH and temperature were within the moderate range maintaining the favourable condition for fish growth (Jana, *et al.* 2012) . Lloyd and Herbert (1960) showed that the toxicity of ammonia decreases with increasing carbon dioxide concentration. In the present study the Free carbon dioxide (mg l^{-1}) in T_3 was highest (14.00±0.85) which may have managed the toxicity of ammonia.

T_1 has significantly higher Dissolved oxygen (mg l^{-1}) followed by T2 then T3 indicating that manuring and increasing stocking density decreases the Dissolved oxygen. No significant difference were observed in T_2 and T_3 regarding Total alkalinity (mg l^{-1}), Chloride (mg l^{-1}), Ammonium-N (mg l^{-1}), and Phosphate (mg l^{-1}) however Nitrite-N (mg l^{-1}) and Nitrate-N (mg



l^{-1}) were found to be significantly different. Boyd (1982) observed that regardless of the source, ponds occasionally contain nitrite concentrations of 0.5 to 5.0mgl^{-1} of NO_2^--N. Again concentrations of NO_2^- as low as 0.5mgl^{-1} were found to be toxic to certain cold water fish (Crawford and Allen, 1977). While examining the interactions of stocking density of common carp and ambient ammonium concentrations, Biswas, *et al.* (2006) expressed the values at three different concentration levels of ammonium (a) favourable concentration range – 0.262 to 0.294 mg l^{-1}, (b)growth-inhibiting concentration range – 0.313 to 0.322 mg l^{-1} and (c) lethal concentration range - 0.323 to o.422 mg l^{-1}. In the present study, all the values of ambient ammonium concentration in T_1, T_2 and T_3 remained lower than the threshold concentration of 0.313 mg l^{-1} and, therefore, perhaps favourable for fish culture.

Primary productivity in respect to zooplankton (no.l^{-1}) was found to be significantly higher ($p=0.05$) in T_2 (146.67±104.37) and T3 (130.08±82.07) than T_1 (42.08±29.61) indicating that cow dung application facilitates zooplankton production in pond (Wohlfarth and Schroeder, 1979; Delmendo, 1980; Little and Muir, 1987).). Jha, *et al.* (2004) also found that application of both cow dung and poultry manure at the rate of 0.26kg per m^2 every 10 days is most suitable for better growth in Koi Carp tanks through maintenance of better water quality and greater abundance of plankton in the system. Rahman, *et al.*(2006) indicated that common carp naturally ingests mainly zooplankton and benthic macro invertebrate and small quantities of phytoplankton but when offered formulated feed, the latter becomes the preferred food item; hence feed administration enhanced growth of the common carp.

The monthly growth rate of IMC was found to be significantly higher (p=0.05) in T2 followed by T_3 then T_1 (Figure 1). The mean±SD of monthly growth rate of Catla catla; Labeo rohita; Cirrhina mrigala; Ctenopharyngodon idella in T_2, T_3 and T_1 were 93.08±47.85, 70.83±47.23 and 41.92±35.81; 67.83±43.79, 57.42±37.99 and 30.33±20.40; 28.17±21.66, 21.50±22.12 and 11.50±10.32; 73.25±35.74, 62.42±44.46 and 32.50±24.16 respectively. In case of Ctenopharyngodon idella (Grass Carp) the monthly growth rate in T2 and T3 were none significantly different but found to be significantly higher than T1(control). As evident by workers in Israel (Moav ,*et al.*1977) the high fish yields are obtainable using cattle slurry and the cattle waste inputs into the pond that were gradually increased over the period, from the equivalent of 57 dairy cows to nearly 400/ ha of fish pond. Hepher (1975) has also correlated yields in manure ponds with the stocking density of the fish and found linear relationship up to 9300 fish/ha although these yields are only likely with optimum management. Throughout the study period, it was again observed that the average monthly growth rate pattern is highest in Catla catla followed by Ctenopharyngodon idella, then by Labeo rohita and lastly by Cirrhina mrigala indicating quick and high return in Catla catla followed by Ctenopharyngodon idella, Labeo rohita and Cirrhina mrigala production under village condition.

Total mean±SD of half yearly production during the study period was significantly (p=0.05) higher in T3 (36.90± 2.54 kg) followed by, T_2(25.15± 3.89kg) and then T_1 (9.15± 1.20 kg) as depicted in Table 3. Therefore, it is evident that, though T3 has a significantly lower monthly growth rate of all the fishes but it fetches the overall highest production and there by higher economic return. Little and Muir, 1987 also opined for higher stocking density to obtain higher production. It was also reported by Schroeder (1978) that manures could achieve75% of the yields attained by using supplementary feeding of grains and 60% of the yields possible with protein-rich pellets. Schroeder(1974) observed fish yields in Israel around 14600 kg/ha/yr, and these yields correspond with those found in Brazil (Carvalho et.al.,1979) where the wastes from calves (aged between 1-180 days) are used in fish culture yields 3977 kg/ha over 130days with a tilapia hybrid. . The mean±SD fish survival (table 4) at the time of harvesting was observed to be significantly highest in T2 (70±7.07%) followed by T_3 (61±5.66%) and T_1 (50±2.83%).

