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Observation of Carp Polyculture with Giant Freshwater Prawn in Solar Heated Fish Pond

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Abstract: The experiment of fish production in solar heated ponds was carried out in an arch shaped greenhouse at farm complex of Central Institute of Freshwater Aquaculture, Bhubaneswar (Latitude-20°15′, Longitude-85°52′ and altitude 33 m above mean sea level) where the climatic condition is warm and humid. Experiments on carp polyculture with prawn during winter periods from 28 October, 2002 to 27 March, 2003 have shown the production levels of 6204-7767 kg/ha/year for carps and 92.5-97.3 kg/ha/year for prawns under greenhouse conditions against 3327-3935 kg/ha/year for carps and 43.8-77.9 kg/ha/year for prawns in open condition. Trials on carp polyculture indicated that higher production levels of 202% for fish and 156% for prawn could be achieved in greenhouse ponds as compared to outdoor ponds. Growth and survival of fish and prawn were higher in greenhouse ponds (fish mean growth 311.0 g with 86% survival; prawn 11 g with 17.6% survival) than open ponds (fish growth 216.5 g with 75% survival; prawn 7 g with14% survival) during the experimentation.

Key words: Greenhouse, fish, prawn, polyculture, water temperature

INTRODUCTION

Aquaculture development based on the utilization of non-traditional resources, which are being widely exploited elsewhere, are likely to bring enormous change in technology improvement and total fish production. Use of greenhouse for raising vegetable and floriculture crops and shelter for human being at high altitude is a common practice in temperate as well as other areas during winter months. Their use in aquaculture is very recent in India (Pillai *et al*., 1999; Kumar *et al*., 2000; Bandyopadhya *et al*., 2000; Mohapatra *et al*., 2002; Tiwari *et al*., 2006; Sarkar and Tiwari, 2006). Carp culture along with prawn offers a vast potential generating large quantity of good animal protein at low cost for human beings. In this direction, the application of greenhouse pond environment, further, may accelerate the fish productivity. Water temperature is one of the important parameter for fish growth. In low temperature periods the metabolic activity of fish greatly reduced, thereby affects fish production (Halver, 1972; Jhingran, 1975). Introduction of greenhouse fish pond environment over a pond helps to increase the water temperature during winter periods (Ra'anan and Cohen, 1980/81; Sarkar and Tiwari, 2006). The standard recommendation for carp culture in India involves a combination of three Indian major carps and three exotic carps. The information on the trials in this direction in greenhouse ponds is lacking in the country. Therefore, an attempt has been made to study the production potential and growth of various carp species and freshwater prawn (*Macrobrachium rosenbergii*) in the greenhouse and open ponds environment, for the first time in the country during low temperature period.

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MATERIALS AND METHODS

Working Principle

The working principle of a greenhouse pond is same as any conventional type of greenhouse. During sunshine hours total solar radiation received by the greenhouse cover is partly reflected, absorbed and transmitted inside greenhouse through walls and roofs (Tiwari, 2003). A large portion of transmitted radiation is absorbed by water. This is utilized in raising the water temperature. The exposed surface area of the pond absorbs rest part of the radiation. This absorbed thermal energy is further convected, radiated and evaporated into the room air and some heat conducted into the ground, respectively. Further, there are heat transfer from greenhouse room air to greenhouse cover by convection radiation and evaporation and finally thermal energy is lost to ambient air by convection and radiation.

Description of the Experimental Greenhouse

Two numbers of arch shaped greenhouse of 13×8 m each and central height of 2.5 m were made over the earthen ponds of 11×7 m for experimental purposes in east-west direction. The greenhouse structure was made of G.I. pipe frame, which was covered with UV-stabilized Low-density Polyethylene Film (LDPE) of 200-micron thickness. The experimental site was located at the Institute farm complex for the warm and humid climate of Bhubaneswar (Latitude-20°15′, Longitude-85°52′ and an altitude 33 m above mean sea level). The warm and humid climate, which represents the region that receives more than 20 inches of annual precipitation and either, has 3000 or more hours of 67°F temperature, or 1500 or more hours of 73°F temperature during the warmest six months of the year (Building Science Corporation). All the ponds were provided with laterite stone lining in all the sides to prevent soil erosion. The open ponds were covered with gill net (75 mm mesh size) to prevent bird catching. There were also provisions of two doors at opposite direction for natural cooling during over heating, if any. The experimental set-up and view of the greenhouse is shown in Fig. 1a and b.

