Asian Fisheries Science 4(1991): 31-39.
Asian Fisheries Society, Manila, Philippines

https://doi.org/10.33997/j.afs.1991.4.1.004

Production of Common Carp *(Cyprinus carpio)* with Supplemental Feeding in Ricefields in North Sumatra, Indonesia

EMMANUEL M. CRUZ*

Fisheries and Mariculture Department
Kuwait Institute for Scientific Research
P.O. Box 24885
13109 Safat, Kuwait

CATALINO R. DELA CRUZ

International Center for Living Aquatic Resources Management
MC P.O. Box 1501, Makati, Metro Manila
Philippines

Abstract

A production trial in nine farmer cooperators' ricefields in North Sumatra, Indonesia, was conducted to evaluate the growth rate, yield and economics of culturing common carp (*Cyprinus carpio*) at different stocking densities with supplemental feeding. Common carp weighing 52.9-111.2 g were stocked at 1,500, 3,000 and 4,500 fish·ha-1. Three ricefields were assigned to each stocking density. A compounded diet (16% crude protein) was given daily at a rate of 5% of the fish biomass. The trial was conducted for 75 days during the long fallow period in between two rice cropping seasons.

Mean individual fish weight decreased, but yield increased with an increase in fish stocking density. The yield at a stocking density of 1,500 f19h·ha-1 was significantly lower than those at densities of 3,000 and 4,500 fish·ha-1. Highest production and profit were obtained at the highest stocking density. However, the rate of return on operating capital was highest at a stocking density of 1,500 fish·ha-1 with a profit in 2.5 months approximating that of one rice crop with a 4-month culture duration. Farmers with financial capability may further increase profit by adopting the 3,000 or 4,500·ha•l stocking rates.

*Present address: 3400 East 8th St., Suite 102, National City, CA 92050, USA.

Introduction

Only a few farmers in Simalungun, North Sumatra, Indonesia, raise common carp *(Cyprinus carpio)* in ricefields. They produce either one crop of table-sized fish in between two successive rice crops in a year or use a rice followed by rice, followed by fish. Such cropping patterns are rapidly increasing in popularity in North Sumatra. In Binong district, Subang, West Java, this pattern comprises 15 of the various cropping systems practiced and comes next to the 74 rice monoculture pattern (rice-rice-fallow) (Taslim and Syamsiah 1987). The potential area to expand this practice throughout Indonesia is great. However, documented information about culture, yield and economics is scarce and often fragmented, especially for stocking larger fingerlings (50-100 g) which are grown for 2-3 months to produce the preferred size of Sumatrans. The use of larger fingerlings differs from the usual practice in Subang, West Java, where fingerlings of 5-8 cm (5-8 g) are stocked and raised to table size in 2-3 months in ricefields during the long fallow period (Taslim and Syamsiah 1987). Thus, an organized culture procedure and knowledge on the growth, yield and economics of culturing common carp in the ricefield environment with given inputs are wanting.

Fish yields vary with the type of production system (fingerling or table-size production), inputs and whether the rice-fish system is concurrent or rotational. Dela Cruz (1988) reported a mean fingerling production of common carp in ricefields in Simalungun, North Sumatra of 205 $kg \cdot ha^{-1}$ at a stocking rate of 5 fry/m^2 and 222-230 $kg \cdot ha^{-1}$ at a stocking rate of 10 fry/m^2. Ardiwinata (1957) reported fish yields of 100-600 $kg \cdot ha^{-1}$ in Indonesia depending on the fertility of the field. In Japan, lower yields of 76-490 $kg \cdot ha^{-1}$ in fertilized fields were reported by Bardach et al. (1972). Ardiwinata (1957) and Bardach et al. (1972) further stated that stocking of 5-8 cm fish at 6,000 ha^{-1} produced fish of about 100 g in 40 days. In Hubei, China, a rotational pattern of two rice crops and one fish crop a year produced 1,119 $kg \cdot ha^{-1}$ of fish and net return of US$583/ha; while a pattern of one rice and one fish crop yielded 1,312 $kg \cdot ha^{-1}$ fish and a net return of $529 (Xu and Guo 1988).

A production trial in selected farmer cooperators' fields was conducted to evaluate the growth rate, yield and economics of culturing common carp at different stocking densities with supplemental feeding. The trial was intended to determine the appropriate stocking density and achievable production in the ricefields within the prescribed culture method and duration.