Cost benefit analysis was done considering the expenditure incurred on the fingerling (@250/kg) and feed (@14/ kg).The mean ±SD of profit/half yearly in rupees are given in Table 4. It has been observed that T3 has achieved significantly (p=0.05) highest profit (Rs 2287±216) than T2 (Rs 1406±359) and T1 (Rs 141±163), indicating that the undigested fraction in animal waste is eaten by fish which may reduces the feeding cost of aquaculture (Delmendo, 1980) along with the higher zooplankton production which further facilitates the fish growth rate resulting the maximum profit inT3.Hence, in the terai region of West Bengal Treatment 3 can be the solution for income generation among the small and marginal farmers.

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Effect of Different Organic Manures on Live Weight Gain of Indian Major Carp and Grass Carp (*Ctenopharyngodon idella*, Hamilton) under Integrated Fish Farming System in Terai Region of West Bengal

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Abstract An experiment was carried out from May to September, 2011 (150 days) to observe the effect of different manures on live weight gain of Indian major carps and grass carp (*Ctenopharyngodon idella*). Three ponds were treated namely, T_1 (no manuring), T_2 (cow dung manuring) and T_3 (pig dung manuring). The results revealed significant increase in live weight gain (g) of *Catla catla* (439.00±5.85, 560.00±5.77, 669.67±1.12), *Labeo rohita* (365±8.66, 434±7.21, 474.67±4.84), *Cirrhina mrigala* (39.66±2.33, 136.33±3.17, 128.33±4.4) and *Ctenopharyngodon idella* (455.33±5.84, 485.67±3.48, 485±3.21) in T_1, T_2 and T_3, respectively. It was concluded that application of organic manure increases the live weight while pig dung showed positive influence on *Catla catla* and *Labeo rohita*.

Keywords Integrated fish farming, Water quality, Sustainability, Indian major carp, Grass carp (*Ctenopharyngodon idella*).

Introduction

Integrated farming system (IFS) is a sequential linkage between two or more farming activities (1). The integration of livestock with fish has received considerable attention during past three decade with emphasis on the incorporation of animal manures as fertilizer and nutrient for promotion of natural feed in fish ponds. It stimulates the natural primary food production in ponds and its maximum utilization by the fish and thereby indicating that animal waste in aquaculture plays an important role. Among the different culture systems, "Integrated fish farming" refers to a combination of practices. It incorporates the recycling of the wastes and recources from one farming system to the other and optimizing the production efficiencies in order to achieve maximal biomass harvest from a unit area with due environmental considerations (2). In the IFS, wastes, leftovers and by-product from other farm activities are used to raise fish. This practice results into the production of highly valued fish protein. IFS seems to be the possible solution to meet the increased demand for food, stabilise the income and manage the limited natural resources in a sustainable manner and thereby improve the nutrition of the small and marginal farmers. Studies of Afzal et al. (3) and Sarkar et al. (4) on animal wastes revealed that fish yield in ponds fertilized with animal

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Table 1. Summary of the experimental designs under different integrated farming systems.

Treatments	T_1 (control)	T_2	T_3
Components of farming	Fish	Fish cum cow	Fish cum pig
Type of farming	Non-integrated (traditional)	Integrated	Integrated
No. of ponds	1	1	1
Average size of pond (ha)	0.01	0.01	0.01
Manuring	No manuring	Manuring 2600 kg/ha/ ten days with cowdung	Manuring 2600 kg/ha/ ten days with pigdung
Stocking density of fingerlings/ha	10,000	10,000	10,000
Types of fish stocked	IMC+Grass carp	IMC+Grass carp	IMC+Grass carp
Stocking ratio	3:3:3:1	3:3:3:1	3:3:3:1
Fish feeding schedule (on daily basis)	2% of total body weight with mustard oil cake and rice bran (1:1)	2% of total body weight with mustard oil cake and rice bran (1:1)	2% of total body weight with mustard oil cake and rice bran (1:1)
Duration of study	2011 (150 days)	2011 (150 days)	2011 (150 days)

excreta was 5—7 times higher than that of normal fish pond. IFS, involving aquaculture, have usually been classified according to the combination of farm enterprises being practised, viz. rice-cum-fish, pig-cum-fish, poultry-cum-fish and multi component systems with three or more enterprises, usually crop-livestock-fish farming system. The integration of duck and chicken with fish poly culture system is amongst the most popular in Asian countries followed by pig-fish and ruminants (cattles)-fish production systems (5). The best way to reduce the cost of fish production is to minimize the use of supplemental food; and this can be best achieved by exploiting the synergetic interaction between natural food and supplemental feed (6). Thus, utilization of resources through IFS increases production per unit area, helps achieve efficient recycling of farm wastes, generates more employment, reduces the risk and ensures environmental safety and sustainability.

