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Economics of paddy cum fish culture: A case study in Sivsagar, Assam

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Abstract
The present experiment has been carried out in the rice field of Kaloogoan of Sivsagar district of Assam during 2009-2011. For which, *Sali* (*Sial Sali*) variety of rice plants were transplanted and fingerlings of *Channa punctatus* were released in the paddy field. In overall, the highest operational cost (Rs. 638.25) was recorded in plot A followed by plot B (Rs. 629.62) and plot C (Rs. 621.00) during 2011. It reveals that the operational cost was found to be highest in 2011 followed by 2010 and 2009. As a whole, in 2009, the percentage of profit was recorded highest in plot B (Rs. 110.81) and lowest in plot C (Rs. 50.45). In 2010, the profit was recorded maximum in plot B (Rs. 646.73) and minimum in plot A (Rs. 357.6) whereas in 2011, plot B (Rs. 533.90) showed the highest profit and lowest in Plot A (Rs 313.32). Total fish production, was found to be the highest in plot B followed by plot A and plot C. As a whole, the highest total fish sale was recorded from plot B (Rs 1230.35) in 2010 followed by plot A (Rs 1098.36) in 2011 and plot C (Rs 784.70) in 2009.

Keywords: *Sali*, *Channa punctatus*, Economics, Field of Kaloogoan, Assam

1. Introduction
Channa punctatus (Bloch) popularly known as spotted murrels are commercially cultured in many countries of the world. Generally, the spotted murrels consume aquatic insects and their larvae in rice-field ecosystem thereby helping the increase of rice production [1]. In some cases, rice and fish are grown serially within the same field side by side by fragmenting it, using the same water body. Rice-fish farming is becoming a popular practice in many countries of the world, particularly in Asia [2, 3]. Though, each country has innovated its own methods, there are also some common problems and practices to be found with some similarities. The potential of rice-fish farming in fighting the poverty and malnutrition has been globally recognized [4, 5]. The growing of rice and fish simultaneously in the same field is named as rice fish farming [6]; Das *et al*., 2009 [7].

In India rice-fish culture is practiced in Arunachal Pradesh, Tripura, Assam, West Bengal, South Bihar, Andhra Pradesh, Tamil Nadu and Kerala [8] but the production is low and many system are inefficient. In Kerala, the *Pokkali* fields are utilized for brackish water aquaculture while, in Arunachal Pradesh, the Apatani tribes practice fish culture in their paddy fields. In Assam, people trap varieties of wild fish including the spotted murrels from rice-fields during rainy season. However, the method of trapping fish from rice-field is still 'primitive' and the yield is therefore, very erratic and often very low. Recently, there was reported on rice-fish culture adopted by Apatani farmers in lower Subansiri District of Arunachal Pradesh [5].

As far as economics and management of rice-fish farming is concerned, Djajadiredia *et al*., 1980 [9] reported the cost and return ratios of rice-fish farm in Indonesia. In India, the benefit/cost ratios for the combined rice-fish system were studied [10]. Chinese workers [11], reported fish in the rice-field reduce the rice plant hoppers and leaf hoppers respectively and *Ctenopharyngodon idella* in rice-fields controlled rice sheath blight diseases; Yu *et al*., 1995 [12] reported that 47-51% less stem borers in fish cum rice culture system compared to monoculture of rice. Furthermore, there was reported on larvicidal activity of fish in rice-field [13] and Yan *et al*., 1995 [14] reported that growing fish was almost three times more profitable than rice alone. Gupta *et al*., 1998 [15] reported the increase of rice yield in fields with fish in Bangladesh was reported. Further, common carp is the preferred bio-control an agent in the rice-fields was reported by [16] and Halwart *et al*., 1998 [17]. Although, rice-fields are a preferred

habitat for murrels, there are hardly any reports from India regarding integrated rice-fish culture using murrel as a candidate species. To fill up the gap of the above lacunae an attempt has been made to study the economy of paddy cum fish culture in rice field ecosystem and to develop of 'package of practices'.

2. Materials and Methods

The present experiment has been undertaken in the rice field of Kaloogoan (Latitude 26º30′N and 94º36′E) of the Sivsagar district during 2009-2011. the experiment was carried out in the wet season. Three plots, with an identical area of 0.03 ha each, were used for rearing of fish. The plots had a 13.3 m^2 (5.0% of total area) peripheral trench each serving as fish refuge. The total refuge area was 40m^2 with an average depth of 0.4m to confirm the characteristic of rice-introduced fish system as suggested by Rothius *et al*., 1998 [18]. A bundh was constructed surrounding the entire plot area to prevent the escape of the rearing fishes during rainy season. Two out-lets were provided to drain out the excess of rain water from the rearing plot area and it was guarded by 5mm mesh size screen at the field water inlet and a 10.0 mm mesh size screen at the main water gate of the rearing plot to prevent weed fish and aquatic predators from entering fish rearing paddy fields.

