



Fish Culture in Intensively Cultivated Rice Fields: Growth Performance of *Cyprinus carpio*

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Abstract – The aim of this paper is to highlight the important role which integrated and concurrent rice- fish culture can play to increase production when land and water resources are becoming scarce. The experiment was comprised of five treatments: rice fields with no fish stocking, (T₁); stocked with *Cyprinus carpio* and no agrochemical spray (T₂); stocked with *C. carpio* and agrochemical exposure as per recommended doses (T₃); fish and agrochemical exposure according to rice farmers (T₄) and rice fields without fish but agrochemical exposure (T₅ or farmers treatment). Fish *C. carpio* with mean body weight of 13±0.471 were stocked @ 1 fish/3sq. m in rice plots of treatment T₂, T₃ and T₄, 15-20 days after seedling transplantation for 90 days. Results revealed significantly (P<0.05) high growth performance in terms of live weight gain, specific growth rate (SGR), growth percent gain in body weight in the group of fishes in treatment T₃. Significant population of planktons were also built up in all the treatments indicating the presence of fish food organisms. The rice production was also significantly (P<0.05) high in treatment T₃ and net profit was high in all the treatments where fish were stocked in comparison to rice monocultures. The treatments with fish may be recommended for dissemination to the farmers considering high yield and economic benefits, in the agro climatic conditions of Haryana, India.

Keywords – Fish Growth, Fish Refuges, Paddy Cum Fish Culture, Paddy Plots, Water Quality.

I. INTRODUCTION

Rice cum fish culture involves the simultaneous production of fish in irrigated paddy fields so as to obtain an added production of fish with rice [1]. Rice is globally important food crop, with diversified varieties grown worldwide in a wide range of ecological conditions and water regimes [2; 3; 4]. Recent realization of declining water resources and need of protein rich human food has given impetus for developing techniques to integrate fish back into rice production. Integrated fish farming has received considerable attention in recent years in many developing countries of Asia, Africa and America [5]. The rice production is being intensified by growing fast maturing short stem varieties which require fertilizers and pesticides, these factors restrict fish production in the rice fields [6]. Fish is usually regarded as a secondary crop, and therefore, require modification of certain agronomic practices, such as selective pesticide use [7], involves management techniques that minimize the harmful effects of fertilizers and pesticides on fish and the construction of fish refuges. The integration of rice and fish production is an efficient means for agricultural land use, and offer great potential in terms of animal protein supply and income generation for small scale farmers. The most important

advantage of integration of fish with rice is that more ecological niches in the rice fields can be exploited, simultaneously [8] In Haryana, 10.08 lakh ha area is under rice cultivation, only kharif rice is grown and largest area is under basmati cultivation in the state. The major fish species cultured in Asian rice farms are the carps (Common carps, grass carp, black carp etc.), Tilapia sp. (especially *O. niloticus*), and cat fishes. But no attempt has been reported for rice cum fish culture. However, it is well known the fish yield in fields/ ponds largely depends on the abundance of planktons which serve as fish food organisms and also on the congenial environmental conditions of water [9; 10; 11; 12,13]. Therefore for the integration of fish culture practices there is need to study the ecology of rice- cum fish culture fields. Common carp (*Cyprinus carpio*) is widely cultured in Haryana and can be grown in rice cum fish systems because it can tolerate fluctuations in physico- chemical conditions of water [14] Therefore, to explore the future possibilities of paddy cum fish culture in Haryana the present investigation was undertaken to study the growth performance of *Cyprinus carpio* in paddy fields at Village Pipal Tha, Distt. Jind, Haryana (India). An attempt has also been made to compare the rice production in fields with and without fish.

II. MATERIALS AND METHODS

Site selection

Four treatments were carried out in three replicates. 12 paddy plots of 120 square meter area were selected at Village Pipal tha, Distt, Jind (Haryana), India. Experimental plots were prepared by ploughing, cultivator passing, cleaning of weeds and vegetation, preparing the bunds (embankment), trench, fish refuges, water inlet and water outlet etc. The soil of the paddy fields was fertile and with high water retaining capacity. Rice production in farmer's treatment (T₅) was also recorded/ calculated for the comparison.