Fig. 1a: Inside view of the experimental greenhouse

Fig. 1b: Outside view of the experimental greenhouse

Experimental Observation

Water, ambient air and greenhouse room air temperature were measured by maxima-minima mercury-filled glass bulb thermometer having least count of 0.1°C. The thermometer used to measure ambient air temperature was hanged outside and its bulb was shaded from direct sunlight. Water temperature was recorded at 6:00 and 14:00 h. Physio-chemical parameters e.g., dissolved oxygen, pH, free CO_2, total alkalinity, ammonia-N and nitrate-N were monitored between 8:00-9:00 h fortnightly intervals following the standard methods of APHA (1989). Plankton sampling and counting were done as per the standard methods. Samplings of fishes were conducted at monthly intervals for survival and growth performance. The mean of the parameters with deviation of open and greenhouse ponds were calculated and tabulated accordingly.

Biological Experiment

The 150 days in growth trial was conducted using carp polyculture incorporating giant freshwater prawn. Before stocking, ponds were prepared as per the recommended practices of aquaculture. The ponds were completely dewatered and elimination of unwanted/predatory fishes was done through hand picking. After drying, the ponds were filled with desired level of water and the fertilization was carried out with application of cow dung at the rate of 10 ton/ha/year, one fifth of which was applied two weeks prior to stocking of fish fingerlings as basal dose. The remaining amount was applied in equally divided doses at fortnightly intervals. Further, inorganic fertilizers in the form of nitrogen and phosphorus were applied fortnightly in split doses. The water levels in the experimental ponds were maintained at 1.0 m during the study period, compensating the loss of water due to seepage and evaporation. Liming by $CaCO_3$ was done intermittent interval of one month at the rate of 80 kg ha^{-1} to maintain the desired pH of water and also for pond hygiene. The polyculture of fish and prawn was started on 28 October, 2002 and got resumed after final harvesting on 27 March, 2003. Advanced carp fingerlings and ten days old post-larvae of prawn were stocked in the open and greenhouse ponds. The stocking density of fishes was 10,000 nos ha^{-1} and prawn was 25,000 nos ha^{-1}. The size range was 8-15 g for fishes and 10-12 mm/10 mg for prawns. The carp species stocked were Silver carp-10%, Catla-20%, Rohu-25%, Common carp-5%, Puntius-25%, Grass carp-10% and Mrigal-5%. Supplementary formulated feed with crude protein level of 35% was given at the rate of 2-3% of body weight twice in a day at 10:00 and 15:00 h. The feeding quantity was adjusted at monthly intervals after estimating the biomass increase through intermittent sampling.

RESULTS AND DISCUSSION

The hourly variation of water temperature in open and greenhouse pond has been shown in Fig. 2. This figure indicates that water temperature attained maximum at 16:00 and minimum in the early morning 4:00 to 5:00 for greenhouse. In case of open condition, the maximum and minimum values were observed at 14:00 and 4:00 h, respectively. There was an increase of 3.1-5.7°C (4.21°C) water temperature as compared to open pond. The results obtained are in accordance with that reported by Kumar *et al*. (2000), Tiwari *et al*. (2006) and Sarkar and Tiwari, (2006). The slight variation of water temperature may be attributed to the location of the places. Table 1 shows the monthly variations of water temperature. The monthly minimum mean water temperature was 17.2°C in open and 21.1°C in greenhouse ponds during January, whereas highest was recoded 32.1°C in open and 35.7°C in greenhouse ponds during March. The range of values of physico-chemical and biological parameters of open and greenhouse ponds are presented in Table 2. Chemical parameters of the water in general, did not show any marked difference in the value throughout the culture period in both types of ponds. The mean fish/prawn growths were higher in the greenhouse ponds than that of open ponds (Table 3). It showed lower mean growth (216.50/7 g) in open ponds than that of greenhouse ponds (309.00/11 g). The survival levels in the experiment were 76/16 and 74/16% in open ponds and 84/20