Terai region of northern region of West Bengal is situated between 25°57′ and 27°N latitude and 88°25′ and 89°54′ E longitude with an altitude of 360 ft above mean sea level (MSL). The ponds in the study area are generally seasonal and water in the ponds is available mostly during April to October of every year. Accordingly the present experiment was for six months (April to September) of a year. Since as the excreta of herbivorous fish can be utilized to fertilize the water and produce plankton for filter-feeding fish to consume (7), the *Ctenopharyngodon idella* (grass carp) are considered along with IMC in this study. The present study is to observe the effect of cow-dung and pig dung on the monthly growth rate of *Catla catla, Labeo rohita, Cirrhina mrigala* and *Ctenopharyngodon idella* and to find the overall pond production within six months in terai region (Jalpaiguri district) of West Bengal.

Materials and Methods

The experiment was carried out during May to September (150 days) period of 2011 in a village Belacoba of Jalpaiguri district, situated in the Terai region of West Bengal having a sub-tropical humid climate at 26°58′ N latitude and 88°58′ E longitude and 43 m above msl. The soil of the research field was sandy and loamy in texture. Three ponds of same size (0.01 ha) were selected to carry out the three treatments T_1, T_2 and T_3 (one ponds for one treatment). The treatments were selected following the procedure mentioned by Jena et al. (8) in carp farming and Srivastava (9) in training manual on breeding, rearing and management of Indian major carps (IMC), air breathing fishes and fresh water prawns. Treatment 1 (T_1) (con-

Table 2. Mean ± SE of water quality parameters and Zooplankton under different Treatments. Different superscripts (a, b and c) denotes significant difference and similar superscripts denote non-significant difference between treatments at 5% level. N=6 for all the parameters.

Parameters (mg/l)	T_1	T_2	T_3
Temperature (°C)	29±0.84^a	28.73±0.64^a	29.13±0.73^a
pH	8.5±0.20^b	7.9±0.24^{ab}	7.7±0.9^a
Dissolved oxygen	7.7±0.09^b	6.42±0.17^a	6.38±0.13^a
Free carbon dioxide	10.87±0.08^a	10.95±0.16^a	11.67±0.15^b
Total alkalinity	22.87±0.65^a	26.52±0.76^b	27.23±0.63^b
Total hardness	42.83±1.87^a	43.17±1.64^a	42.17±2.77^a
Chloride	18.0±2.11^a	24.33±3.75^a	27.16±4.86^a
Ammonium-N	0.02±0.005^a	0.03±0.001^a	0.04±0.002^a
Nitrite-N	0.28±0.027^a	0.30±0.017^a	0.35±0.04^a
Nitrate-N	0.24±0.017^a	0.34±0.023^b	0.32±0.02^b
Phosphate	0.25±0.075^a	0.45±0.08^a	0.48±0.70^a
Zooplankton (no/l)	23.14±1.5^a	126.33±4.6^b	135.85±3.0^b

trol), was stocked with Indian major carps and *Ctenopharyngodon idella*, an exotic carp at 10,000 fingerling per hectare following traditional farming system without any integration. Treatment 2 (T_2) was integration of cow dung at 2,600 kg/ha per 10 day interval with the aquaculture stocked with Indian major carps and *Ctenopharyngodon idella*, an exotic carp, at 10,000 fingerling per hectare. Treatment 3 (T_3) was integration of pig dung at 2,600 kg/ha per 10 days interval with the aquaculture stocked with Indian major carps and *Ctenopharyngodon idella*, an exotic carp, with stocking density at 10,000 fingerling/ha. Table 1 shows the details of the three treatments. The stocking ratio followed was 1:1:1 with IMC and 10% *Ctenopharyngodon idella* (9) considering the market preferences of fishes with average weight 14.0—15.0 g.

All the ponds under the experiment were seasonal with an average size of 0.01 ha and depth of 1.5 to 2 m. During March, ponds were dried and the bottom soil along with aquatic weeds was removed. Raw cow-dung at the rate of 3 tonnes per ha was applied as the basal dose 15 days prior to stocking. Lime was applied at 250 kg per ha three to four days prior to stocking (8). The fingerlings of IMC and grass carp were stocked in the month of April at 10,000 fingerlings/ha in the pond under T_1, T_2 and T_3. Application of cow dung at 2,600 kg per ha once in ten days (10)

Table 3. Mean ± SD of absolute monthly growth rate of different species of fish under different treatments (N=6).