Sali (*Sial Sali*) variety of rice plants were transplanted in the paddy field and after 7 days of transplantation of rice plants, fingerlings of *C. punctatus* (length 3.4 cm. to 4.5 cm. and weight 0.60 gm. to 0.65 gm.) were released in each plots. The income from the experimental plots was calculated by applying the formula:-

Total profit (Rs.) = Total return (Rs.) – Total cost (Rs.)

$$\text{Percent profit to investment} = \frac{\text{Profit (Rs.)}}{\text{Total Return (Rs.)}} \times 100$$

The experiment was laid out in a complete randomized design with three replicates. Rearing was done at two levels: fish present (rice-fish culture) and fish absent (rice-monoculture).

3. Results Aand Discussion

3.1. *Economics of culture of C. punctatus in Rice-fields:*

Cost and return of *C. punctatus* culture in rice-fields is represented in the table 1 & 2. In overall, the total operational cost (per unit of 0.03ha) was found to be highest in plot A (Rs. 546.25) and lowest in plot C (Rs. 519.50) for the year 2009. In case of 2010, the highest operational cost (Rs. 592.25) was observed in plot A and followed by plot B (Rs. 583.62) and plot C (Rs. 575.00). Similarly, in 2011, plot A was found to be highest (Rs. 638.25) and it's lowest in plot C (Rs. 621.00). In overall, it could be predicted that the highest operational cost was recorded in plot A followed by plot B and plot C.

The total return from the fish sale was highest in plot B (Rs 1230.35) during 2010 followed by plot A (Rs 1098.36) during 2011 and lowest in plot C (Rs 784.70) during 2009. As whole, the highest total fish sale was recorded from plot B followed by plot A and plot C. Net profit was highest in plot B (Rs 646.73) during 2010 followed by plot A (Rs 460.11) during 2011 and lowest in plot C (Rs 265.55) during 2009. The results reveals that the net profit was found to be highest in plot B next followed by plot A and plot C. Again, the percent profit to investment was also highest in plot B (110.81%) during 2010 followed by plot A (72.08%) and lowest in plot C (50.45%) during 2011. Similarly, percent profit to turn over was highest in plot B (52.56) during 2010 followed by plot A (41.89%) and lowest in plot C (33.53%) during 2011.

Regarding the average total fish production, the highest was recorded in plot B followed by plot A and plot C. As far as the profit is concerned, in 2009, the highest profit was recorded from plot B (Rs. 518.58) and followed by plot A (Rs. 371.85) and lowest in plot C (Rs. 265.55). Similarly, in 2010, profit was recorded maximum in plot B (Rs 646.73) followed by plot C (Rs 391.90) and minimum in plot A (Rs 357.6). Again in 2011, plot B showed the highest profit of Rs 533.90 followed by plot A (Rs 460.11) and lowest in plot C (Rs 313.32).

Table 1: Production cost (in Rs.) of rice cum fish culture

Input Variables	Plot A			Plot B			Plot C		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
1. Field preparation including dyke, net and trench.	100.00	110.00	120.00	100.00	110.00	120.00	100.00	110.00	120.00
2. Fingerling cost	75.00	75.00	75.00	67.50 @ 0.50 p	67.50 @ 0.50 p	67.50 @ 0.50 p	51.50 @ 0.50 p	60.00 @ 0.50 p	60.00 @ 0.50 p
3. Harvesting	100.00	110.00	120.00	100.00	110.00	120.00	100.00	110.0	120.00
4. Maintenance and incidental	200.00	220.00	240.00	200.00	220.00	240.00	200.00	220.0	240.00
5. Interest @ 15% on recurring cost	71.25	77.25	83.25	70.12	76.12	82.12	67.65	75.0	81.00
Total Cost	546.25	592.25	638.25	537.62	583.62	629.62	519.50	575.00	621.00