Materials and Methods

Nine farmers from Totap Mojawa, Simalungun District, North Sumatra, Indonesia, were selected as cooperators in the trial. The dikes were raised to a height sufficient to hold at least a 40-cm depth of water. The standing rice stubble was retained while loose rice straw was stacked in small mounds inside the field.

Common carp fingerlings weighing 52.9-111.2 g were stocked in the ricefields at densities of 1,500, 3,000 and 4,500 fish$\cdot$ha^{-1} with three ricefields assigned to each stocking density (Table 1). A supplemental feed, using locally available ingredients of plant origin to lower the cost, was formulated to provide 16% crude protein (Table 2). The daily feeding rate, 5% of the fish biomass, was adjusted weekly based on an estimated feed conversion ratio (FCR) of 2.5. Farmer cooperators were provided with a prepared daily feeding schedule.

Fields were drained after 35 days (first culture period) to determine fish growth and survival. After sampling, the ricefields were refilled with water and the same fish were restocked.

Table 1. Area (m^2) of each farm involved in the trial.

Replicates	Fish stocking density (fish$\cdot$ha^{-1})		
	1,500	3,000	4,500
1	1,928	2,128	2,522
2	1,450	1,462	755
3	1,537	887	1,960

Table 2. Formulated fish pellet containing 16% crude protein.

Ingredients	Per cent
Rice bran	72.0
Copra meal	20.0
Soybean meal	8.0
Calculated composition	
Moisture	9.10
Crude protein	16.00
Ether extract	9.92
Crude fiber	9.65
Nitrogen-free-extract	45.57
Ash	9.76

Ethoxyquin added at 200 mg$\cdot$kg^{-1} feed.

After another 40 days (second culture period), the fish were harvested. The fish were counted and weighed to determine the yield and survival rate.

Statistical analysis of the growth, yield and survival rate was done using the Statistical Analysis Systems (SAS) (1985) procedure for randomized block design. When means were significantly different, the Duncan Multiple Range Test at 5% level was used (Snedecor and Cochran 1973).

A partial budget analysis of the system was conducted assuming that supplemental feed and fish stock were the only input costs.

Results and Discussion

Growth

Fish stocked at 1,500 and 3,000 fish·ha^{-1} exhibited similar daily gains in weight but grew significantly faster than fish stocked at 4,500 fish·ha^{-1} in the first 35 days (Table 3). However, in the next 40

Table 3. Effect of stocking density on growth, feed conversion and yield of common carp *(Cyprinus carpio)* raised in ricefields with supplemental feeding.

Parameter	Stocking density (fish·ha^{-1})		
	1,500	3,000	4,500
Fish culture period (35 days):			
Initial weight/fish (g)	97.8	94.4	75.2
Final weight/fish (g)	222.9^{a}	213.3^{a}	162.3^{b}
Daily weight gain (g)	3.6^{a}	3.3^{a}	2.5^{b}
Gross yield/ha (kg)	333.2^{a}	620.7^{b}	711.0^{b}
Feed conversion ratio	1.9	2.2	2.1
Survival (%)	96.6	96.9	97.5
Second culture period (40 days):			
Final weight/fish (g)	355.1	303.8	257.2
Daily weight gain (g)	3.3^{a}	2.3^{b}	2.4^{b}
Gross yield/ha (kg)	508.0^{a}	913.3^{b}	1,044.4^{b}
Feed conversion ratio	5.0	7.2	6.3
Survival (%)	95.0	100.0	89.7
Both periods (75 days):			
Daily weight gain	3.4^{a}	2.8^{ab}	2.4^{b}
Gross yield/ha (kg)	598.0^{a}	913.3^{b}	1,044.4^{b}
Feed conversion ratio	3.4	4.5	4.1
Survival (%)	95.0	100.0	89.7

Means with the same superscript in a row were not significantly different.

days fish stocked at 1,500 fish·ha^{-1} grew significantly faster than those stocked at 3,000 and 4,500 fish·ha^{-1}. Regardless of the stocking density used, daily gain in weight of fish in the second was slower than in the first period, indicating that the quality of food was limiting as the carrying capacity was being attained.

The daily gain in weight for the entire culture period indicated significant differences at 5% level. Fish stocked at 1,500·ha^{-1} had higher daily gains than fish stocked at 4,500·ha^{-1}. No other significant differences were observed.

Feed Conversion Ratio (FCR)

Fish fed on natural food in the ricefield and the supplemental feed given. Thus, the FCR of supplemental feed was gross as nutrition from the two sources was not separated.