Treatments	*Catla catla* (g/month)	*Labeo rohita* (g/month)	*Cirrhina mrigala* (g/month)	*Ctenopharyngodon idella* (g/month)
T_1	69.16±4.16	61.16±3.54	4.56±7.86	71.50±3.89
T_2	90.83±6.96	67.8±4.15	21.5±2.69	78.66±4.62
T_3	109.17±5.86	75.33±5.85	19.83±2.29	77.66±3.93

was followed for the ponds under T_2 and in the same way application of pig dung was followed at 2,600 kg per ha once in ten days for the ponds under T_3 in this study. The cow-dung and the pig dung were collected everyday and stored for application in the pond after every 10 days. The cow-dung and the pig dung were spread equally covering the whole pond. Application was started after 10 days from the stocking of fish fingerlings.

Optional application of lime at 200 kg per ha was done when the pH of pond water was found to be slightly acidic during the experiment. Supplementary feed (mustard oil cake and rice bran at 1:1) was given once daily starting from the day of stocking at 2% of total body weight (9). The feeds were supplied in the pond in powdered form at the beginning and then in a dough form after 2 months of stocking.

Samples of water were collected bimonthly at a fixed hour of the day (9:00 am), using the standard water samples. Samples were collected from different sites of each pond then pooled into one for each pond before final analysis. Water quality parameters were examined following the standard methods described by APHA (2005). Samples of zooplankton were collected from each pond using plankton net made of standard bolting silk cloth (60 µm) and the samples were concentrated to a suitable volume for quantitative determinations following the methods described in APHA (11).

Before sampling of fish, fishes were starved for 24 h to avoid stressful effect of netting and handling and 0.5% of the fishes were netted from each of the pond on a monthly basis (12) and data relating to absolute growth rate of fish were collected. The absolute fish growth rate was observed monthly during the study period and calculated as follows:

$$\text{Absolute growth rate (g)} = (W_1 - W_0)/(t_1 - t_0)$$

Table 4. Mean ± SE of different live weight gain of fish under different treatments. Different superscripts (a, b and c) denotes significant difference and similar superscripts denote non-significant difference between treatments at 5% level. N=6 for all the parameters.

Treat-ments	*Catla catla*	*Labeo rohita*	*Cirrhina mrigala*	*Ctenopha-ryngodon idella*
T_1	439.00 ± 5.85[a]	365 ± 8.66[a]	39.66 ± 2.33[a]	455.33 ± 5.84[a]
T_2	560.00 ± 5.77[b]	434 ± 7.21[b]	136.33 ± 3.17[b]	485.67 ± 3.48[b]
T_3	669.67 ± 1.12[c]	474.67 ±4.84[c]	128.33 ± 4.4[b]	485 ± 3.21[b]

Where W_0=mean body weight at time t_0 and W_1=mean body weight at time t_1

One-way ANOVA (13) was used for the analysis of data. If the main effect was found significant, the ANOVA was followed by least significant difference (LSD) test. Statistical analysis was made by using SPSS (Version 18) software. All statistical tests were performed at a 5% probability level.

Results and Discussion

Water quality

During the study period the mean±SE of pond water quality of the three treatments observed are summarized in Table 2. It shows that within the treatments T_1, T_2 and T_3 the values of all physico-chemical parameters except, temperature, total hardness, chloride, ammonium-N, nitrite-N and phosphate-p are significantly different ($p \leq 0.05$).

The pH and temperature were found to be within the moderate range maintaining the favorable condition for fish growth (14). T_3 and T_2 had significantly lower dissolved oxygen than T_1 indicating that manuring decreases the dissolved oxygen. Ammonia is more toxic when dissolved oxygen concentration is low (15). Free carbon dioxide was observed to be significantly higher in T_3 than T_2 and T_1. The concentrations of total alkalinity and nitrate-N are found to be significantly higher ($p \leq 0.05$) in T_2 and T_3 than the control (T_1).

Biswas et al. (16) expressed the values at three different concentration levels of ammonium (a) favorable concentration range : 0.262 to 0.294 mg/l, (b) growth-inhibiting concentration range : 0.313 to 0.322 mg/l and (c) lethal concentration range : 0.323 to 0.422 mg/l. In the present strudy, all the values of ambient ammonium concentration in T_1, T_2 and T_3 remained lower than the threshold concentration of 0.313 mg/l and, therefore, perhaps favorable for fish culture under waste fed condition though the dissolve oxygen was low in T_2 and T_3. Murad and Boyd (17) stated that ponds should have at least 20 mg/l total alkalinity for good fish production. In the present study, the total alkalinity was found to be more than 20 mg/l in T_2 and T_3 throughout the experiment. Hence, the use of organic inputs may keep total alkalinity at higher levels.

