

ECONOMIC VIABILITY OF TAMBAQUI PRODUCTION IN THE MUNICIPALITY OF ARIQUEMES-RO

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ABSTRACT

The rise increase in family income and the conditions conducive to aquaculture activity have allowed Brazil to increase fish production in recent years. As a result, tambaqui (*Colossoma macropomum*) farming has become an interesting alternative because it is adaptable to different production systems and widely accepted by consumers. Ariquemes, in the State of Rondônia stands out because it presents adequate logistic and edaphoclimatic conditions for the production of this species. The objective of this paper is to analyze the economic viability of tambaqui farming in excavated nursery in the municipality of Ariquemes - RO. Revenues and expenses were financially analyzed in a 420-day production cycle, using values of 2015 as a reference. Fish farming was sufficient to pay Total Operational Cost. The Net Margin was R\$ 0.44 kg⁻¹ of fish. However, Total Revenue was insufficient to cover the Total Cost, generating negative Net Income of R\$ 839.57. Labor hiring and feed purchase were the items that impacted the most and accounted for 16.1% and 73.7% of the Operational Cost, respectively. It has been found that tambaqui farming in an excavated nursery has not shown to be promising and economically viable and tends to become economically unsustainable in the long term.

Key words: *Colossoma macropomum*; costs of production; labor; fish farming; feed.

VIABILIDADE ECONÔMICA DA PRODUÇÃO DE TAMBAQUI NO MUNICÍPIO DE ARIQUEMES-RO

RESUMO

A elevação da renda das famílias e as condições propícias para a atividade aquícola têm permitido ao Brasil elevar a produção de pescado nos últimos anos. Em razão disso, a produção de tambaqui (*Colossoma macropomum*) tornou-se alternativa interessante por apresentar adaptabilidade aos diferentes sistemas de produção e grande aceitação pelos consumidores. Ariquemes, RO destaca-se por apresentar condições logísticas e edafoclimáticas adequadas para produção dessa espécie. Objetivou-se com o presente trabalho analisar a viabilidade econômica da produção de tambaqui em viveiro escavado no município de Ariquemes, RO. Analisaram-se financeiramente receitas e despesas em um ciclo produtivo de 420 dias, tendo como referência valores de 2015. A produção de pescado foi suficiente para quitar o Custo Operacional Total. A Margem Líquida foi de R\$ 0,44 kg⁻¹ de peixe. Entretanto, a Receita Total foi insuficiente para cobrir o Custo Total, gerando Renda Líquida negativa de R\$ 839,57. Contratação de mão de obra e aquisição de ração foram os itens que mais impactaram e responsáveis por 16,1% e 73,7% do Custo Operacional Efetivo, respectivamente. Verificou-se que a produção de tambaqui em viveiro escavado não se mostrou promissora e economicamente viável e tende a se tornar, a longo prazo, insustentável do ponto de vista econômico.

Palavras-chave: *Colossoma macropomum*; custos de produção; mão de obra; piscicultura; ração.

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INTRODUCTION

The economic results achieved by the agribusiness in recent years have raised Brazil as one of the great protagonists in the international agricultural scenario. The country has achieved successive records in the production of grains, mainly in relation to the soybean complex, and since 2008, it has been the largest beef exporter. Together, these two sectors accounted for 55% of Brazilian agribusiness exports and contributed to the supply of food at low prices, generation of employment, income and foreign exchange for helping the trade balance (MAPA, 2015). The agricultural component has undoubtedly become one of the economic pillars of the country. However, that strength might have been more pronounced if the country had better exploited the potential of fish as a source of animal protein and wealth generation.

Fish is the most globally demanded source of animal protein and with the highest market value (SIDONIO *et al.*, 2012). It is considered one of the foods with the greatest nutritional benefit because it contains proteins of high biological value, easily digestible, presenting low cholesterol and a great source of vitamins A, B, D and E (JAMAS *et al.*, 2015). The per capita consumption of fish is 20 kg year⁻¹ and the world production is just over 160 x 10⁶ t (FAO, 2014). In Brazil, the per capita consumption is approximately 9 kg year⁻¹, a value below that recommended by the World Health Organization (WHO), which is 12 kg year⁻¹ (SIDONIO *et al.*, 2012). However, in recent years, because of the increased family income, fish has been characterized as a relevant alternative for Brazilian population feeding (KUBITZA *et al.*, 2012). The rise in demand for this type of product, combined with the inherent environmental resources and conducive to the development of aquaculture in the country, created conditions for fish to become an important element in Brazilian agricultural policy for domestic supply and the sustainability of fishery resources (BRASIL, 2009). Hence, the valuation of native species with great potential for production and consumption, such as tambaqui, pacu, matrinxã, has become a promising alternative for food supply, income generation, and development of aquaculture. Tambaqui (*Colossoma macropomum*) is considered the leading native species of Brazilian fish farming (RODRIGUES, 2014). It presents good growth potential, high rusticity, adaptability to several production systems and great

acceptance in the consumer market (OSTRENSKY *et al.*, 2008). In 2014, the production of tambaqui in Brazil was 139 x 10³ t, which is 57% higher than the amount produced in 2013 (PEDROZA FILHO *et al.*, 2016). Due to the climatic issues, tambaqui production is mainly concentrated in the North and Central-West regions and the leading producing states are Amazonas, Roraima, Rondônia and Mato Grosso.

