FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE

ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION

CARPAS/6/74/SE 36
Noviembre 1974

FAO/CARPAS SYMPOSIUM ON AQUACULTURE IN LATIN AMERICA

Montevideo, Uruguay

26 November to 2 December 1974

ECONOMIC EVALUATION OF TILAPIA HYBRID CULTURE IN NORTHEAST BRAZIL[1/]

by

J.E. Greenfield[2/], E.R. Lira and J.W. Jensen
Centro de Pesquisas Ictiologicas, DNOCS
Fortaleza, Brazil

International Center for Aquaculture
Auburn University
Auburn, Alabama, U.S.A.

Contents

1/ Project: Contract AID/csd-2270 Task Order No. 8

2/ Chief, Economics Research Division, Southeast Region, National Marine Fisheries Service, St. Petersburg, Florida, U.S.A.

Abstract

To help alleviate the animal protein shortage in northeast Brazil, the National Department of Works Against Drought (DNOCS) is conducting research in intensive fish culture to find fishes suitable for culture, and to develop improved methods for their culture in the northeast. Research has demonstrated that the all male tilapia hybrid of male Tilapia hornorum X female T. nilotica possesses many characteristics of a good culture fish. An economic evaluation of the tilapia hybrid under commercial conditions within DNOCS "colonization" programmes on irrigated agricultural land indicated that annual net profit/ha should reach B.Cr. 4 668 (U.S.$ 1.00 = B.Cr. 6.4) with an annual rate of return before taxes of 27 percent on a total investment of B.Cr. 16 885. In addition, the average farmer should enjoy B.Cr. 312 in added family labour income and B.Cr. 800 in capital gain from increased equity in land.

Extracto

Con objeto de aliviar la escasez de proteina animal en el nordeste de Brasil, el Departamento Nacional de Obras contra las Sequías (DNOCS) está llevando a cabo investigaciones en piscicultura intensiva para identificar especies adecuadas para cultivo, y para desarrollar mejores métodos para su cultivo en el nordeste. Las investigaciones han demostrado que las tilapias híbridos todos machos, de Tilapia hornorum (macho) X T. nilotica (hembra) poseen varias de las características de un buen pez de cultivo. Una evaluación económica del híbrido, en condiciones comerciales dentro del programa DNOCS de "colonización" de tierras irrigadas, uso agrícola, indicó que el beneficio neto anual por hectárea podría alcanzar B.Cr. 4 668 con una tasa anual de 27 por ciento sin descontar tasas, sobre una inversión total de B.Cr. 16 885. Además, el piscicultor medio gozaría de B.Cr. 312 por ingresos familiares de trabajo adicional, y B.Cr. 800 de ganancía del capital por aumento de la plusvalia del terreno.

1. INTRODUCTION

Although high fish yields were not characteristic of the semi-arid northeast region of Brazil, almost 70 years of water conservation effort by the Brazilian Government has established freshwater fish as high value food products. Rising fish prices reflect increasing demand working against a nearly static supply. One factor in the increasing demand for fish is a burgeoning 2.8 percent rate of population growth; another is the increasing income of the Brazilian citizen, particularly in small cities and the suburbs of larger cities.

With the above factors in mind, the National Department of Works Against Drought (DNOCS), an agency of the Brazilian Federal Government, began to investigate ways of alleviating this problem in 1969 through research in intensive fish culture with the aims of:

(a) increasing the supply of animal protein available to the people of the northeast,

(b) developing technology to permit the establishment of commercial freshwater fish culture.

Several years of research with numerous species of native and exotic fish resulted in the selection of an all male hybrid tilapia (male Tilapia hornorum X female T. nilotica) for culture in the northeast region. This paper presents an economic evaluation of commercial tilapia hybrid culture by individual farmers, based on results obtained in experiments conducted at the DNOCS Intensive Fish Culture Research Station in Pentecoste, Ceara, Brazil.

2. BACKGROUND

2.1 The Northeast Region

The northeast of Brazil is composed of nine states, representing about 19 percent of the total area of Brazil and 30 percent of the country's total population. Since 1940, the population has more than doubled, reaching 28.3 million in 1970. Approximately 60 percent of this population is rural and the vast majority are tenant farmers.

The *per caput* income in the northeast was U.S.$ 127 in 1955. By 1970, this increased to approximately U.S.$ 200. The average annual *per caput* income for the rural population is, however, only about U.S.$ 60.