Table 2: Total output from rice cum fish culture

Input Variables	Plot A			Plot B			Plot C		
	2007	2008	2009	2007	2008	2009	2007	2008	2009
1. Total fish production (kg)	9.181	8.635	9.153	10.562	11.185	9.696	7.847	8.790	7.786
2. Sale rate (Rs/kg)	100.00	110.00	120.00	100.00	110.00	120.00	100.00	110.00	120.00
3. Total sale (Rs)	918.10	949.85	1,098.36	1056.20	1230.35	1,163.52	784.70	966.90	934.32
4. Profit (Rs)	371.85	357.60	460.11	518.58	646.73	533.09	265.55	391.90	313.32
5. % profit to investment	68.07	60.37	72.08	96.45	110.81	84.79	51.16	68.16	50.45
6. % Profit turnover	40.50	37.64	41.89	49.09	52.56	45.88	33.84	40.53	33.53

Fish culture in rice-field increases the production of rice. Although some production in rice growing area meant for rice plants is lost from construction of trenches, overall rice yields are reported to increase by 7-30% in integrated rice-fish culture [19]. Controlled experiments with identical management strategies resulted 7-14% higher production when fish is cultivated in rice-field by fertilizing the rice-field and by loosening the soil and controlling rice pests by fish. Again, 10-20% increase of rice is probably as a result of improved management practices. As a result of better management of water in rice-fish field and to increase fertilization which can benefit fertilizer responsive rice varieties and maintain the growth of rice in case of draught.

Various experimental results of rice cum fish culture reveal that higher economic benefit in rice-fish culture than in rice monoculture. Djajadiredia *et al.,* 1980 [9] reported the benefit/cost ratio as 1.68 for rice only and 1.91 for rice-fish culture in Indonesia whereas, the ratio was 1.63 for rice-fish culture and 1.54 for rice monoculture in India [10]. The present investigation was similar with the result recorded in the paddy fields of Arunachal Pradesh [5]. In the present study net income from rice murrel culture is about Rs. 17,500/ha/100days and the net profit/cost ratio from rice cum fish culture has been worked out as 1.304 (Table 3). With proper application of fertilizer and supplementary feeding, the production from integrated fish farming is expected to be much higher. Further, round the year fish farming in rice-fields, which are otherwise remain unutilized for most part of the year, will help in strengthening the rural economy of the marginal farmers besides providing food security and employment generation. Lastly, it may be summarized that fish culture in rice-field is technically an almost ideal method of land-use combining the production of both vegetal and animal protein quoting [20]. Its further development is important as it may contribute to a guarantee of the world food supply.

3.2. Package of practice for rice cum fish farming (Integrated rice farming with murrels)

Recently, several farm trials for improvement of the rice-fish culture system were conducted in various parts of India [21] and Grayu *et al*., 2007 [22]. On the basis of the environmental specificity and locally available resources a package of practice for murrels culture in rice-field has been developed in Sivasagar District of Assam. The package dealt with the rice-fish farming for snakehead fish *C. punctatus* is raised synchronously with *Sali* (*Sial*) paddy during July to December. The system, meant for marginal farmers, is expected to enhance the gross production of food crops as well as facilitates better livelihood option for the rural people of this region. The system may also be implemented in similar such agro system in other part of the country for sustainable development of agro economic system.

A. Rearing and production of murrels in rice-fields

I. Modification of farm land for rice murrels integration

a. Selection of plot: The productivity of the plot should be good enough for both rice and fish yield. The following conditions should be fulfilled when selecting a paddy plot for murrels culture. Normal paddy land, suitable for *Sali* with good water retention capacity and not affected by monsoon flood is preferred for rice-murrel integrated farming. It should be close to a farmer's house for better monitoring and management of the field. The soil should be slightly alkaline and preferably be loamy and alluvial type

b. Source of water: Water is critical for the survival and growth of murrels during post monsoon months. To maintain at least 30.0cm of water in the trench, rain water is to be stored in the field, or there should be provision for surface or ground water source in close proximity of the farm land.

c. Field modification and design: Preparation for construction of paddy plot should be started from March onwards. Winter and pre-monsoon months are the best period for excavation purpose. The first step of preparation is 'trench' construction for shelter of murrels in the event of drought as well as saving the murrels from scorching sunlight during August-September. Digging of trenches may be carried out in the middle of the plot or it may be in the periphery of the selected field. If the trench is dug out in the periphery of the plot, it may be 45.0cm wide and 30.0cm deep, parallel to the dyke; however, if dug out in the middle, the preferred size will be 10.0x1.0x0.5m. Alternatively, several small trenches of 40.0-45.0cm wide and 20.0-25.0cm deep may be excavated with a provision for interconnection. One of the main trenches is connected to the outlet and another is connected to inlet. The outlet must be placed at such a depth that facilitated the dewatering through main trench whenever required. While construction of trenches the top soil deposited should be spread out in the portion demarked for paddy cultivation. The rest excavated soil is utilised for constructing the dyke. In any case, total area for excavation of trenches should not exceed 20% of the farm land.

