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FISH-MAKHANA (*EURYALE FEROX* SALISB) INTEGRATION- A CASE STUDY OF SUSTAINABLE AQUAFARMING SYSTEM IN NORTH BIHAR

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ABSTRACT

The paper deals with a technique to synchronize two crops, fish and makhana (*Euryale ferox* Salisb) in a pond. In such eco-friendly integration both crops are mutually benefited. Decomposed plant parts of makhana crop form organic matter that releases nutrients in the water to enhance plankton population. Organic detritus not only acts as food for bottom dwelling fishes (mrigal and common carp) but also provides a suitable substratum for the growth of zooplankton, insect larvae, nematodes and gastropods. Fishes contribute to the control of makhana pests. Their faecal matter acts as organic manure for makhana crop. Plankton population fluctuated between 1260 u/l to 4030 u/l in the control pond and 1630 u/l to 4722 u/l in the experimental pond. During the grand growth period of makhana crop(April to July) the dissolved oxygen content fluctuated between 5.02 mg/l to 6.68 mg/l in the covered areas and 6.04 mg/l to 6.92 mg/l in uncovered areas. Makhana leaves acting as blanket barrier over the water surface brought down the D.O. content in the covered areas of the pond. Free CO_2 content showed wider fluctuation in the experimental pond (25.2 mg/l to 30.9 mg/l) than in the control pond.(25.1 mg/l to 28.6 mg/l). This could be due to decomposition of plant parts of the presiding crop lying as debris at the pond bottom. Autochthonous supply of nutrients enhanced the content of Nitrogen, Phosphorous and Organic Carbon in the soil of experimental pond. The experimental pond covering an area of 0.40 ha yielded 852 kg fish and 200 kg pops whereas the control pond covering the same area produced 777 kg fish only. The net profit per ha came out to be Rs. 1,04,700 and Rs. 66,200 in integrated and non-integrated system respectively. Owing to crop diversification, the present integrated system was found to be more viable than the non-integrated system in terms of production and net profit.

Key Words : Fish – Makhana (*E. ferox*, Salisb), Integration, Aquafarming, North Bihar.

INTRODUCTION

Integrated fish farming is a diversified and co-ordinated way of farming or producing agricultural crops in the fish farms with fish as the main product (NACA, 1989). This method of clubbing aquaculture with agriculture, dairy, duckery, poultry and horticulture recycles the organic wastes derived from integrated system. This mutually enhances the production without creating an adverse effect on the environment and has become popular in India (Hora, 1951, Alikunhi, 1955, Belsare *et al.*, 1979, Sharma *et al.*, 1979, Ghosh and Saha, 1980, Sinha, 1986, Edwards *et al.*, 1988, Das, 1992). However, not much work has been done on integration of makhana (*Euryale ferox*, Salisb.) with air-breathing fishes (Dehadrai, 1972, Verma *et al.*, 1996) and carps (Verma, 1994, 1999, 2005). The present study was conducted to evaluate and standardize the management of the pond through eco-friendly integration of two aquacrops (fish and makhana).

MATERIALS AND METHODS

Two ponds, situated at the outskirts of Darbhanga city ($26^0 10'$N and $85^0 54'$E) and traditionally used for makhana and fish cultivation, were selected as experimental and control ponds respectively for the present study (July' 98 to Aug' 99). Each of the pond covering an area of 0.40 ha has a depth of 1.02 m. Important parameters of water (pH, D.O and CO_2) soil (phosphorous, nitrogen and organic carbon) and plankton population were analysed following standard methods (APHA, 1985). In each pond, a total of 1400 fingerlings of catla, rohu, mrigal, common carp, silver carp and grass carp were released in July 98 in the ratio of 20:15:25:30:5:5 respectively. The grass carp were stocked in February 1999. this was in order to avoid makhana seedlings being fed upon by the voracious phytophagous grass carp. By this time slender stage of the makhan plant, which could be easily devoured by the grass carp is over. Increase in length and weight of the stocked species were recorded at monthly intervals. Total harvest of fish was done in August, 1999 and species wise weights were taken. Seeds of the preceding crop lying at the pond bottom sprouted during December - January to form the seedlings of the present crop (auto-seeding).Transplantation of these seedlings were done in March 1999 from the dense pockets to areas with thinner distribution. This was aimed at ensuring uniform distribution of the plants. During transplantation in the experimental pond vacant spaces were left in two regions i.e., central region and in corners. In the centre of the pond, 7 m long and 3 m broad vacant space was left. This space was enclosed with the help of bamboo poles (Fig-1). The purpose was not only to prevent the growing leaves from occupying the vacant space in the middle but also to compensate the depletion of oxygen in covered areas of the pond. Four vacant spaces, one on each corner were also left. In July, 1999, leaves of all the plants were cut from the petiolar region with the help of sickles. The cut leaves were left to get decayed and decomposed after keeping them in inverted position. In August, 1999 seeds scattered at the bottom of the pond were collected by the skilled fishermen virtually sweeping the floor. These seeds were finally lifted up with the help of bamboo appliances called *Gaanj* by making dives into the pond water. The seeds were weighed and were processed to get pops. The crop cycle of fish and makhana under integrated system is given in Fig- 2.