Zooplankton production

Quantitative study of zooplankton was found to be significantly higher ($p \leq 0.05$) in T_2 (126.33 ± 4.6 no./l) and T_3 (135.85 ± 3.0 no./l) than T_1 (23.14 ± 1.5 no./l) indicating that cow dung application facilitates zooplankton production in pond. Jha et al. (10) also found that application of both cowdung at the rate of 0.26 kg/m^2 per 10 days is most suitable for better growth of koi carp in tanks through maintenance of better water quality and greater abundance of plankton in the system. Rahman et al. (18) too indicated that common carp naturally ingests zooplankton and benthic macro invertebrate and small quantities of phytoplankton but when offered formulated feed, the latter becomes the preferred food item; hence feed administration enhanced growth of the common carp.

Growth rate and live weight gain of different fishes

The mean±SD of monthly growth rates (g/month) of *Catla catla; Labeo rohita;* and *Cirrhina mrigala;* in T_1, T_2 and T_3 are shown in Table 3. However, the monthly growth rate was found to be non-significantly different ($p \geq 0.05$) among the three treatment but throughout the study period, it was again observed that the average live weight gain after 150 days was significantly higher ($p \leq 0.05$) in T_2 and T_3 for all the fishes (Table 4) namely *Catla catla, Labeo rohita, Cirrhina mrigala* and *Ctenopharyngodon idella* indicating quick and high return from aquaculture when applied organic manure under village condition. Pig dung was found to be significantly ($p \leq 0.05$) influencing the weight gain in *Catla catla* and *Labeo rohita*. Singh and Sharma (19) determined the efficiency of cow dung and pig dung and conclude that ponds treated with pig dung has higher production (2,219 kg per ha per year) of fishes than cow dung (789 kg per ha per year). Zoccarato et al. (20) also obtained high fish production (3,369.0 kg per ha per 4 months) when feed supplementation along with fertilization with pig dung were done. Thus, it was observed that application of organic manure increases the live weight of fishes while pig dung showed positive influence on *Catla catla* and *Labeo rohita*.

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Economics of Different Livestock-Carp Integrated Farming Systems over Traditional Non Integrated Farming System in Terai Region of West Bengal

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ABSTRACT

Economics of different integrated farming systems in Terai region of West Bengal were studied by observing three treatments as T1 (Control): Traditional farming system, T2: Integrated cattle farming with aquaculture and T3: Integrated cattle and ducks farming with aquaculture. The fish and milk production was significantly higher (Pd"0.05) in T3 as 27.8±0.5 kg and 441.3±81.4 l., respectively followed by T2 as 20.6±0.3kg and 405.4±27.8 l., respectively and T1 as 10.7±0.3kg and 219±5.6 l. with addition of 2,939±32.0 numbers of eggs in T3. Hence, the profit was significantly higher in T3 (Rs 25,126.8±394.0) than T2 (Rs 9,566.8±185.7) and T1 (Rs 4,982.2±206.1).

Key Words Cow-dung, Grass carp, Indian Major Carp, Livestock-Carp Integrated Farming System, Water Quality, Economics

INTRODUCTION

Integrated Farming Systems (IFS) have received considerable attention in recent years due to the reason that the resources being used under non-integrated farming system are depleting and thus the prevailing farming system is not sustainable in long run resulting threat to the environment. During past three decades great emphasis was given on the incorporation of animal manures as fertilizer and nutrients for promotion of feed and fauna in fish ponds and utilized by the fish . According to Dhawan and Toor (1989) more than 50 per cent of the total input cost in fish culture may be reduced by recycling the animal waste. Hence integrated livestock- carp farming became important to ensure waste management as well as in reducing the production cost (Nnaji *et al.*, 2011)

As the integrated farming system seems to be profitable by reducing the input cost and probable solution to meet the increased demand for food stability, the present study was therefore executed to observe the economics of two IFS models, using different existing components such as cow, ducks and fish ponds in Terai region of West Bengal.

MATERIALS AND METHODS

Study area

The experiment was carried out during the years 2010 and 2011 at a village Belacoba of Jalpaguri district, situated in the northern region of West Bengal, India having a sub- tropical humid climate at 26Ú58´N latitude and 88Ú58´E longitude (43 m above msl). The soil of the research field was sandy - loam in texture.