It was predicted that the FCR would be about 2.5 or lower which held true for the first culture period (35 days). However, the value of 2.5 was exceeded during the second culture period. The mean FCR for the entire duration (first and second periods) ranged from 3.4 to 4.5. The highest FCR obtained for the nine ricefields was 5.9 and the lowest value was 3.0. This is indicative of the difference in the fertility of the ricefields and may also be due to varying skills of the cooperators in culturing fish in ricefields.

The better growth rate and FCR of the first 35 days of the trial implied that the available natural food in the ricefield was still sufficient. The increase in the overall FCR suggested that from the second half of the culture period onwards the fish became more and more dependent on the supplemental feed given. Thus, an economical way to improve the FCR during the second half of the culture period would be for the farmer to divide his stock into two and stock the other half in another area. However, to optimize fish production in ricefields, optimum levels of natural food should be maintained continuously through regular application of fertilizer.

Production

The highest mean production of 1,044 kg·ha^{-1} was obtained from 4,500 fish·ha^{-1} followed by 913 kg·ha^{-1} at 3,000 fish·ha^{-1} although the difference was not significant. The lowest mean yield of 508 kg·ha^{-1} obtained from 1,500 fish·ha^{-1} was significantly different. The highest mean weight of 355 g was attained at the lowest and the smallest mean weight of 257 g was obtained at the highest stocking rate although the size differences were not sufficient to command a price difference in the market.

The production data suggested that, with sufficient supplemental feeding and improved skill of farmers, the production of table-sized fish from ricefields could reach 1,000 kg·ha^{-1} in two and half months, with an initial size of 50-100 g and a stocking density of 3,000·ha^{-1}. The highest yield obtained by one of the farmers at this stocking rate was 1,050 kg·ha^{-1}. At 4,500 kg·ha^{-1}, the highest yield was 1,324 kg·ha^{-1}, obtained by the farmer with the smallest area of 755 m^2. This indicates that a small area may be more closely and efficiently managed. The yields obtained in this trial are higher than those reported by Bardach et al. (1972) in Japan with supplemental feed (700-1,200 kg·ha^{-1}).

Fish Survival

The mean survival rate of the three stocking densities tested ranged from 90 to 100%, the lowest value obtained from the nine ricefields being 81%. This supports the claim of some farmers that under normal conditions, fish recovery is very high. A farmer who had a 113% recovery rate suspected that fish from an adjacent area had moved into his field during the second culture period.

One major problem encountered by the farmers towards the end of the trial was the reduction or brief interruptions of irrigation water flow. This could have affected the growth of the fish stock.

Economic Analysis

Profit increased with an increase in stocking density (Table 4). Although fish production at stocking density of 3,000 and 4,500 fish·ha^{-1} was about twice that at 1,500 fish·ha^{-1}, the profit was not correspondingly high. With stocking rates of 3,000 and 4,500 fish·ha^{-1}, the profits were 46 and 61% greater than the 1,500 fish·ha^{-1}, respectively. Profit at 4,500 fish·ha^{-1}, was only 11% greater than at 3,000 fish·ha^{-1}.

Considering the risk involved and the operating capital requirement, stocking at 1,500 fish·ha^{-1}, has the least risk. The 3,000

Table 4. Partial budget analysis of the production of table-sized fish in ricefields on a per-hectare basis.[a]

Stocking rate (number of fish·ha^{-1})	Stock cost ($)	Supplemental feed cost ($)	Fish sales ($)	Profit ($)	Rate of return (%)
1,500	285.61	257.54	899.12	355.96	65.5
1,500[b]	142.81	257.54	899.12	498.77	124.6
3,000	551.36	545.56	1,616.46	519.53	47.4
3,000[b]	275.68	545.56	1,616.46	875.75	96.8
4,500	658.83	614.78	1,847.79	574.17	45.1
4,500[b]	329.42	614.78	1,847.79	574.17	95.7

[a]Original values in Rupiah were converted to US$ at the rate of US$1 = Rp 1,130 as of August 1986.
Costs ($/kg): Supplemental feed = 0.21; Actual stock (50-100 g) = 1.95; Sales = 1.77.
[b]Assumed cost of stock (1-3 cm) is $0.97/kg.
Profit = Fish sales - (Costs of stock + supplemental feed)
Rate of return = Profit/(Costs of stock + supplemental feed) X 100

and 4,500 fish·ha^{-1} stocking rates needed 102 and 134% greater operating capital than the 1,500 fish·ha^{-1} stocking density, respectively. Furthermore, the rate of return at a stocking density of 1,500 fish·ha^{-1} (65.5%) was higher than at 3,000 and 4,500 fish·ha^{-1} (47.4 and 45.1%, respectively).