The northeast's semi-arid climate is plagued by prolonged, frequent droughts that almost totally destroy agricultural crops. During normal years, rain falls regularly for only three to four months. Crop production in the other eight months is limited to irrigated land. Even when sufficient rain falls during the rainy season (February to May) to support crops of cotton, corn, beans and manioc, malnutrition is a constant reality. The daily *per caput* calorie intake in the northeast was only 1 940 in 1971, and probably much lower in rural areas. World health authorities consider a daily calorie intake of 2 500 the daily minimum necessary to support adults.

2.2 National Department of Works Against Drought (DNOCS)

Even though the northeast is a semi-arid land, fish are important in the diets of rural populations. Since DNOCS was formed in 1909 to combat the effects of droughts, the organization has built 850 reservoirs and assisted in building thousands of small, private reservoirs and ponds. These reservoirs and ponds trap and hold run-off water that falls during the rainy season. Since 1933, DNOCS has maintained a programme of stocking fish in these reservoirs for commercial fishing and for individuals to supplement their food supply. Several species of freshwater fish are now widely known and highly regarded in most villages of the northeast. Every reservoir has a local commercial fishery, and even the smallest ones are fished regularly by basket traps and other traditional methods.

To strengthen this programme, USAID signed an agreement with DNOCS and SUDENE (Superintendency for the Development of the Northeast) in 1966 to assist in the development of a fisheries research centre in Fortaleza, Brazil. In 1968, USAID contracted with Auburn University's International Center for Aquaculture, Auburn, Alabama, U.S.A., to provide technical assistance. At this point, interest was directed to research in intensive fish culture as an addditional way of utilizing impounded water to supply fish.

2.3 Tilapia Hybrid

Research began in 1969 on intensive fish culture at the Intensive Fish Culture Research Station in Pentecoste, Ceara, Brazil. In the station's 56 earthen ponds, native as well as exotic species of fish were tested and evaluated for their potential. Among the many species studied were two species of tilapias, which, when crossed (male *Tilapia hornorum* X female *T. nilotica*), result in 100 percent male offspring (da Silva, *et al.*, 1974).

The tilapia hybrid shows excellent possibilities as a culture fish in northeast Brazil and can be raised by following simple instructions for feeding and fertilization. Fingerlings for stocking are easily produced. The hybrids are resistant to poor water quality and disease, and have the ability to utilize a wide range of natural and inexpensive agricultural waste products, efficiently converting them into fish flesh. Tilapia hybrids are not differentiated from other tilapias already common to the marketplace, and are readily accepted by consumers.

2.4 Irrigation Projects

Below most of the large reservoirs built by DNOCS are lands suitable for irrigated agricultural production. For several years DNOCS has been establishing "colonization projects" on these lands based on cooperative principles. To small farmers (colonists), DNOCS leases at no cost a small parcel (5 ha) of irrigated land for agricultural production. Each farmer receives long-term financing and continuous technical assistance and basic education from DNOCS. Farmers are able to rent tractors, sprayers, and other modern agricultural equipment from their DNOCS-sponsored cooperative to enhance the productivity of their labour and management. Some land in the irrigation projects, not suitable for terrestrial crop farming because of soil quality or topography, is suitable for fish culture. For example, heavy, tight soils, unsuitable for cultivation, are highly desirable for pond construction. DNOCS plans to integrate fish culture with the other agricultural enterprises to fully utilize available land.

This evaluation, analysing the economic feasibility of tilapia hybrid culture by individual farmers in DNOCS irrigation projects, was considered a prerequisite to a final DNOCS decision to initiate development on a commercial scale.

3. METHODS

3.1 Tilapia Hybrid Experiments

This analysis is based upon an experiment carried out in two 355-m^2 earthen ponds stocked with fingerlings averaging 20 g at 8 960/ha. Actual commercial conditions were simulated as closely as possible. The experimental ponds were fertilized with cow manure at the rate of 1 400 kg/ha/week. A ration of 50 percent wheat chaff and 50 percent castor bean meal, formulated as a moist feed ball, was fed at a daily rate of 3 percent of total body weight, six days a week. Feeding rates were recalculated each month to reflect actual body weight as estimated from sampling (Lovshin and da Silva, 1974).