d. Construction of dyke: Dyke should be constructed in trapezoid shape and it should be strong enough to hold the good amount water and to prevent the escape of fish. Compactness and imperviousness of the dyke should be tested before releasing of fingerlings. The measurement of various parts of dyke will be as follows: Height- 80.0 cm, width-45cm and crest width-35.0 cm.

e. Construction of water inlet and outlet: Specially designed outlet and inlet are to be provided for maintenance of the water balance during rearing period. The inlet and outlet are guarded by bamboo splits (mesh size 5.0 mm) to prevent weed fish and aquatic predators from entering into paddy fields and prevent the escape of the stock fish.

II. Agronomic practice of rice

a. Recommended variety of rice: Any of the traditional variety of *Sali* viz., *Sial Sali, Gejep Sali, Manohar Sali* may be selected for integrated farming with murrels.

b. Preparation of seed bed and sowing of rice sapling: Seed bed is prepared in March. Soil is first loosen using bullock and it is followed by manuring with cow dung and lime in appropriate doses. The water is poured to make the soil softer and in early June, rice seed are sprinkled over the wet soil. After 5.0-10.0 days tender sapling come out and the saplings are then raised for 30.0-45.0 days.

c. Preparation of main field: The soil of the paddy plots is to be harrowed, puddle and leveled by using bullock immediately after construction of dykes and trenches. Liming and manuring has to be done as per requirements. Plantation of paddy seedling (*Sali*) has to be done in the later part of July. Artificial shading is necessary to protect the fingerling from high temperature.

d. Transplantation of rice sapling: The saplings are transplanted from the seed bed to the main plot in late July. Transplantation is done manually maintaining a distance of 25.0-30.0 cm from hill to hill as well as row to row.

e. Weeding: Weeding is done 2-3 times in a farming season (August-November). No insecticides/pesticides are to be applied. Traditional methods of pest control may be practiced.

f. *Harvesting*: Harvesting of paddy and murrel can be done simultaneously. Since murrels hibernate during winter, there is no point of retaining them in rice -field beyond November.

III. Murrel culture practice.

a. Maintenance of brood stock: Mature male and female murrel (*C. punctatus*) can be identified by longer ventral fin (reaches beyond vent) in male and protruding belly of the female. Brooders are to be stocked in cemented cistern or earthen pond (2x0.8x1m). The cistern is to be filled with 40.0 cm water followed by appropriate dose of liming and manuring with 2.0 kg of cowdung. Aquatic weeds such as *Eichhornia crassipes* or *Pistia sp*. is be provided to the cistern/earthen pond to create favourable condition for fish growth and spawning. Brooders are fed with live earthworm, silk moth pupae, insects, mosquito larvae etc.

b. Breeding practice and seed production: If dry weather prevails in March- April, the induced breeding of murrels may be adopted. Intramuscular injection of 'ovaprim' @ 0.2ml and 0.4ml/kg body weight of male and female respectively is to given to gravid fish. The fish displayed pairing behaviour about 4.0 hours after injection of hormone. Each female paired with a single male. Pairing of male and female after hormone injection is an indication of spawning display of murrels. In *in-situ* breeding, mature male and female brooders are stocked in the hapa in the rice-field. After proper feeding and in suitable environment they begin to spawn in the hapa. The hatchling may be collected as fish seed for rearing in the cemented tank/earthen pit.

c. Stocking size and density: After 7 -10 days of paddy plantation (late July), about 135-150 nos fingerlings (@ 4500-5000/ha) of 3.5-4.0 cm size are to be released. Before releasing of fingerlings, other predatory fishes, frogs and aquatic insects should be removed from the paddy field by hand netting.

d. Feeding and monitoring of fish health: The fingerlings are to be fed with supplementary feeding such as trash fishes, live earthworm, silk moth pupae @ 10% of the body weight daily. Neither manuring nor pesticides are to be applied while fish are reared in paddy field. However, removal of unwanted plants and provision for water upto a permissible depth (8.0-10.0 cm) has to be done regularly. Also, netting of fish, at least once in a month has to done to monitor the growth and general health of the fish.

e. Harvesting of murrels: Harvesting of fishes is to be done by November (before or after harvesting of paddy) when water in the paddy field is dried up and fishes take shelter in the trench. Harvesting of fishes may be done by manually or simple netting. By this time paddy also ready for harvesting.