The biggest possible reduction in expense could be made in the cost of fish for stocking. At stocking density of 1,500 fish·ha^{-1}, a farmer could increase his profit from $356 to $499 and consequently increase his rate of return on operating capital from 65.5 to 124.6% by reducing the cost of his stock by one-half. It would be possible to reduce the cost of fish seed (50-100 g) by initially buying fry (1-3 cm) and growing them concurrently with rice until they reached the desirable stocking size, instead of buying ready-to-stock fish seeds which are more expensive.

From the results of the trial, it appears that a farmer could satisfactorily adopt a 1,500-fish·ha^{-1} stocking rate. Profit from the 1,500-fish·ha^{-1} stocking rate for a two and one-half month fish culture period was similar to the profit for one four-month rice crop. Profit from rice production for one crop was estimated to be about $388 (dela Cruz 1986). However, even the lowest stocking density of 1,500 fish·ha^{-1} required a greater operating capital than pure rice cultivation under the given conditions and inputs in the trial. Estimated capital for one rice crop/ha was about $354 whereas a fish crop at a 1,500 fish·ha^{-1} stocking density required at least $543. This suggests that the return on operating capital was higher for rice production than for fish culture with supplemental feeding. Dela

Cruz (1980) however, reported that the cost-benefit ratios of rice culture and fish culture were almost identical.

If a farmer grew two rice crops and one fish crop/year, the income would be comparable to three rice crops/year. However, to obtain three rice crops/year is rather difficult due to time constraints and also due to strict enforcement of the prescribed planting calendar of the Indonesian government, not to mention depletion of natural soil properties due to continuous cultivation. It has been established that fallowing is a desirable practice to allow the field to "rest" and "recover". It may therefore be argued that there are merits to a farmer embarking on one fish crop after two rice crops. It is economically profitable, offers another consumable product, allows the farm to rest and in the fish culture process, actually enhances soil fertility. The rice-rice-fish culture pattern may be an acceptable practice for optimum farm utilization assuming that farmers are trained in fish culture management.

Acknowledgements

This study was part of the Small-Scale Fisheries Development Project sponsored by the United States Agency for International Development and the Government of Indonesia.

References

Ardiwinata, R.O. 1957. Fish culture on paddy fields in Indonesia. Proc. Indo-Pacific Fish. Counc. 7(II&III): 119-154.

Bardach, J.E., J.H. Ryther and W.O. McLarney. 1972. Aquaculture the farming and husbandry of freshwater and marine organisms. Wiley-Interscience. New York.

Dela Cruz, C.R. 1988. Fingerling production trials in ricefields in North Sumatra, Indonesia, p. 97-109. *In* E.A. Huisman, N. Zonneveld and A.H.M. Boumans (eds.) Aquacultural research in Asia: management techniques and nutrition. Proc. of the Asian seminar on aquaculture organized by IFS, Malang, Indonesia. 14-18 November 1988. Pudoc, Waginengen. 275 p.

Dela Cruz, C.R. 1986. Small-scale fisheries development project: rice-fish culture sub-project. Final report for the DGF, Indonesia and USAID. US Agency for International Development/ARD Project No. 497-0286. Jakarta, Indonesia. 226 p.

Dela Cruz, C.R. 1980. Integrated agriculture-aquaculture farming systems in the Philippines, with two case studies on simultaneous and rotational rice-fish culture, p. 209-224. *In* R.S.V. Pullin and Z.H. Shehadeh (eds.) Integrated agriculture-aquaculture farming systems. ICLARM Conference Proceedings 4. ICLARM, Manila, Philippines.

SAS. 1985. SAS Introductory Guide. Helwig, J.T. (ed). Third Edition. Cary, North Carolina: Statistical Analysis Systems Institute Inc. 99 p.

Snedecor, G.W. and W.G. Cochran. 1973. Statistical methods. The Iowa State University Press, Ames, Iowa.

Taslim, H. and I. Syamsiah. 1987. Rice-fish farming system at Binong, Subang, West Java, Indonesia, p. 149-164. *In* Report of the 18th Asian Rice Farming Systems Working Group Meeting, 30 August-4 September 1987. Pakistan Agricultural Research Council, Pakistan and International Rice Research Institute, Los Baños, Laguna, Philippines.

Xu Yuchang and Guo Yixian. 1988. Rice-fish farming systems research in China. Paper presented at the International workshop on rice-fish farming systems research and development on 21-25 March 1988, Ubon, Thailand.

Manuscript received 9 March 1990; accepted 15 June 1990.