Monthly seine samples indicated a linear growth rate over 11 months with only a slight decline in the 12th month. Because of the decline in rate of growth in the 12th month, and because the individual fish size had already exceeded the maximum market unit value, the experiment was terminated.

3.2 Marketing

Historic, empirical data concerning the northeast's freshwater fish market are almost non-existent. To estimate the characteristics of demand for the tilapia hybrid, arrangements were made to test market fish in three public markets in Fortaleza and one market in Pentecoste, Ceara. Fish were transported to Fortaleza under probable commercial conditions in containers without water. After a two-hour shipping period out of water, the fish arrived in Fortaleza alive and were sold for prices ranging from B.Cr. 3.00-4.00/kg in conventional retail booths in the fish and produce markets. Each dealer was given 30 kg of fish ranging in size from 200-300 g. In Fortaleza, where freshwater species were less familiar and competitive with marine species, two days were needed to sell all the fish. In the interior town of Pentecoste, however, where freshwater fish are commonly sold and readily accepted by the people, 30 kg of fish were sold within four hours at B.Cr. 4.00/kg. Although market prices have since risen to the B.Cr.5.00-6.00/kg range due to shortages of other meats, this study was based on a more conservative B.Cr. 4.00/kg.

3.3 Operational Concept

The economic evaluation was based upon a concept where each farmer would build and operate a single 1-ha pond on land that would be provided on a long-term lease or grant arrangement as part of an irrigation project. No cost would be incurred by the farmer for the unimproved land itself. All other costs of improvements and operations to be incurred by the farmer were budgeted, including certain costs presently borne as subsidies by DNOCS.

It is important that the actual economic consequences of the project are recognized by DNOCS and the farmer, whether or not DNOCS ultimately decides to transfer all real costs directly to the farmer.

Initially, it is assumed that each farmer will harvest and market his own fish. There are several small cities within a 50 km radius of most DNOCS irrigation projects under consideration. All of these markets handle at least some quantity of wild freshwater fish six days a week and all are open to direct fisherman sales. In most markets, Saturday accounts for the heaviest volume. It is assumed that farmer's harvests could be scheduled over a two-week period, embracing three Saturday markets, by seining twice before draining the pond for the last harvest. It is further assumed that DNOCS would be in a position to operate a hatchery, sell fingerlings to farmers at cost, and assist them in acquiring feedstuffs. The farmers would be part of a general DNOCS-supported agricultural cooperative within their irrigation project. DNOCS would also supply technical extension assistance directly to farmers. The cooperative would endeavour to help farmers schedule their harvest so production would be staggered over the year. The non-seasonal climate and predictability of the weather should make harvest scheduling relatively easy.

4. ECONOMIC ANALYSIS

4.1 Investment

Assuming that virgin land is available to the farmer without cost, and that the pond unit could be located adjacent to an irrigation lateral, an adequate operating unit could be constructed for a total cost of about B.Cr. 17 000/ha. In addition to pond and water system construction, only a minimal amount of operating equipment is necessary. A simple shelter to protect feed supplies from the weather, a seine, and a few hand-tools are all that is required (Table I).

TABLE I

Direct Investment

	B.Cr./ha
Fixed	
Unimproved land	0
Pond and water system improvements	15 935
Feed shelter	300
Other	
Seine	500
Miscellaneous tools and equipment	150
Total	16 885

TABLE II

Costs

		Annual cost B.Cr./ha
I.	**Fixed**	
A.	DNOCS administrative surcharge	111
B.	Pond and equipment maintenance	350
C.	Amortization, real estate	1 514
D.	Amortization, personal property	112
II.	**Variable**	
A.	Start-up costs:	
(1)	Initial fertilization, 60 kg triplesuperphosphate at B.Cr. 3.00/kg	180
(2)	Water cost, initial filling	212
(3)	Fingerlings, 9 000 at B.Cr. 0.06 (20 g each)	540

B. Operating costs:

(1) Feed cost at 25.4 days feeding per month at 3% of last month's body weight with feed priced at B.Cr. 0.32/kg

Month	Cost/month	Cumulative cost
1	45	45
2	150	195
3	211	406
4	262	668
5	325	993
6	434	1 427
7	541	1 968
8	650	2 618
9	758	3 376
10	863	4 239
11	1 009	5 248
12	1 169	6 417