Experimental design

Nine ponds were selected in triplicates for each treatment of same size 0.01 hectare (ha) to carry out the three treatments T1, T2 and T3 (Table 1). Ponds were stocked with Indian Major Carp (IMC) as *Catla catla, Labeo rohita* and *Cirrhina mrigala* and Exotic Carp *Ctenopharyngodon idella*, in the stocking ratio of 3:3:3:1 as suggested by Jena *et al.*, (2007).

Pond Management under different treatments

All the ponds under experiment were seasonal (April to September) from 2010 to 2011 with an average size of 0.01 ha and depth of 1.5 to 2.0 m. During March, ponds were dried and the bottom

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soil along with aquatic weeds and unwanted fishes were removed. Raw cow-dung at 3 t/ ha was applied as the basal dose 15 days prior to stocking. Lime was applied @250 kg/ha three to four days prior to stocking. The fingerlings were stocked in the month of April @ 10,000 fingerlings/ha in the ponds under T1, T2 and T3. The average weights of the fingerlings were 14-15g. Application of cow dung @ 2600kg/ ha once in ten days was followed for the ponds under T2 and T3. Optional application of lime @ 200kg / ha was done to maintain the pH of the ponds between 6.5 to 8.5. Supplementary feed in the form of Mustard Oil Cake and Rice Bran in the ratio 1:1 was applied after stocking @ 2 per cent of total body weight once a day. The cow-dung was collected everyday and stored for application in the pond after each 10 days. The cow-dung was spread equally covering the whole pond. Starting application of manuring was 10days after stocking of fingerlings. The methology followed was as suggested by Jha *et al.*, 2004 and Jena *et al.*, 2007.

Livestock Management under different treatments

The livestock considered in this study was non descriptive (local variety with no specific breed character) cows and ducks mostly prevalent amongst small and marginal farmers of this area with the production potentiality of 500 to 800 l/ lactation and 80-120 eggs/year , respectively. In T1 the cattle was reared in extensive system of rearing where, the cow was allowed to graze whole day and at night shelter was provided along with some paddy straw and water. The cow dung was not stocked to integrate with aquaculture. Milking of the cow was done twice a day.

The cattle under T2 and T3 were reared in semi-extensive system where the cows were allowed to graze for 6 hours every day considering the climatic condition to avoid stress. In cattle house, the cows were provided concentrate feed @ 1kg /day along with some green grass and paddy straw. The cow dung was collected to integrate with aquaculture. De-worming of the cows were done routinely thrice in a year.

Additional twenty ducks were reared in extensive system in T3 along with the cattle. After one month of stocking five months old ducks were brought into use. Ducks were allowed to graze on the pond from 9.00 am to 5 pm daily and fed with kitchen left overs and agricultural by-products @75g/d. The eggs produced were collected in the morning.

Sampling of pond water

Water samples were collected from different sites of the ponds at bimonthly intervals at a fixed hour of the day (9:00 am). The water quality parameters were analysed following the standard methods as described by APHA (2005).

Cost-benefit analysis

Cost-benefit analysis of the data was carried out on the basis of current market prices for the investment made as input cost and the total returns of fish harvested , milk and egg produced as gross output from the farm and following the simple procedure as suggested by Jolly and Clonts (1993).

Profit = Gross output –Total Cost

Statistical analyses

One-way ANOVA (Gomez and Gomez, 1984) was used for the analysis of data. If the main effect was found significant, the ANOVA was followed by a least significant difference (LSD) using Duncan's Multiple Range Test (DMRT). All statistical tests were performed at a 5 per cent probability level using the statistical package SPSS-18.

RESULTS AND DISCUSSION

Water Quality

It was found that within the treatments i.e., T1, T2 and T3 the values of all physico-chemical parameters except total hardness were significantly different (pd" 0.05). Total alkalinity, concentration of chloride, ammonium-N, nitrite-N, nitrate-N and phosphate- p were found to be significantly higher (pd"0.05) in T2 and T3 than the Control (T1). T3 significantly had the higher (pd"0.05) Phosphate- p concentration indicating that duck grazing may have affected the Phosphate- p concentration in pond water. Phosphorus is commonly considered the major limiting nutrient in freshwater, and additions of phosphorus often result in increased primary production in aquaculture systems (Daina *et al.*, 1991).

Table 1. Experimental Designs under different Integrated Farming Systems.