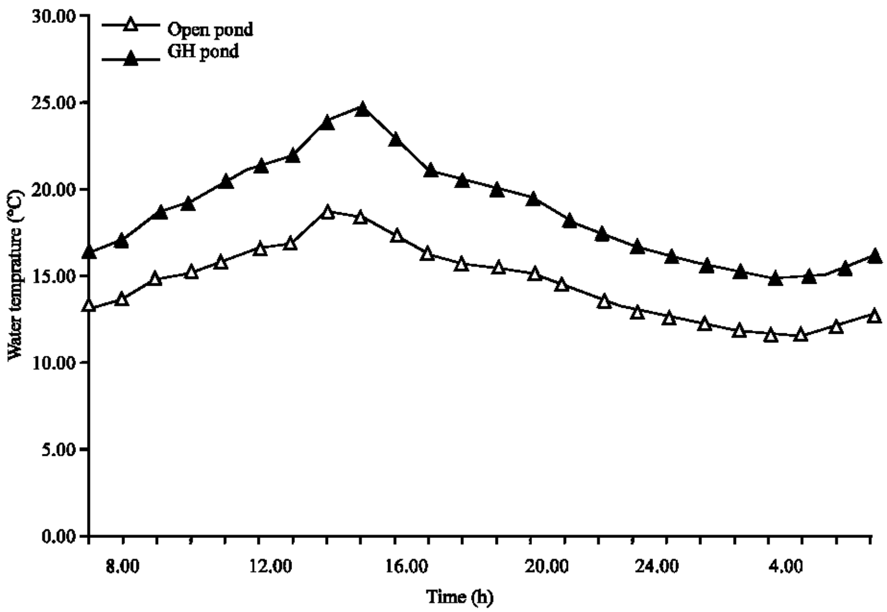

Fig. 2: Hourly variation of water temprature in pond and greenhouse pond on 13.01.2003

Table 1: Variation of mean (±SD) water temprature (°C) in open and greenhouse pond

	Months											
	October		November		December		January		February		March	
Temperature (°C)	Open	GH	Open	GH	Open	GH	Open	GH	Open	GH	Open	GH
Minimum	25.6	29.4	22.2	26.1	18.1	22.4	17.2	21.1	20.1	25.3	23.9	29.6
	±1.62	±0.90	±0.98	±1.10	±0.78	±1.13	±1.57	±1.23	±0.67	±0.73	±1.12	±232
Maximum	30.9	34.1	29.3	32.4	27.0	32.4	26.1	30.7	29.0	32.8	32.1	35.7
	±1.91	±2.76	±1.87	±1.76	±1.09	±1.07	±1.49	±1.29	±1.47	±1.82	±1.33	±1.87

GH: Greenhouse

Table 2: Chemical and biological parameters of open pond and greenhouse ponds (mean±SD)

Parameters	Open pond	Greenhouse pond
Dissolved oxygen (mg L^{-1})	4.0 ± 0.6	4.2±0.8
Free CO_2 (mg L^{-1})	9.6±2.0	10.6±2.4
pH	7.6±0.3	7.4±0.2
Total alkalinity ((mg L^{-1} as $CaCO_3$)	110.0±26.3	106±20.8
NH_4-N (mg L^{-1})	0.036±0.012	0.042±0.18
NH_2-N (mg L^{-1})	0.024±0.014	0.020±0.01
NO_3-N (mg L^{-1})	0.032±0.020	0.061±0.01
PO_4-P (mg L^{-1})	0.046±0.018	0.056±0.021
Phytoplankton density ($\times 10^3$)	8.6±3.8	18.2±2.8
Zooplankton density ($\times 10^3$)	4.2±1.3	2.6±0.9

and 88/15.2% in greenhouse ponds, respectively. The biomass production in different ponds is presented in Table 3. The mean fish biomass productions were 1413/25 kg/ha/150 days in open ponds and 2870/5 kg/ha/150 days in greenhouse ponds, respectively. The prawn productions were 40 and 38 kg/ha/150 days in greenhouse ponds and 32 and 18 kg/ha/150 days in open ponds, respectively. Comparing the production levels of both fish and prawns, it was observed higher gross and net productions in the greenhouse ponds. Gross and net productions were 3322 and 2968.7 kg/ha/year in case of first open pond and 3935 and 3581.9 kg/ha/year for second open pond. Where as, these were 6204 and 5840 and 7767 and 7397.3 kg/ha/year for the first and second greenhouse ponds, respectively. The corresponding net gains in greenhouse were 202% for carps and 156% for prawns (Table 4).

Table 3: Results of carp and prawn polyculture in open and greenhouse ponds

	Open pond			Greenhouse pond		
Parameters	O-1	O-2	Avg. open	GH-1	GH-2	Avg.GH
Effective water area (m2)	50	50	50	50	50	50
Stocking size (Fish-g/prawn-mg)	8-15/10	8-15/10	8-15/10	8-15/10	8-15/10	8-15/10
Fish/prawn recovered (Nos)	38/20	40/15	39/18	42/25	44/19	43/22
Final size range-Fish/prawan (g)	145-295/6-10	128-358/5-8	128-358/5-10	208-433/8-15	225-425/8-12	208-433/10-15
Mean size-Fish/prawn (g)	212.14/8	220.85/6	216.50/7	313.40/12	304.60/10	309.00/11
Survival-Fish/prawn(%)	76/12	74/16	75/14	84/20	88/15.2	86/17.6
Production (kg/ha/crop)	1346/32	1472/18	1413/25	2549/40	3192/38	2870/5
Gross production (kg/ha/year)	3321.5/77.87	3934.7/43.8	3638.1/60.83	6204/97.3	7767.2/92.46	6985.5/94.9
Net production(kg/ha/year)	2968.7/76.2	3581.9/42.6	3275.3/59.4	5840/95.4	7397.3/90.6	6618.7/93
Net gain	-	-	-	-	-	202/156