(2) Interest on working capital

Month	Cash outlay	Cumulative cash outlay	Monthly interest	Cumulative interest
1	1 303	1 303	20	20
2	594	1 897	28	48
3	644	2 541	38	86
4	696	3 237	49	135
5	760	3 997	60	195
6	870	4 867	73	268
7	879	5 746	86	354
8	989	6 735	101	455
9	1 099	7 843	118	573
10	1 212	9 046	136	709
11	1 370	10 416	156	865
12	1 550	11 966	179	1 044

		B.Cr.
(3)	Water, to replace evaporation and seepage (monthly)	35
(4)	Fertilizer (monthly), 60 kg at B.Cr. 3.00/kg	180
(5)	Operator's labour (monthly)	26
(6)	Miscellaneous and contingencies (monthly)	20
(7)	Harvesting and marketing costs:	

Gasoline: 80 km/trip at 5 km/l at B.Cr. 1.60, 3 trips/harvest, 1 harvest/year	B.Cr. 77
Added truck maintenance	50
Farmer's labour, 3 days at B.Cr. 10	30
Hired harvesting labour	42
Hired pond bottom maintenace labour	35
Total	Br.Cr. 234

4.2 Costs

Conservative estimates were made for all costs to be incurred by the farmer, both fixed and variable (Table II). All costing data were furnished by DNOCS.

The DNOCS surcharge presently is a function (1 percent) of gross revenue. The basis for charging farmers for DNOCS support services is subject to considerable revision and may become a function of acreage. Since acreage is more closely associated with actual DNOCS expenses than gross income, it was arbitrarily assumed that this would become fact. The surcharge, therefore, was treated as a fixed cost. Debt servicing, both principle and interest, was treated as a fixed cost (Table II). Labour furnished by the farmer and his family was treated as a variable cost at the prevailing rate for semi-skilled agricultural labour. Net income or profit would then reflect cash income accruing to the farmer as a return to his management and risk.

It would seem likely that cattle manure would be the lowest cost source of enrichment for fish culture in irrigated areas where livestock are part of the general farming scheme. Surprisingly, in the rare instances where manure is sold on the open market, it appears to have a higher value in crop agriculture where its organic content is an important advantage. Chemical, inorganic fertilizer is budgeted for this project on a least cost basis, acknowledging that individual farmers may choose to use animal manure where its value in other applications is low (Table II). Hauling expense was based on the assumption that the farmer already has access to a vehicle, and that fish hauling is a marginal expense based on unused, surplus vehicle time.

The total benefit to the farmer and his family will be the sum of his net income (profit), his increase in equity (capital gain) arising from payment of principle on his debt, and the operator's (family) labour income.

4.3 Optimization analysis

A pro forma optimization analysis was prepared from the actual growth rates over 12 months, together with conservative estimates of what various sizes of fish would be worth on the open market (Table III and Fig.1). Some reduction in the rate of growth is expected to occur during this period.

TABLE III

Optimization Analysis
(per hectare)

Month	Based on original stocking	Adjusted for 10% mortality	Unit value or price per kg a/	Gross income b/	Marginal income c/	Fixed cost	Variable cost	Total cost	Marginal cost d/	Net income or profit e/
Start	184 kg	166 kg	B.Cr.	B.Cr.	B.Cr.	B.Cr.	B.Cr.	B.Cr.	B.Cr.	B.Cr.
1	613	552	1.0	552	72	174	1 492	1 666		1 114
2	865	779	1.5	1 168	616	348	1 931	2 279	613	1 111
3	1 075	968	2.2	2 127	959	522	2 441	2 963	684	836
4	1 332	1 199	3.0	3 597	1 470	696	3 013	3 709	746	112
5	1 780	1 602	3.3	5 287	1 690	870	3 659	4 529	820	758
6	2 219	1 997	3.5	6 990	1 703	1 044	4 427	5 471	942	1 519
7	2 668	2 401	3.6	8 644	1 654	1 218	5 315	6 533	1 062	2 111
8	3 108	2 797	3.8	10 629	1 985	1 392	6 327	7 719	1 186	2 910
9	3 539	3 185	4.0	12 740	2 111	1 566	7 464	9 030	1 311	3 710
10	4 136	3 722	4.0	14 888	2 148	1 740	8 724	10 464	1 434	4 424
11	4 791	4 312	4.0	17 248	2 360	1 914	10 150	12 064	1 600	5 184
12 f/	5 413	4 872	3.8	18 514	1 266	2 087	11 759	13 846	1 782	4 668