Paddy plot preparation

Embankments around the paddy plots were increased up to 30-35 cm in height. A trench of 1m² was prepared in between the two paddy plots for maintenance of water level. Trench was used to filled up the rice fields and accommodate all the fishes during weeding, drying and pesticide spreading. Fish refuges were deeper area provided for fish within rice fields for feeding and facilitate fish harvest at the end of rice season. Plastic tubes or bamboo tubes were provided as permanent ways of conveying water in or out just like a regular fish pond. Screens were made from piece of fish net material was

installed across the water flow. Rice seedlings were planting in rows, roughly 25-30cm apart and fish refuges were filled with water. The experiment was carried out in four treatments and each treatment conducted in triplicates:

Treatment 1: No Fish, no pesticide in rice fields (T_1)

Treatment 2: Fish in Rice fields without pesticide exposure (T_2)

Treatment 3: Fish in rice fields with recommended dose of pesticide (T_3)

Treatment 4: Fish in rice fields with pesticide exposure whatever the dose used by farmers (T_4)

Farmer's Treatment: Rice fields without fish but pesticide exposure according to rice farmer that means farmer's treatment (T_5). Here no fish refuges or trench were constructed and water level was also not raised. Water quality was also not monitored in this treatment. Only rice production was recorded.

Fish stocking

Fingerlings of *Cyprinus carpio* with mean body weight 13 ± 0.47 g were stocked in rice fields @ 1 fish per 3 sq. m and 10- 15 days after transplanting the seedling (one month after sowing seeds in direct cropping or after bottom favouring proper rooting of the seedling) in the fields with and without pesticide exposure (in T_2 , T_3 and T_4). After seedling transplantation in the rice fields water level across the fields was increased up to 12- 15cm.

Fish Feeding

Fish were kept in experimental fields for duration of 90 days. No supplementary feed was given. The fields were fertilized using cow-dung (2000-2500 kg/ha/year) during fields preparation, sufficient planktons were developed and served as natural food for growing fingerlings.

Water quality monitoring of paddy fields

Physico- chemical characteristics

Water samples in triplicates were collected from each treatment (T_1 , T_2 , T_3 and T_4) in paddy season, (July – October), during preparation of fields before seedling transplantation and during seedling transplantation at fort nightly intervals for the study of physic-chemical characteristics following APHA [15].

Biological characteristics

Net and gross primary productivity (NPP and GPP) were determined using light and dark bottle technique [16]. Plankton samples were collected by filtering 10L of water from a plankton net (50 μ m) and enumerated as numbers L^{-1} using Sedgwick Rafter cell. Phyto- and zooplanktons were identified using suitable keys and monographs from [16-19].

Fish Harvesting

Fish were kept in experimental fields for duration of 90 days. (July to September 2011). Individual weight of fish were recorded with the help of top pan balance (Make AFCO SETEX- 1200), length of the fish were measured using a simple centimetre scale. Weight gain, Specific Growth Rate (SGR) and growth per cent gain was calculated using standard formulae [20]. The dead fishes if any, were removed and recorded for calculating the survival rate.

Proximate composition of fish

Fish carcass (initial and final) were analysed [21]. Dry matter after desiccation in an oven (at 105°C for 24 $^\circ\text{C}$), ash (incineration at 550°C for 4 hour in a muffle furnace), nitrogen using micro- Kjeldahl method were determined and crude protein content was estimated by multiplying nitrogen by a factor of 6.25. Crude fat was determined by petroleum ether extraction (Soxhlet's apparatus). Carcass phosphorus was determined spectrophotometrically after acid digestion (nitric acid: perchloric acid 10:1). Per cent nitrogen free extract (NFE) was calculated by subtracting the sum of per cent crude protein, crude fat, ash, moisture (% wet weight) and crude fibre from 100. Energy content of fish, fish feed and periphyton were calculated using the average caloric conversion factors of 0.3954, 0.1715 and 0.2364 kJ g^{-1} for lipids, carbohydrate and protein, respectively [20].

Statistical analysis

All values were represented as mean \pm S.E of mean of three replicates. ANOVA followed by Duncan's multiple range test [21] was applied to find out significant differences among different treatments

III. RESULTS

Fish growth

During the 120 days of paddy cum fish culture experiment, 50 fingerlings were stocked for 90 days in treatments T_2 , T_3 and T_4 , 15-20 days after seedling transplantation or when bottom favoured the rooting. Rice fields were dewatered 10 days prior to harvest, allowing the fish to take refuges in rescue pits. Fishes were recovered from each treatment soon after harvest. The number of fishes recovered, final weight, final length, weight gain, growth % gain in BW (%), specific growth rate and percent survival are given in Table 1. The percent survival was high in treatment T_2 (90) % and lower in treatment T_4 (76%). Fish weight gain, specific growth rate and growth percent gain in body weight was significantly ($p < 0.05$) high in treatment T_2 (fish in rice field without pesticide exposure) followed by T_3 and T_4 (Table. 1).