RESULTS AND DISCUSSION

During this study, the important parameters of water in experimental and control ponds (Table-1) were within the favourable range for makhana cultivation (Dutta, 1984, Mishra *et al.*, 1996) and for fish production (Banerjee, 1967). The water pH remained neutral to slightly alkaline both in experimental (7.3 to 8.2) and control ponds (7.5 to 8.0). The dissolved oxygen content in the control pond ranged between 7.15 mg/l to 8.10 mg/l. In the covered areas of the experimental pond, the D.O. ranged between 5.02 mg/l to 6.68 mg/l during April to August, 1999. This decrease in D.O. content could be attributed to the dense arching leaves of makhana which did not allow the water to come in contact with air during the grand growth period of the crop. However, the uncovered portion of the same pond during the same period witnessed the range of D.O. between 6.04 mg/l to 6.92 mg/l. Free CO_2 content showed wider fluctuation in experimental pond (25.2 mg/l to 30.9 mg/l) than that in the control pond (25.1 mg/l to 28.6mg/l).This could be due to decomposition of plant parts of the preceding crop lying as debris at the pond bottom. Monthly variations of nitrogen, phosphorous and organic carbon in soil of both experimental and control ponds are presented in Table 2. The highest percentage of organic carbon and nitrogen content recorded during August 1999 might be due to decomposition of plant parts of *E. ferox* after harvesting the crop. Progressive increase in the content of phosphorous from July to October 1998 was due to break down of dead plants of preceding makhana crop.

Plankton population fluctuated between 1260 unit per litre (u/l) to 4030 unit per litre (u/l) in the control pond and 1630 u/l to 4722 u/l in the experimental pond(Table 1). Decomposition of organic matter lying as detritus brought about a release of nutrients through mineralization. This augmented the plankton population in the experimental pond. But during May to August, 1999 plankton density was reduced due to auto-shading of the sprawling makhana leaves.

Fish production

It is evident from Table 3 that mrigal gained highest weight followed by common carp, silver carp, catla, rohu and grass carp respectively with a total fish production of 852 kg. In a previous study made by Dehadrai (1972) in a makhana swamp, a total production of 1200 kg ha^{-1} of air-breathing fishes only was obtained. Another previous study made by the present authors (Verma *et al.*, 1996) recorded a total production of 3600 kg ha^{-1} yr^{-1} of air breathing carnivorous fishes. Decomposed plant parts of makhana crop supplied organic matter, which forms food for bottom dwelling fishes like mrigal and common carp and also for benthos. This also provided a suitable substratum for enrichment of the natural food chain in this pond. Accumulation of dead plankton and other biomass contribute to accumulation organic matter in the fish ponds (Hopher, 1965) and this promotes the growth of bottom dwelling fishes (Kausal and Tyagi, 1990). Thus total fish production in such a system of integration could be increased with stock enhancement dominated by mrigal and common carp. In the control pond the highest growth was recorded for silver carp followed by common carp, mrigal, catla, grass carp and rohu respectively with a total fish production of 777 kg (Table 3). The surface feeders (silver carp and catla) witnessed highest increase (38.6%) in their growth increment followed by the bottom dwelling mrigal and common carp (36.2%). Abundance of plankton favours the growth of planktophagous fishes (Sukumaran *et al.*, 1968, 1972).