a/ The average size of fish was obtained by dividing total weight per hectare by the stocking rate. Market value was estimated from field observations of local retail and wholesale markets

b/ Gross revenue is obtained by multiplying total weight by unit value

c/ The previous month's gross revenue was subtracted from the current month's gross revenue to obtain marginal income

d/ Marginal cost was obtained by subtracting the previous month's total cost

e/ Net income, or profit, is obtained by subtracting total cost from gross income

f/ Actual production at the termination of the experiment, at the end of 19 days of the last month, was 4 882 kg. Actual mortality was only 3 percent. These data assume 10 percent mortality and are extrapolated to a full 30 day month

Gross income and total cost figures for each month were computed assuming that the crop was terminated, harvesting and marketing expenses incurred, and income from sales realized at that point. Costs are cumulative and income is based on the cumulative weight of the fish and their value at that size. Marginal income and marginal cost for each month were computed as the added income and cost resulting from delaying harvest one more month.

This analysis indicates an optimum growth period of about $11\frac{1}{2}$ months. At this point, net income (or profit) is maximized (Fig. 1) and marginal income is equal to marginal cost.

4.4 Profit and loss analysis

The following budget was prepared to illustrate a pro forma profit and loss statement approximating as closely as possible expected performance for a 1 ha farm pond unit. It is clear that a farm unit would break even just after the end of the fourth month of operation (Fig. 2). Assuming that the pond remains dry for the remainder of the 12th month, a new crop cycle could begin annually. The pro forma profit and loss statement (Table IV) applies to a farmer growing fish on one ha on an annual production cycle.

TABLE IV

Annual Profit and Loss Statement
(per hectare)

	Annual production cycle B.Cr.
Fixed cost	
DNOCS administrative surcharge	111
Pond and gear maintenance	350
Amortization, real estate	1 514
Amortization, equipment	112
Total fixed cost	2 087
Variable cost	
Feed	6 417
Fertilizer	2 340
Water	632
Fingerlings	540
Interest on working capital	1 044
Operator's labour	312
Hired harvesting labour	42
Hired pond bottom maintenance labour	35
Hauling and marketing expense	157
Miscellaneous and contingencies	240
Total variable cost	11 759
Total cost	13 847
Total income (4 872 kg at B.Cr. 3.80/kg)	18 514
Profit	4 668