Fish Carcass Composition

Carcass composition revealed higher accumulation of protein, fat and energy in fish grown in T_2 (No pesticide were used) as compared T_3 and T_4 . No differences in moisture content among all the four treatments were observed. (Table. 2)

Water Quality Characteristics of experimental fields

Physico-chemical characteristics

pH values during the experimental period fluctuated between 7.9- 8.4 indicating that field waters were well buffered. No significant ($P < 0.05$) variations in dissolved oxygen (DO), alkalinity, hardness, turbidity, calcium, magnesium and $\text{O}^- \text{PO}_4$ were observed in different treatments however, the values were lower in treatment 3 and 4. Total dissolved solids, conductivity, chlorides and ammonia increased significantly ($P < 0.05$) in treatment T_3 and T_4 in comparison to treatment T_2 (Table 3), where fish growth performance was high.

Table 1: Number, size range, weight, percent survival of fish after 90 days of observation

Sr. No.	Parameters	Treatment 2	Treatment 3	Treatment 4
1.	Plot area (sq. m)	120	120	120
2.	No. of fish stocked	50	50	50
3.	No. of fish recovered	46±0.720 ^A	42±0.942 ^{AB}	38±0.942 ^B
4.	Percent survival	92±1.440 ^A	84±1.885 ^{AB}	76±1.885 ^B
5.	Initial wt. (g)	12±1.18 ^B	14±1.41 ^A	13±1.24 ^{AB}
6.	Initial Length (cms)	5.3±0.42 ^B	6.2±0.44 ^A	5.4±0.37 ^{AB}
7.	Final wt. (g)	65±2.49 ^A	63.5±2.85 ^A	59.37±1.68 ^B
8.	Final Length (cms)	16.50±0.38 ^A	15.64±0.40 ^A	14.75±0.30 ^B
9.	Weight gain (g)	52.66±2.05 ^A	50.35±1.247 ^A	47.73±1.69 ^B
10.	Growth per cent gain in BW (%)	441.66±9.228 ^A	351.55±10.674 ^B	356.15±8.84 ^C
11.	Specific Growth rate	70±0.471 ^A	61.8±0.303 ^B	57.8±0.711 ^C

All values are Mean ± S.E of mean.

Means with different letters in the same row are significantly (P<0.05) different.(Duncan's Multiple Range test).

Table: 2.Proximate composition of fish carcass after 90 days with and without pesticide exposure

Parameter	Initial	Treatment 2	Treatment 3	Treatment 4
Moisture%	70.8±0.165 ^C	71.7±0.313 ^{BC}	72.6±0.378 ^{AB}	72.9±0.098 ^A
Crude Protein%	8.6±0.165 ^C	15.3±0.212 ^A	14.6±0.268 ^A	12.03±0.118 ^B
Crude Fat%	5.0±0.072 ^C	5.6±0.178 ^B	6.2±0.098 ^{AB}	6.2±0.144 ^A
Crude Ash%	3.9±0.141 ^D	4.8±0.212 ^C	5.5±0.118 ^B	6.7±0.118 ^A
NFE%	3.7±0.411 ^C	3.9±0.237 ^C	5.2±0.151 ^B	7.1±0.124 ^A
Gross energy	4.5±0.178 ^C	8.7±0.205 ^A	6.4±0.178 ^B	5.0±0.098 ^C
Muscle glycogen	2.4±0.144 ^A	2.3±0.212 ^A	1.9±0.124 ^{AB}	1.2±0.205 ^B

All values are Mean ± S.E of mean.

Means with different letters in the same row are significantly (P<0.05) different (Duncan's Multiple Range test).