Treatment	T1(Control)	T2	T3
Components of farming	Fish and cow	Fish cum cow	Fish cum cow cum duck
Type of farming	Non-integrated (Traditional)	Integrated	Integrated
No. of ponds	3	3	3
Average size of pond(ha)	0.01	0.01	0.01
Manuring	No manuring	Manuring @ 2600kg/ ha / ten days with cowdung	Manuring @ 2600kg/ ha / ten days with cowdung
No. of ducks per pond	nil	nil	20
Stocking density of fingerlings/ha	10,000	10,000	10,000
Types of fish stocked	IMC+Grass carp	IMC+Grass carp	IMC+Grass carp
Stocking ratio	3:3:3:1	3:3:3:1	3:3:3:1
Fish feeding schedule (on daily basis)	@ 2% of total body weight with Mustard oil cake and Rice Bran (1:1)	@ 2% of total body weight with Mustard oil cake and Rice Bran (1:1)	@ 2% of total body weight with Mustard oil cake and Rice Bran (1:1)
No of Cattle	1	1	1
System of cattle rearing	Extensive	Semi extensive	Semi extensive
Feeding schedule of cow	12 hours grazing with	6 hours grazing and Concentrate feed and green grass along with paddy straw	6 hours grazing and Concentrate feed and green grass along with paddy straw
Type of cow	Non descriptive	Non descriptive	Non descriptive
System of duck rearing	Nil	Nil	Extensive
Type of Duck	Nil	Nil	Non descriptive
Duration of Study	2008-2011(4 years)	2008-2011(4 years)	2008-2011(4 years)
Harvesting of Fish	Six months	Six months	Six months

Table-2: Mean ± SE of water quality parameters under T1, T2 and T3.

Parameters	T1	T2	T3
Temperature (°C)	29.70 ± 0.23^{b}	28.67 ± 0.20^{a}	28.86 ± 0.20^{a}
pH	8.17 ± 0.07^{b}	8.11 ± 0.05^{b}	7.74 ± 0.07^{a}
Dissolved oxygen (mg l^{-1})	7.38 ± 0.08^{b}	6.72 ± 0.05^{a}	9.25 ± 0.15^{c}
Free carbon dioxide (mg l^{-1})	11.02 ± 0.17^{c}	10.34 ± 0.13^{b}	9.45 ± 0.09^{a}
Total alkalinity (mg l^{-1})	22.64 ± 0.33^{a}	23.15 ± 0.28^{ab}	23.97 ± 0.29^{b}
Total hardness (mg l^{-1})	44.54 ± 0.62^{a}	44.17 ± 0.59^{a}	44.58 ± 0.76^{a}
Chloride (mg l^{-1})	17.14 ± 0.54^{a}	24.17 ± 0.70^{b}	29.18 ± 0.67^{c}
Ammonium-N (mg l^{-1})	0.04 ± 0.01^{a}	0.08 ± 0.02^{b}	0.08 ± 0.02^{b}
Nitrite-N (mg l^{-1})	0.40 ± 0.02^{a}	0.40 ± 0.03^{ab}	0.49 ± 0.03^{b}
Nitrate-N (mg l^{-1})	0.21 ± 0.04^{a}	0.49 ± 0.03^{b}	0.48 ± 0.03^{b}
Phosphate (mg l^{-1})	0.24 ± 0.023^{a}	0.41 ± 0.03^{b}	0.59 ± 0.02^{c}

Different superscripts (a, b and c) denotes significant difference and similar superscripts denote non-significant difference between treatments at 5% level. N=72 for all the parameters.

Table 3. Mean ± SE of different productions of fish, milk and eggs under different Treatments.

Treatments	*Catla catla*	*Labeo rohita*	*Cirrhina mrigala*	*Ctenopharyngodon idella*	Total fish production (kg/six month)	Milk (l/year/cow)	Eggs (no./year)
T1	4.93± 0.11^{a}	3.65±0.22^{a}	0.48±0.04^{a}	1.61±0.11^{a}	10.67±0.33^{a}	219±5.56^{a}	.0000^{a}
T2	9.48± 0.19^{b}	6.65±0.14^{b}	1.37±0.11^{b}	3.07±0.14^{b}	20.57±0.33^{b}	405.42±27.81^{b}	.0000^{a}
T3	12.59± 0.26^{c}	8.84±0.17^{c}	2.93±0.15^{c}	3.42±0.15^{b}	27.78±0.50^{c}	441.25±18.42^{b}	2939±32.41^{b}

Different superscripts (a, b and c) denotes significant difference and similar superscripts denote non-significant difference between treatments at 5% level. N=12 for all the parameters.

Table 4. Mean ± SE of net income (profit) under different Treatments.

Treatments	Total Expenditure (Rs)	Gross income (Rs)	Net Income(profit) (RS)
T1	1175.50±50.70^{a}	6157.75±212.22^{a}	4982.25±206.09^{a}
T2	2812.50±81.48^{b}	12379.25±257.76^{b}	9566.75±185.74^{b}
T3	3873.00±153.03^{c}	28999.75±541.07^{c}	25126.75±393.99^{c}

Different superscripts (a, b and c) denotes significant difference between treatments at 5% level. N=4 for all the parameters and 1$=50 Rupees.