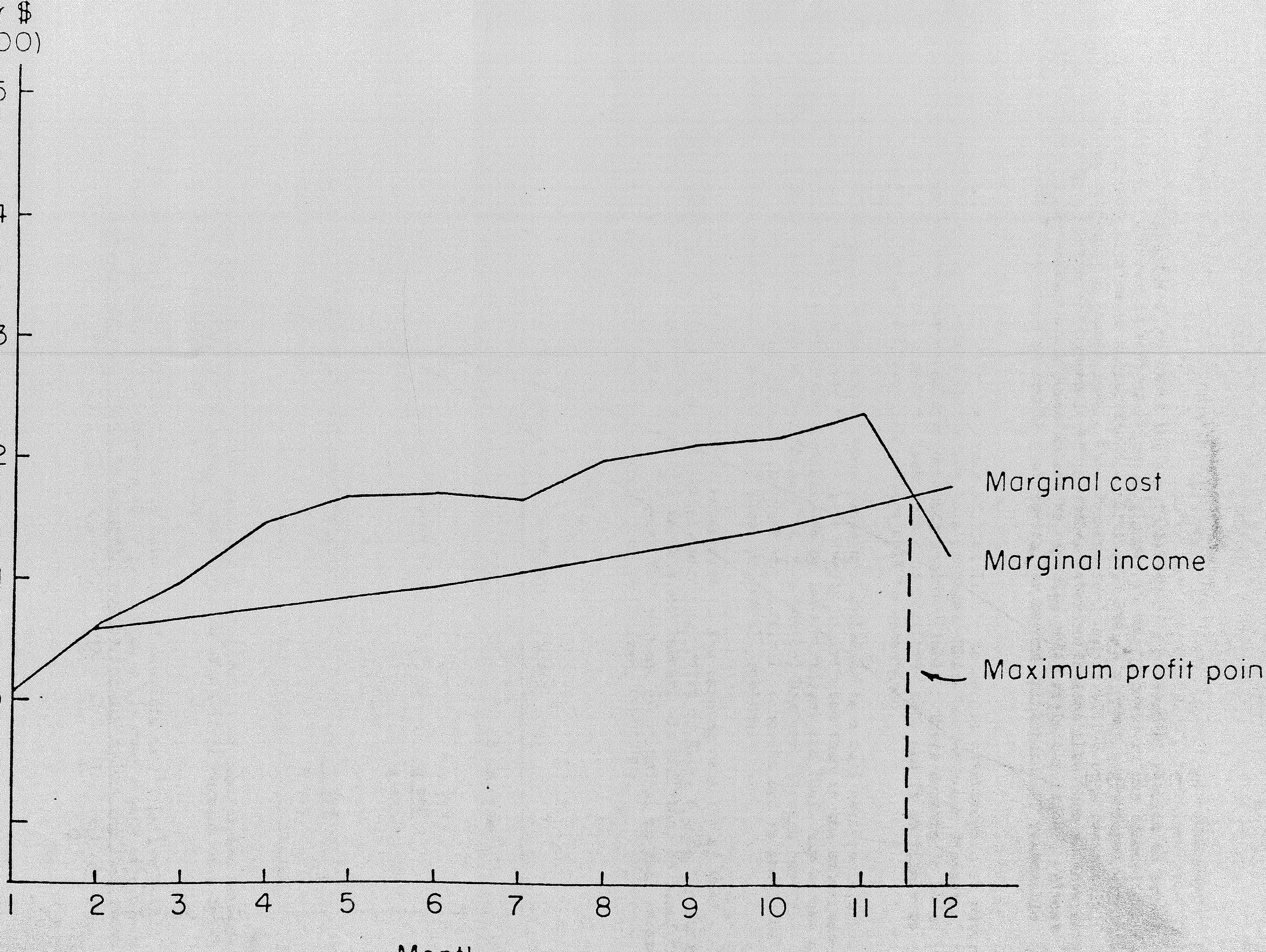

Fig. 1 - Optimization Analysis

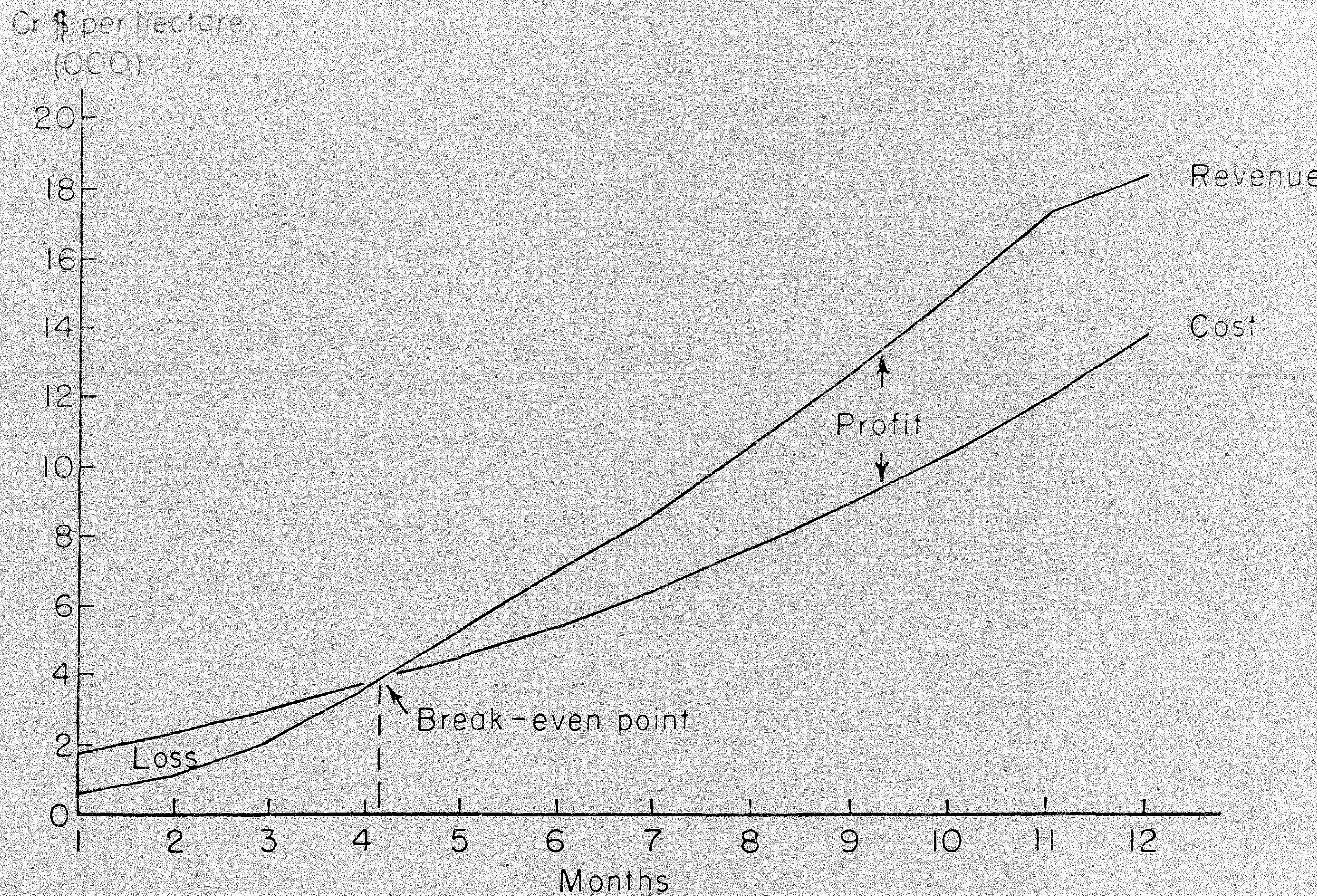

Fig. 2 - Break-even Analysis

5. DISCUSSION

There are always questions about the applicability of experimental results to actual field conditions. The experiment on which this paper is based, however, was conducted under circumstances very similar to actual field conditions. Even a minimum educational extension effort by the cooperative should insure that farmers feed and fertilize on a reasonably regular schedule. Dissolved oxygen level and other water conditions have been as adverse and variable in the experimental ponds as can be expected under field conditions. Almost no further habitat management is required of the farmer beyond maintenance of reasonable water levels.

There appear to be relatively few areas of risk likely to become catastrophic in nature. With proper engineering, flooding should not be a problem. There are no known disease, parasite or predator problems capable of becoming uncontrollable. There appears to be an appreciation of the potential danger to fish from crop pesticide use, and it is likely to be only a minor risk in areas where fish culture will be encouraged.

Some variation might be introduced when ponds are scaled up to a full hectare in size. Feed and fertilizer almost certainly will be less evenly distributed than in the experimental ponds. Security conditions are also likely to be less stringent and theft may become a major area of loss. Both problems lend themselves to solution, however, through careful management and training. Neither problem involves any difficult concepts and it should be relatively easy to make farmers conscious of these potential problems.