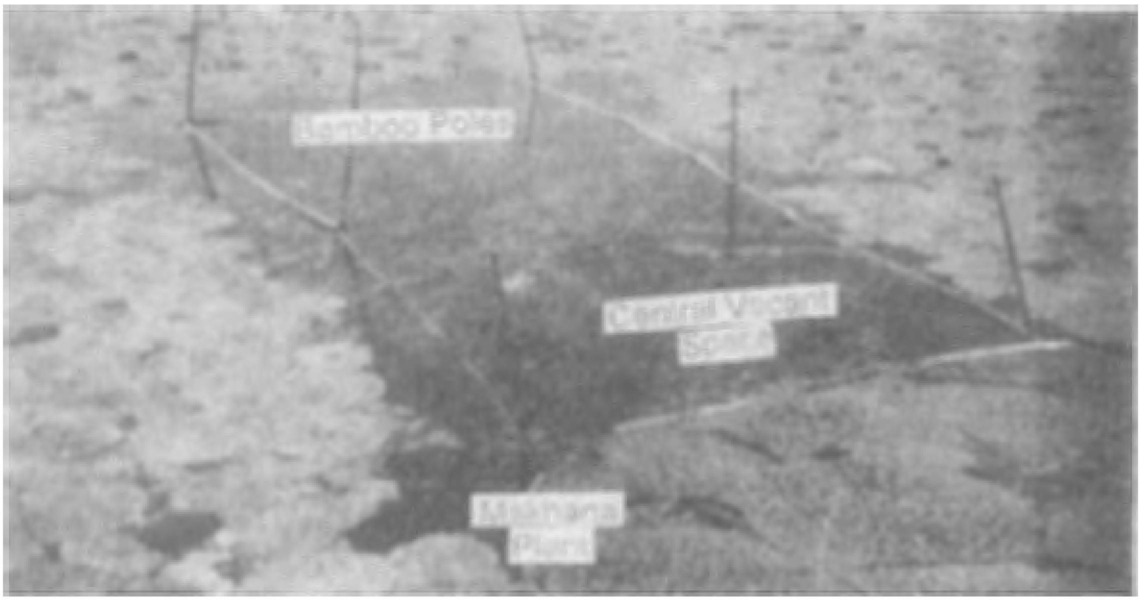

Fig. 1 Experimental pond showing central vacant space encircled with bamboo poles