The pH and temperature were found to be within the moderate range maintaining the favourable condition for fish growth (Jana *et al.* 2012). Biswas, *et al.* (2006) expressed the values at three different concentration levels of ammonium (a) favourable concentration range : 0.262 to 0.294 mg/ l, (b)growth-inhibiting concentration range : 0.313 to 0.322 mg/ l and (c) lethal concentration range : 0.323 to o.422 mg/ l. In the present study, all the values of ambient ammonium concentration in T1, T2 and T3 remained lower than the threshold concentration of 0.313 mg/ l and, therefore, perhaps favourable for fish culture under waste fed condition. Murad and Boyd (1991) stated that ponds should have at least 20 mg/ l total alkalinity for good fish production. In the present study, the total alkalinity was found to be more than 20 mg/ l in three treatments throughout the experiment where T3 had significantly higher total alkalinity than T2 and T1. Hence, the use of organic inputs may keep total alkalinity at higher levels.

T3 has significantly highest dissolved oxygen followed by T1 then T2 indicating that manuring decreases the dissolved oxygen and Duck grazing on pond increases the same. Ammonia is more toxic when dissolved oxygen concentration is low. No significant difference were observed in T2 and T3 regarding total alkalinity, ammonium-N, nitrite-N and nitrate-N. Free carbon dioxide is observed to be significantly higher in T1 followed by T2 and T3, respectively.

Economics Under Different Treatments:

Total Mean±SE of yearly production during the study period was significantly (pd"0.05) higher in T3 (27.8 ± 0.5 kg) followed by, T2 (20.6 ± 0.3kg) and T1 (10.7± 0.3 kg) (Table 3). High fish yield were also obtained in Israel, 30 kg/ha/d with cattle manure (Schroeder, 1975), 40 kg/ha/d with duck manure and waste feed (Wohlfarth, 1978) and 20 kg/ha/d with chicken manure (Milstein *et al.* 1995). It has also been reported that the application of 15,000 kg/ ha of cow manure resulted in an average fish yield of 300 kg/ ha while the control ponds averaged 97 kg/ ha of fish. T3 has significantly highest production of *Catla catla* (12.6±0.3 kg); *Labeo rohita* (8.8±0.2 kg); *Cirrhina mrigala* (2.93±0.2 kg) and *Ctenopharyngodon idella* (3.4± 0.2 kg) followed by T2 then T1. It was also reported by Schroeder (1975), that manures could achieve75 per cent of the yields attained by using supplementary feeding of grains and 60 per cent of the yields possible with protein-rich pellets. Fish yield in properly designed and managed manure loaded ponds can reach 5 to 10 t/ha./yr without any supplemental feeding (Schroeder, 1978). The Mean±SE of milk yield was also observed to be significantly higher in T2 (405.4 ± 27.8 lt.) and T3 (441.3±18.4 l. than T1 (219±5.6 l.). This was due to the improved feeding practice followed during the integrated farming systems. T3 had additional production of duck eggs (2939±32.41). Sharma and Olah (1986) and Sharma *et al.*, (1988) observed, that the excreta of 35 to 45 pigs, 200 to 300 ducks and 250 to 300 layer poultry birds or 150 to 200 broiler birds produced 6 to 7 t, 3 to 4 t and 4 t of fish /year, respectively when recycled in one hectare of water area under the polyculture of Indian and exotic fish.

Cost benefit analysis was done considering the expenditure incurred on the fingerling (@Rs250/kg) and feed (@Rs14/kg). It was observed, that T3 has achieved significantly (pd"0.05) higher profit (Rs 25,126±394.0) than T2 (Rs 9,566±185.7) and T1 (Rs 4,982.3±207.0), indicating that the undigested fraction in animal waste was eaten by fish which may reduce the feeding cost of aquaculture along with the higher zooplankton production which further facilitates the fish growth rate resulting in maximum profit inT2 and T3. Studies of Afzal *et al.* (2007), Sarkar *et al.*(2011) and Bhakta *et al* (2004) on animal wastes revealed that fish yield in ponds fertilised with animal excreta was 5-7 times higher than normal fish pond. Panda (2002) indicated, that the approach of integration of duck farming is profitable and acceptable to the farmers in the developing world for maximum utilization of land and water resources. The droppings of ducks act as a substitute to fish feed and pond fertilizer up to 60 per cent of total feed cost.

CONCLUSION

It was concluded that integrated farming system responds well when the number of component involved are increased. T3 had ducks as additional component which increased the potentiality of the farming system resulting in highest return (BC ratio 7.5) than T2 and T1. The BC ratio in T2 (4.4) was found to be lower than T1. Hence, in the northern part of West Bengal, integration of livestock-carp and duck can be considered the best integrated farming system model for income generation among the small and marginal farmers.

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