Analysis of physico-chemical parameters of integrated cultivation (swine-fish) in Southern Brazil and Northern Italy

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Fish nursery fertilization is a practice used extensively in many countries to improve both plankton production and fish development (Wohlfart and Schroeder 1979, Pekár and Oláh 1990, De la Noüe *et al.*1995). The Italian production of cyprinids is very limited (700 tons/year); carp and tench are used almost exclusively in the sport fishery. However, carp cultivation could be interesting as a means of recycling pig manure (Zoccarato *et al*. 1995, Sicuro *et al*. 1997). This research provided substantial information on the use of pig manure in carp nurseries under the specific climatological conditions of Northern Italy.

Over the last 30 years Santa Catarina State (Southern Brazil) has developed a fish cultivation system where a substantial increase in yield was recorded. Yields increased from 65 tons/year in 1983 to 16, 000 tons in 1999. During this period great attention was paid to the social, economic and environmental aspects associated with the production system. The present work, developed by EPAGRI in conjunction with Universitá Degli Studio di Torino, recorded the physico-chemical parameters and yields obtained by this fish culture model when applied to different regions.

Culture System Model

In Italy, the work was carried out at the Experiment Station of Animal Production Department, University of Torino, for 112 days. Six ponds, averaging 600 m^2 and 1.2 m deep, were stocked with 6,250 common carp/ha (*Cyprinus carpio*). The fish were counted and weighted at the beginning and end of the experiment. The average fish biomass was 990±18 kg/nursery, or 158±3 g/fish. The nurseries were fertilized with pig manure (11±1.15 percent dry matter), obtained from a manure disposal of the experiment station, at three different levels: 25 kg (L), 50 kg (M) and 75 Kg (H) of manure per hectare. The manure was applied once a day for five days a week. In addition, the fish were fed a pelleted ration (12 percent moisture, 30 percent crude protein, 4.6 percent lipids, 3.2 percent fiber and 11 percent ash) at three percent of initial biomass. The feed was distributed five days a week by automatic troughs and the amount was adjusted weekly. Estimated weight gains were based on the nursery productivity model reported by Sarig (1988). The ration was completely consumed by the fish. The water temperature and dissolved oxygen level (DO) were recorded once a day by YS1 DO meter at 50 cm depth; the pH by a Crison pH meter; total hardness as $CaCO_3$, nitrites, nitrates, ammonia, phosphates and chemical oxygen demand were monitored twice a week with a Merck spectrophotometer. The data associated with yield and water quality parameters were analyzed by ANOVA.

Table 1. Results of survival, yield and feed efficiency.

Treatment	L	M	H
Survival (percent)	100	93	86
Final weight (kg/ha)	1,949	1,394	883
Food conversion ratio[1]	1.94	2.92	3.73
Feed index[2]	1.54	4.62	11.47
Total manure applied (kg/ha)	27,500	55,011	82,517

[1]*kg feed offered/kg of live weight gain*
[2]*kg of dry matter/kg of live weight gain*

In Santa Catarina, Brazil the nurseries measured 5,000 m^2 on average and fish density was 2.24 fish/m^2. Sixty pigs between 25 and 100 kg were used. As supplementary diet containing 28 percent crude protein was provided at three percent of total biomass daily. Water was only added to compensate for seepage and evaporation losses (Schappo and Tamassia 2000). The experimental design proposed by EPA (1996), was that of "before and after the study unit" and the results obtained were subjected to a t-test to compare differences between the two experiments. The means were compared using the Wilcoxon signed rank test. Colorimetric determinations of nitrate and orthophosphate were recorded at 14-day intervals. The results obtained were compared to those of existing legislation (CONAMA 20/86).

Results and Discussion

Yield and other results obtained from the experiment in Italy are resented in Table 1. No differences were observed between the two treatments. The survival rate varied from a minimum of 86 percent (treatments H) to a maximum of 100 percent (treatments L). The final mean weight was 470±2.8 g (L), 407±45.2 g (M) and 358±19.1 g (H). Increased fertilization rate was negatively correlated with survival, individual weight gain and mean fish weight. The feed conversion ratio increased with increasing fertilization rate (Table 1).

Table 2. Water quality results and carp yield in Torino.

Parameter	L	M	H
Dissolved oxygen (mg/L)	10.08	7.41	7.48
pH	7.61	7.74	7.80
$CaCO_3$ (mg/L)	12.26	13.51	11.88
Nitrate (mg/L)	7.15	6.06	6.39
Nitrite (mg/L)	0.16	0.18	0.17
Total ammonia (mg/L)	0.50	0.54	0.80
Phosphate (mg/L)	0.26	0.45	0.39
Chemical oxygen demand (mg/L)	58.21	71.86	68.29
Yield (kg/ha)	1,949	1,394	883

Table 3. Water quality and carp yield in Santa Catarina.

Parameter	T1	T2	T3
Nitrate (mg/L)	0.96	0.02	0.27
Total ammonia (mg/L)	1.6	0.77	0.24
Hardness (mg/L	34	32	14
O_2	3.82	3.53	4.46
Mean yield (kg/ha)	5,450		

The water quality results are shown in Table 2. DO differed significantly among treatments. The pH was significantly lower in the L treatment than in the other two treatments. No problems were found with respect to total hardness, nitrites, nitrates, ammonia or phosphates. The water temperature fluctuated between 18-20 C from September to May and remained around 27 C from May to July.

Fish survival depends primarily on DO. The introduction of pig manure leads to pond eutrophication, which, during the day, is characterized by intense photosynthesis by the phytoplankton community. On the other hand, at night, as a result of pond biota respiration, treatments M and H showed high DO consumption, caused by the DO fluctuation, and, consequently, by the critical concentrations of more than 3 mg/l that may occur in the early hours of day.

Carp survival may be improved using a mechanical aerator during the night. In addition, fertilization causes a significant increase in pH level; this effect is important inasmuch as the alkalinity keeps the water free from most fish pathogens. The other water quality parameters were not very high, thus, did not affect the carp adversely.

Regarding the yield performance, it is important to emphasize that carp feed primarily on zooplankton found in the sediment and that nursery fertilization stimulates the plankton production. Therefore, these research results confirm that the pond fertilization system may be a low cost treatment; however, attention must be dedicated to the DO level and its fluctuation. Even in a small nursery, nitrogen may occur in many different forms: nitrite, nitrate, ammonia and organic nitrogen. In these systems the nitrogen cycle is almost exclusively regulated by biological activity (Boyd 1990).

In the ponds of Santa Catarina, Brazil, the nitrate did not exceed the stipulated limit, either being analyzed on the basis of CONAMA 20/86 or through the system proposed by FEPAM/DPD (1998). In addition, none of the fish cultivation systems exhibited significant differences from zero between the before and after collections (Table 3). In spite of the phosphate concentration at both collecting times being beyond the limits regulated by CONAMA resolution 20/86, they did not differ significantly in the carp cultivation systems studied. Furthermore, no change was observed in water quality during its passage through the production units.

Conclusion

The results obtained in the two studies suggest that with respect to physico-chemical parameters, the application of pig manure in fish cultivation does not cause negative environmental effects in the receiving body of water that may pose a risk to aquatic life or contradict existing legislation.

Notes

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