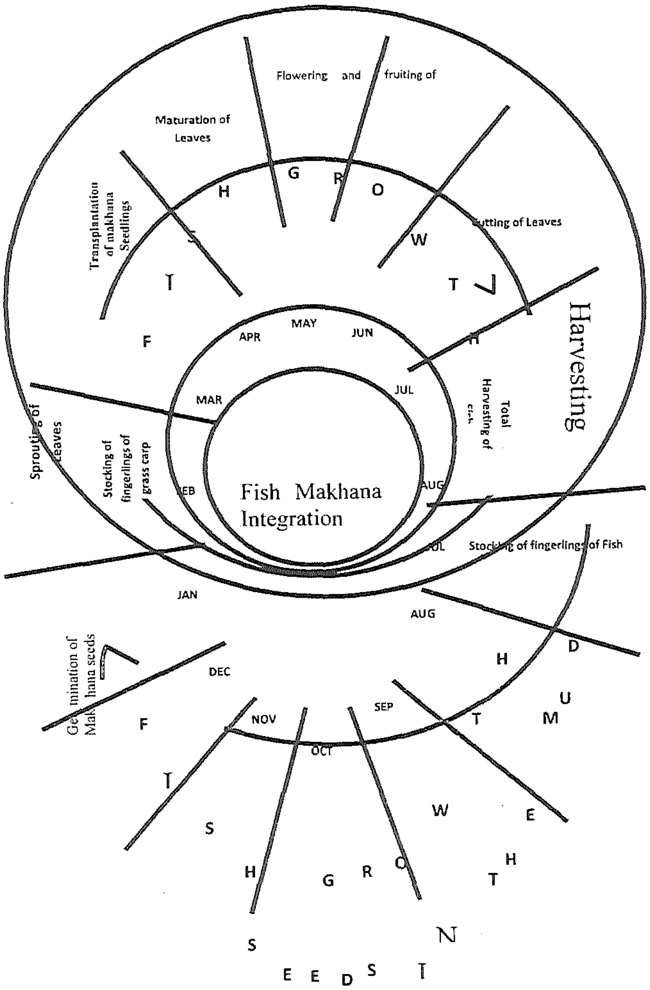

Fig. 2 Crop cycle of fish and makhana under integrated system

Table 1. Water Quality and Plankton Population in Control and Experimental Ponds

Parameter	Unit	Jul., 98	Aug., 98	Sept., 98	Oct., 98	Nov., 98	Dec., 98	Jan., 99	Feb., 99	Mar., 99	Apr., 99	May., 99	Jun., 99	Jul., 99	Aug., 99
pH	Control pond	7.8	7.7	7.7	7.8	7.9	8.0	8.0	7.9	7.9	7.7	7.7	7.5	7.5	7.5
	Eperimental pond Open Area	7.9	7.7	7.7	7.9	8.0	8.2	8.2	8.0	8.0	7.6	7.4	7.4	7.5	7.5
	Covered Area	-	-	-	-	-	-	-	-	-	7.6	7.4	7.3	7.4	7.5
Dissolved Oxygen (mg/1	Control pond	7.81	7.90	7.50	7.61	7.70	8.10	8.10	8.04	7.90	7.15	6.91	6.91	7.90	8.01
	Eperimental pond Open Area	7.08	7.10	7.48	7.52	7.64	8.02	7.94	8.10	7.12	6.92	6.12	6.04	6.88	6.90
	Covered Area	-	-	-	-	-	-	-	-	-	6.68	6.02	5.05	6.45	6.52
Free Co_2 (mg/l)	Control pond	28.6	27.9	27.3	26.1	25.2	25.1	26.4	26.2	26.1	27.3	27.7	27.9	27.1	26.9
	Eperimental pond Open Area	29.1	28.2	28.0	28.4	27.0	26.4	27.0	26.1	25.2	29.1	30.2	30.4	30.1	30.0
	Covered Area	-	-	-	-	-	-	-	-	-	29.2	30.4	32.0	30.9	30.4
Plankton (u/l)	Control pond	3720	3630	2930	2310	3940	1610	1260	1420	1630	3740	3920	4030	3920	3810
	Eperimental pond	3832	2043	2170	2183	4010	1630	1648	1786	4608	4722	2125	3121	2820	2601

Table 2. Soil Characteristics of Control and Experimental Ponds

Parameter	Unit	Jul., 98	Aug., 98	Sept., 98	Oct., 98	Nov., 98	Dec., 98	Jan., 99	Feb., 99	Mar., 99	Apr., 99	May., 99	Jun., 99	Jul., 99	Aug., 99
Organic Carbon(%)	Control pond	0.40	0.40	0.30	0.20	0.40	0.72	0.90	0.89	0.90	0.90	1.10	1.08	0.30	0.10
	Experimental pond	1.03	1.09	1.09	0.84	0.83	0.84	0.80	0.79	0.70	0.63	0.61	0.61	0.90	1.10
Nitrogen(%)	Control pond	0.032	0.028	0.020	0.030	0.038	0.035	0.040	0.048	0.050	0.060	0.047	0.045	0.030	0.028
	Experimental pond	0.095	0.081	0.083	0.020	0.092	0.092	0.090	0.063	0.055	0.049	0.050	0.050	0.070	0.096
Phosphorus (mg/100g)	Control pond	7.00	6.00	5.20	7.21	7.32	8.10	8.40	10.20	10.25	12.00	11.20	7.00	6.90	5.12
	Experimental pond	12.70	19.90	13.69	14.54	11.93	10.20	9.81	9.61	10.10	7.83	7.21	7.20	10.90	11.50

Table 3. Growth and production of fish in Experimental (E) and Control (C) Ponds (Area – 0.4 ha)