B. Production levels, economics of rice cum murrel culture

a. Economics of murrels seed procurement: An estimated expenditure incurred for production of about 6000 fry of *C. punctatus* is given as follows:

Sl. No.	Head of expenditure	Quantity	Approx. Cost (Rs)
1.	Cemented cistern	1	700/-
2.	Water supply	-	300/-
3.	Cost of brooders	6 pairs	100/-
4.	Ovaprim	10ml	400/-
	Total expenditure		1,500/-

b. Economics of sali paddy cum murrels farming: The average cost of production of rice and murrels in a 0.03ha plot including construction of farm land, plantation of paddy and other associated cost are worked out as follows (Table 3):

Table 3: Economics of sali paddy cum murrels farming

Sl. No.	Head of expenditure	Qty/No.	Approx.cost (Rs)
1.	Earthwork (trench & dyke)	--	600/-
2.	Bamboo netting	--	200/-
3.	Sali crop	--	200/-
4.	Agriculture lime	3 kg	50/-
5.	Fish seed	135-150 nos.	75/-
6.	Cowdung	100 kg	50/-
7.	Urea	5 kg	50/-
8.	SSP	3 kg	25/-
9.	Harvesting cost	--	100/-
10.	Misc. expenditure	--	150/-
	Total		Rs. 1,500/-
	Interest @ 15%		Rs. 225/-
	Total expenditure		**Rs. 1,725/-**

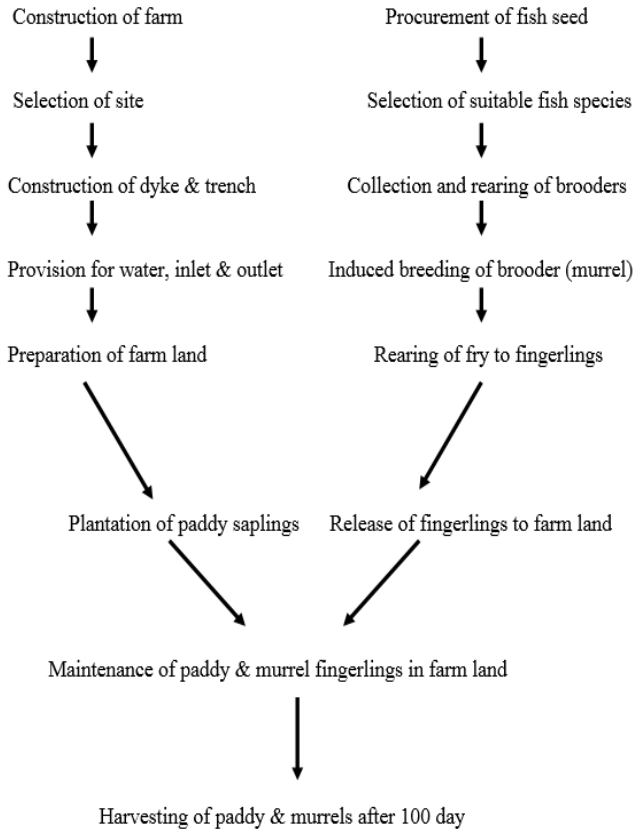
Return				
Sl. No.	**Product**	**Qty (kg)**	**Rate (Rs/kg)**	**Sale proceeds (Rs)**
1.	Paddy	105	10	1050/-
2.	Fish	10	120	1200/-
	Total			Rs. 2250/-

Net profit: Rs 2,250 – 1,725 = Rs 525/- i.e., Rs 17,500/ha/100days

C. Calendar for integrated farming activities

1. Collection of brood stock of murrel (February and March)
2. Preparation of rice seedling bed (March).
3. Maintenance and acclimatization of brood stock in the cemented cistern (March-April)
4. Preparation of main paddy field (March–July).
5. Administration of ovaprim to the brood stock in April
6. Rearing of hatchling to fingerling stage (April-July)
7. Transplantation of rice seedling (July)
8. Collection of fingerling from the cemented cistern /earthen pond and releasing them in rice-field (late July-early August)
9. Maintenance of fingerling and murrels fish in the rice-field upto November.
10. Management of the rice-field (July to November).
11. Harvesting of the fish in November and rice in late November or early December.

A model layout of rice cum murrel culture for marginal farmers



4. Conclusion

From the above study, it can enhance and to motivate the rural people by encouraging them to take up culture of native fish in the wet rice-field to boost the rural economy through community participation. As the murrel is an excellent candidate for rice-fish culture in agro-climatic conditions of Assam to a great extent. The proper management and package of practice on rice-cum murrel culture developed on the basis of the present study is expected to act as a guideline for marginal farmers.

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