The impact of this kind of fish culture enterprise on the earning capacity of the farmer is profound. In addition to a substantial operating profit of B.Cr. 4 668, the farmer also receives a small cash income of B.Cr. 312 for his own labour. In addition, he benefits from a capital gain averaging almost B.Cr. 800/year from payment of principal on real estate debt. Cash income and capital gain total about B.Cr. 5 800/year (Table V).

TABLE V

Potential Impact on the Farmer's Income

	B.Cr./year
Cash income	
Return to personal labour	312
Profit	4 668
Total cash income	4 980
Capital gain	
Average annual increase in real estate equity	797
Total income	5 777

Excluding labour income, the enterprise produces a total return to capital and management of about B.Cr. 5 400. This is an annual rate of return of about 32 percent on a total investment in plant and equipment of B.Cr. 16 855.

It appears that intensive culture of the tilapia hybrid presents an attractive method of increasing the earning capacity of farmers while presenting a low cost source of protein to the people of northeast Brazil. DNOCS is presently moving rapidly toward implementation of the concept.

6. REFERENCES

da Silva, A.B. *et al.*, 1974 Observations préliminaires sur l'obtention d'hybrides tous mâles des espèces *Tilapia hornorum* et *Tilapia nilotica*. Notes et Documents, *Centre Technique Forestier Tropical*, 7:1-8

Lovshin, L.L. and A.B. da Silva, 1974 The intensive culture of the hybrid of *Tilapia hornorum* (male) X *Tilapia nilotica* (female) in Northeast Brazil (MS.) *Paper presented* to the FAO/CARPAS Symposium on Aquaculture in Latin America CARPAS/6/74/SE 22