O-1: open pond 1; O-2: open pond 2; GH-1: Green house pond-1; GH-2: Greenhouse pond-2

Table 4: Pond wise perfomance of species during the experimental period

Species	Survivals (%)	Mean weight stocked (g)	Total weight harvest (g)	Net Production (kg ha^{-1})
Open pond-1				
Sc	40	255	510	435(7.5)*
C	60	210	1260	1110(18.5)
R	83.3	135	1080	900(15.8)
M	100	145	435	410(6.3)
Pg	91.67	220	1980	1800(29.0)
Cc	100	295	885	840(13.0)
Gc	60	225	675	610(9.9)
Total	76	212.1	6825	6105(100)
Prawn	16	10 (mg)	160	158.75
Open pond-2				
Sc	60	220	660	585(8.2)
C	80	185	1480	1330(18.3)
R	100	128	1535	1355(19.0)
M	100	155	465	440(5.7)
Pg	58.3	290	2030	1850(25.1)
Cc	100	358	1075	1030(13.3)
Gc	80	210	840	775(10.4)
Total	80	220.9	8085	7366(100)
Prawn	12	10 (mg)	90	88.75
Greenhouse pond-1				
Sc	60	325	975	905 (6.8)
C	70	285	1995	1805(14.0)
R	83.3	250	2500	2320(37.2)
M	60	205	625	600(4.2)
Pg	91.7	315	3465	3285(20.4)
Cc	100	430	1300	1255(8.0)
Gc	84	380	1890	1825(9.4)
Total	84	313	12746	11995(100)
Prawn	20	10 (mg)	200	198.75
Greenhouse pond-2				
Sc	60	360	1080	1005(6.8)
C	80	280	2240	2090(14)
R	100	245	5940	5760(37.2)
M	100	225	675	650(4.2)
Pg	83.3	325	3250	3070(20.4)
Cc	100	425	1275	1230(8.0)
Gc	100	300	1500	1435(9.4)
Total	88	308.57	15960	15240(100)
Prawn	15.2	10 (mg)	190	188.75

* Figure in parenthesis indicates a percentage contribution

The computed carp polyculture production levels obtained in the present experiment was comparatively higher than the production levels of carp monoculture in the same greenhouse ponds reported earlier (Bandyopadhya *et al*., 2000). In comparing the results with other similar six-month polycultures without greenhouse environment, the present production levels were higher than those reported (Lakhamanan *et al*., 1971; Sinha *et al*., 1973; Chakraborty *et al*., 1979; Aravindakshan *et al*., 2000; Jena *et al*., 2002). This higher production may be due to the higher feed intake by fish and prawns, higher water temperature in the greenhouse ponds and greenhouse effects. The analysis of production performance of both ponds showed that, under polyculture, gross production of 6204-7767 kg/ha/year for carps and 92.5-97.3 kg/ha/year for prawns is possible in greenhouse ponds during winter months. The slower growth patterns of fishes and prawns of open ponds were due to lower water temperature and poor feed intake of fishes (Pillai *et al*., 1999, Bandyopadhay *et al*., 2000; Kumar *et al*., 2000; Mohapatra *et al*., 2002; Tiwari *et al*., 2006). Through heat preservation methods like greenhouse fish culture, the fast rate of carp growth could be further enhanced by incorporating plastic bottom lining (Ra'anan and Chohen,1981/82). Fish and prawn showed higher growth and survival in greenhouse ponds compared to that of open ponds (fish av. growth 311 g with 86% survival; prawn 11 g with 17.6% in greenhouse ponds and fish 216.5 g with 75%; prawn 7 g with 14% in open ponds). In the present experiment, exotic carps showed proportionately higher growth contribution in comparison to the Indian major carps. Similar observations were made by other researchers (Chaudhury *et al*., 1975; Tripathi *et al*., 2000; Jena *et al*., 2002). The water quality parameters prevailing in both the experimental ponds were within optimum ranges throughout the culture periods. The water temperature showed marked variations between both the treatments due greenhouse effects. The other parameters did not show any significant variations between the treatments.

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