Table 3: Mean values of physico-chemical characteristics of water recorded from different treatments paddy cum fish culture fields stocked with and without *Cyprinus carpio*

Parameters	T ₁ (No fish, no pesticide)	T ₂ (fish, no pesticide)	T ₃ (Recommended dose)	T ₄ (Pesticides dose used by farmers)
pH	8.4±0.238 ^{AB}	8.3±0.162 ^{AB}	8.5±0.141 ^A	7.9±0.461 ^B
Free CO ₂ mg L ⁻¹	Absent	Absent	Absent	Absent
DO mg L ⁻¹	5.8±0.389 ^{AB}	6.3±0.225 ^A	5.0±0.437 ^B	4.6±0.55 ^C
Alkalinity mg L ⁻¹	586±25.302 ^A	585±29.346 ^A	508±23.652 ^B	500±21.291 ^B
TDS mg L ⁻¹	646.43±53.198 ^C	679.05±47.437 ^{BC}	765.66±54.028 ^{AB}	863±55.541 ^A
Coductivity µm cm ⁻¹	719.38±181.56 ^C	713.50±150.65 ^C	760±164.87 ^B	796±156.59 ^A
Chloride mg L ⁻¹	28.83±1.056 ^C	28.11±1.459 ^C	41.38±5.161 ^B	51.06±7.344 ^A
Hardness mg L ⁻¹	140± 7.671 ^A	144±9.774 ^A	119±7.308 ^B	102±8.938 ^C
Turbidity NTU	136.08±22.41 ^B	140.61±0.348 ^B	166±0.029 ^{AB}	175.96±0.328 ^A
Calcium mg L ⁻¹	26±2.385 ^A	26±2.206 ^A	19±2.063 ^{AB}	13±2.755 ^C
Magnesium mg L ⁻¹	27.86±1.827 ^A	28.87±2.438 ^A	24.40±1.658 ^A	22.38±12.808 ^A
Gross primary productivity (g Cm ⁻³ d ⁻¹)	2.1±0.220 ^A	2.07±0.223 ^A	2.1±0.280 ^A	1.71±0.188 ^A
Net primary productivity (g Cm ⁻³ d ⁻¹)	0.92±0.169 ^{AB}	0.80±0.110 ^{AB}	1.5±0.250 ^A	0.5±0.053 ^B
Ammonia mg L ⁻¹	0.143±0.038 ^C	0.268±0.049 ^B	0.360±0.069 ^A	0.449±0.096 ^A
O-phosphate mg L ⁻¹	0.168±0.034 ^{AB}	0.246±0.024 ^A	0.247±0.014 ^A	0.122±0.183 ^B
Nitrate mg L ⁻¹	0.234±0.015 ^B	0.256±0.010 ^{AB}	0.280±0.01 ^A	0.233±0.017 ^B
Nitrite mg L ⁻¹	0.078±0.018 ^B	0.089±0.02 ^{AB}	0.083±0.015 ^A	0.090±0.022 ^A

All values are Mean ± S.E of mean.

Means with different letters in the same row are significantly (P<0.05) different (Duncan's Multiple Range test).

Biological characteristics

Phytoplankton and zooplankton were collected from the experimental plots T₁ to T₄ at fortnightly interval. Total phytoplankton and zooplankton showed the development of persistent population after 15 days (Fig. 1 A & B). Among phytoplanktons the groups in order of abundance were Chlorophyceae (*Microspora*, *Tetraspora*, *Zygnema*, *Spirogyra*, *Closterium* and *Ulothrix*), Bacillariophyceae (*Navicula*, *Pinularia*, *Penium*, *Nitzschia*, *Fragillaria*) and Cyanophyceae (*Spirulina*, *Oscillatoria*, *Anabaena*, *Nostoc*). Quantitative dominance of zooplanktons was observed as Cladocera (*Daphnia magna*, *Daphnia pulex*, *Moina*, *Moinodaphnia*), Protozoa (*Euglena viridis*, *Euglena velata*), Rotifera (*Asplanchnia*) and Copepoda (*Cyclops*, *Diaptomus*). Among copepods Cyclopidae was found to be dominant over Diaptomidae.

Rice production

Rice production was calculated from mono rice and rice fish plots. There was a significant increase in rice yield in the rice-fish plots in comparison to control (T₁). Significantly (P<0.005) high rice yield was observed in T₃ (55q/ha) where farmers used recommended dose of pesticides. Fish production from concurrent rice cum fish culture system were high in treatment T₂ (249.16 Kg/ha) as compared to T₃ (222.20 kg/ha) and T₄ (187.7 kg/ha) because the pesticide adversely affect the fish production. Rice production in farmer's plots (T₅) was 45q/ha which is significantly (P<0.005) low in comparisons to rice cum fish plots with same pesticide dosage (T₃). Economics of the rice cum fish culture was calculated per hectare taking into account of expenditure on field preparation, agrochemicals etc (Table 4).