	Fish Species*	No. Stocked		No Harvested		Initial Wt. (gm.)		Final Wt. (gm.)		Growth Increment (gm.)		Production (Kg.) **	
		E	C	E	C	E	C	E	C	E	C	E	C
1	Rohu (15%)	210	210	200	202	21.0	21.0	500.0	410.0	479.0	389.0	100.0	82.0
2	Catla (20%)	280	280	267	265	21.0	20.0	550.0	600.0	529.0	580.0	147.0	159.0
3	Mrigal (25%)	350	350	339	340	24.0	24.0	725.0	610.0	701.0	586.0	246.0	207.0
4	Common Carp (30%)	420	420	410	407	29.0	29.0	700.0	630.0	671.0	601.0	287.0	256.0
5	Silver Carp (5%)	70	70	64	65	18.0	17.0	620.0	700.0	602.0	683.0	40.0	45.0
6	Grass Carp (5%)	70	70	63	61	27.0	27.0	457.0	460.0	430.0	433.0	32.0	28.0

* Free Life Days – 392 days except grass carp (176 days)
** Total Productivity (Kg) – 852 (Experimental Pond) 777 (Control Pond)

Table 4. Total input cost of experimental and control ponds

Item	Experimental Pond		Control Pond	
	No.	Cost (Rs.)	No.	Cost (Rs.)
Lease of the pond	1	1000	1	1000
Labour charges	90*	7000	68**	3400
Fingerlings of fish	1400	200	1400	200
Total input cost		8200		4600

* Include transplanting of makhana seedlings, cutting of leaves, harvesting of makhana crop, pops preparation and netting of fishes
** Include netting (pre-stocking and harvesting)

Table 5. Input cost and net benefit of experimental and control ponds

Unit	Input Cost(Rs.)	Qty Produced (Kg.)		Gross Income		Net benefit (Rs.)
		Fish	Makhana pops	Fish	Makhana pops	
Experimental	8200	852	200	34080	16000	41880
Control	4600	777	-	31080	-	26480

Calculated Net profit per ha : Experimental pond Rs. 1,04,700, Control pond Rs. 66,200.

Makhana production

Total yield of makhana seeds obtained from the experimental pond was 469 kg. These were processed to get 200 kg pops of makhana (Table 5). On the basis of overall seed production the present experimental pond may be categorized as a pond of moderate yield (Verma, 1995a). Earlier Dehadrai (1972) reported the production of 320 kg ha^{-1} makhana seeds after integration with air-breathing fishes in a derelict swamp. Verma *et al.*, (1996), however, obtained 1400 kg ha^{-1} seeds from a similar integrated system in a derelict wetland in Saharsa district of North Bihar.

Cost-benefit analysis

Details of inputs as given in Table 4 revealed higher input cost in the experimental pond. This was due to extra labour charges for makhana cultivation and for its post harvest processing. No costs were incurred on seeds as the pond does have an auto-seeding system. Gross income and net benefit of control and integrated systems are presented in Table 5. Gross income from the integrated unit (fish and makhana crops) was Rs. 50,080 whereas the same from the control unit (fish culture) was Rs.31,080. The net benefits from experimental and control ponds were Rs. 41,880 and Rs. 26,480 respectively. Earlier Verma *et al.*, (1996) reported a net profit of Rs. 49,171 ha^{-1} $crop^{-1}$ from integrated culture of air breathing fishes with makhana.

CONCLUSION

Integrated fish culture with makhana is the most economic utilization of a pond with the production of two crops from the same pond. This process of crop diversification also reduces the risk of failure of either of the two crops. This further enhances the aquatic productivity and helps to raise economic status of the fish farmers. In such system both the components (fish and makhana) are mutually benefited. Makhana plants provide mechanical support and suitable substrata for the growth and reproduction of plankton and periphyton. This also provides a safeguard against the poaching of fishes, which is much rampant in this area (Verma, 1995b). Decomposition of organic matter enlivens the aquatic food chain through the production of plankton, insects, nematodes and gastropods as natural fish food organisms. In return, the faecal matter of the fishes adds to the nutrient status of the system. These fishes feed upon the insect pests like *Elophila spp., Plea litruata, Galerucella birmanica* and *Frankliniella intonsa* which act as severe pests (Banerji, 1972, Mishra *et al.*, 1992). This system of integration, if adopted at larger scale by the fish farmers, would help getting a better productivity in the aquatic system of North Bihar.

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