IV. DISCUSSION

In the present experiment Basmati 1121, a rice variety of 120 days duration was used. Several high yielding rice varieties produced by rice research centres such as IR8, IR20, ADT 32 etc. are used in South India for pisciculture trials. IR 26, 30, 39, 32, 38 and 40 have been used for the culture along with Tilapia and [24]. The length of duration of crop is important in view of pisciculture practice to be adopted. Therefore, the rice fields where Basmati 1121 variety is cultured were selected for the present study so that the fish growth can be easily monitored for 90 days. The results of present study revealed that survival rate of fish *C. carpio* was high 90%, 84% and 76% in treatment T₂, treatment T₃ and treatment T₄ respectively. Rahman *et al.* (2000) [5] reported survival rate (46.6%) of *C. carpio* in coastal paddy fields. Sarkar *et al.* [25] reported higher survival rate (72.2%) in rice- fish culture fields in Aman season. The high survival in the present studies may be due to better management practices. This supports the claim of some farmers that under managed conditions, fish recovery is very high [26]. For the profitable approach it is essential that aquatic conditions of rice cum fish fields including production of fish food organism should be conducive for the fish. Present analysis has indicated that the range of important water quality parameters *viz.* Dissolved oxygen, pH, free CO₂, alkalinity, hardness, chlorides salinity, calcium, magnesium and nutrients are within the optimum limits of fish culture [27], [28]. Planktonic analysis has also shown that there is sufficient food available in these rice fields and can be utilized by fish. Since the depth of water in rice fields were maintained up to 35cm, therefore the conditions appeared to be conducive for fish *C. carpio* which considered as plankton feeder and bottom dweller.

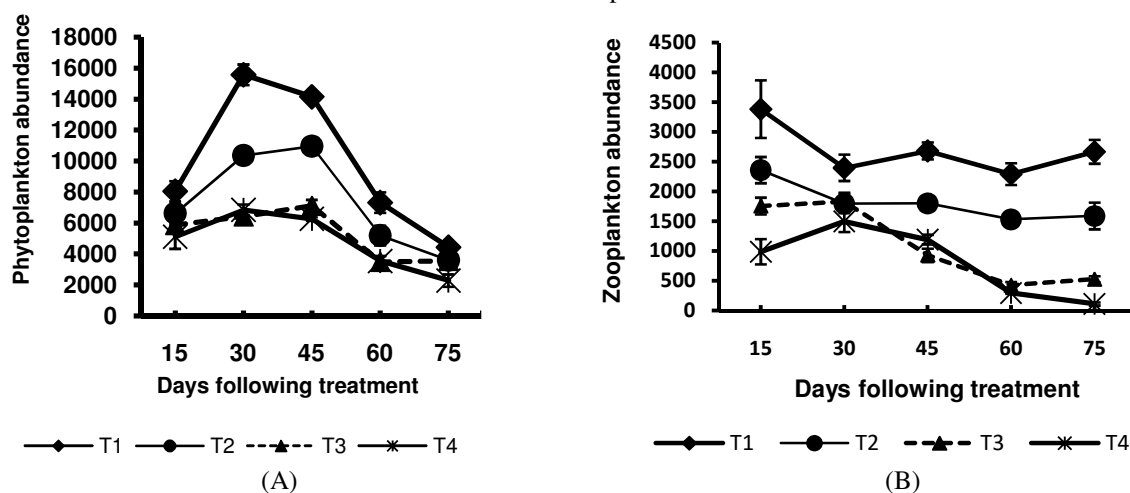


Fig.1. Phytoplankton (A) and Zooplankton (B) Abundance (Nos. L⁻¹) in different treatments at fortnightly intervals

Fish growth in terms of weight gain, growth % gain in body weight and specific growth rate was significantly (P<0.05) high in treatment T₂ and T₃ in comparison to T₄. ANOVA followed by Duncans Multiple Range Test (DMRT) indicated that there were no significant (p<0.05) variations in fish growth parameters in treatments T₁ and T₂ depicting that exposure of agrochemicals according to

recommended doses did not have any effect on fish growth. High fish growth in treatment T₂ and T₃ also coincides with congenial environmental conditions as indicated by optimum DO, nitrate and phosphate (Table 3). Garg and Bhatnagar [9,10,29] have also advocated the positive condition of fish growth with DO, phosphate and nutrients supporting optimum DO levels of present study

Table 4: Economics of Rice cum Fish culture

Rice cultivation and Fish Farming					
Treatments	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5
Recurring Expenditure for Rice and fish farming					
Rice Field Area	1 hectare	1 hectare	1 hectare	1 hectare	1 hectare
Agrochemical cost					
Total cost (₹) (Labour charges and agrochemicals)	19,000	20,000	21,715	26,368	25,000
Rice Yield, cost and earnings					
Rice yield (q/ha)	20± 1.44	32± 1.186	55± 1.186	50± 1.414	45±0.942
Total cost (₹)	40000	64,000	110000	100000	90000
Total Revenue from Paddy (₹)	21000	44000	88285	73632	65000
Fish Yield, cost and earnings					
Fish production(kg)	-----	249.16 ±0.471	222.20 ±1.186	187.7±0.942	-----
Total cost (₹)	-----	18675	16665	14077.5	-----
Net profit (₹)	21,000	66675	104950	87709	65000

in rice cum fish culture fields. Water quality characteristics further depict significantly ($p < 0.005$) high ammonia in treatment T_4 . Ammonia increases in the holding water as a result of metabolic wastes of excretion of aquatic organism and depends on the utilization of dietary protein. Fish food organisms, on day 15 (when fish were stocked) were almost similar in all the treatments and thereafter varied with time and also with respect to treatments. Decrease in number of planktonic organisms in treatment T_2 to T_4 is associated with the grazing pressure exerted by the fish. Bhatnagar and Singh [12] have also reported low plankton population in managed ponds and high fish growth because of grazing pressure exerted by the fish. The synergistic effects of pesticides and low utilization of the dietary protein in T_4 , where grazing pressure was high might be the reason for increased ammonia in treatment T_4 . The population of planktons (Fig. 1 A & B) in the rice-fish plots (T_2 , T_3 and T_4) were lower than those in rice only plots indicating that common carp which is planktons feeder consumed them as food. Rahman and Meyer [30] have advocated that common carp can consume planktons, benthic invertebrates as food. Caguanan [31] have advocated that *C. carpio* can control weed and arthropoda sort of practice of integrated pest management and leading to decreased pesticide usage. There was a significant increase in rice yield in the rice-fish plots in comparison to control (T_1). Significantly high rice yield was observed in T_3 (55q/ ha). Sinhababu *et al.* (1983) [32] have reported that fish in paddy fields increases the soil nutrient status leading to increased yield of rice supporting the present results. Nutrients influence the rice yield in fields [33], it appears that the fish in paddy fields might have increased the soil nutrient status in the present studies. Ochme (2007) [34] have reported that uptake of nitrogen by rice plants in rice-fish culture is always higher than monoculture. In the present study ammonia and nitrate in the water in rice-cum fish plots were significantly higher than in the treatment without fish (Table 3). Fish perturbation at the soil water interface might have made the soil porous for nutrients absorption

and have led to release of nutrients from soil supporting the views of Vromant and Chau (2005) [35]. Moreover, fertilizing effect from fish excrements might have also contributed significantly to increased nutrient release in turn increased rice yield. Farmers treatment (T_5) in which agrochemicals were sprayed at random and no fish were stocked showed rice production less than production in treatment 3, confirming that stocking of fish increases nutrient status of rice fish plot [4] leading to economic gain (Table 4).

V. CONCLUSION

The results thus clearly reveal that integration of rice with fish in agroclimatic conditions of Haryana appears to be a successful approach and are probably an attempt for environmental sustainability. With some modifications in management practices like construction of fish rescue pits in each plot, raising dykes and suitable screening of outlets and inlets, maintaining water level and spraying of pesticides at suitable time there is possibility of profitable fish cum rice culture. The use of fertilizers can be decreased in rice fish culture because of the fertility effect of fish excrements. Inclusion of fish in the rice culture plots is also important in terms of a decreased use of pesticides as fish can control pests in paddy fields and can also lead to food security of household/ nation.

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