The State of Rondônia is the largest tambaqui producer and accounts for 45.4% of the country's total production (IBGE, 2014). The State presents a favorable condition for the development of aquaculture since it has a flat topography, a defined rearing system and environmental legislation, technically qualified professionals to support activities and a large volume of water network composed of rivers and streams with natural preservation that provide excellent water quality (LOOSE *et al.*, 2014; COSTA *et al.*, 2015). In Rondônia, there are approximately 800 fish farmers, of which 180 are in the region of Ariquemes (COSTA *et al.*, 2015), a municipality considered an aquaculture center and the largest tambaqui producer in the State (NUNES, 2014). Factors such as climate, proximity to fish consuming centers, ease of production drainage, high availability of water and a high number of fish farms promoted the development and increase of fish industry in the region (COSTA *et al.*, 2015).

Despite being promising, tambaqui farmers still lack information to support them in the management of the farm, mainly related to economic aspects, since the purchase of rations and hiring labor are the items that most add cost to the production system. There is no doubt that the economic factor plays an important role in the productive component and must be considered in order to achieve results. Therefore, the objective of this work was to analyze the economic viability of tambaqui production in an excavated nursery in the municipality of Ariquemes, State of Rondonia.

METHODS

This study was elaborated from technical and economic information collected in a modal aquaculture enterprise, located in the municipality of Ariquemes, State of Rondônia. The city is in the center-north part of the state, at latitude 09°54'48" S and longitude 63°02'27" W, distant 203 kilometers from the capital Porto Velho. It has a population of 104,401 inhabitants,

distributed in an area of 4,426,571 km². In 2013, the Gross Domestic Product and the per capita income of the municipality reached R\$ 1,778,919,000.00 and R\$ 17,566.27, respectively (IBGE, 2015). The Ariquemes Municipal Human Development Index is 0.702, which places it in a high position in the Human Development range ($0.700 \geq 0.799$) (PNUD, 2013).

The evaluated fish farm presented 5 ha of water depth distributed in 11 excavated nurseries, of which two, 2,500 m² each, were used for the rearing phase, and nine, of 5,000 m² each, for the finishing phase.

The production system is a biphasic one, categorized into rearing and finishing. Fish stocking in the rearing phase began on November 1, 2013, and lasted 120 days. The initial average weight was 2 g and the average weight at the end of the rearing phase was 286 g. The number of fish initially stocked was 20,000 units, the survival rate was 70% and the apparent feed conversion (kg diet/ kg body weight) was 1.25: 1 during the period. The initial density was 4 fish m⁻² and the final biomass was 4,004 kg. The amount of feed consumed in the rearing phase was 4,950 kg. The finishing phase lasted 300 days and it started on March 1, 2014, with 14,000 fish stocked. The initial and final average weight was 286 g and 2,500 g, respectively. The survival rate was 100%, feed conversion was 1.85: 1 and the initial density was 0.31 fish m⁻², with a final biomass of 35,000 kg, compared to a consumption of 57,450 kg of the ration. For calculations, an average feed conversion of 1.55: 1 was considered. In the system used in this study, the total production of fish obtained in each phase (rearing and finishing) was considered a plot. Over the year, 1.5 lots were produced. Data on animal performance for the production cycle used in the system are described in Table 1.

Table 1. Technical indicators used in tambaqui farming system in excavated nurseries in Ariquemes, RO, 2015

Technical Indicators	Unit	Quantity
Total area of the nurseries	ha	5
Average feed conversion	un.	1.55
Average production period	day	420
Amount of used ration	kg	62,400
Mass of kg of fish produced per cycle	kg	35,000
Mass of kg of fish produced per year	kg	52,500

The nurseries were prepared to make them suitable for receiving the fish. They were built according to the legal environmental restrictions imposed for this type of system, especially those related to deforestation, preservation of environmental protection areas, riparian forests and rational use of water. The nurseries were built using the availability of water present in rivers, streams and dams adjacent to the farm. The average flow rate for cultivation was 15 L s⁻¹ ha⁻¹ of water depth. For each hectare of water depth utilized, R\$ 50,000.00 was spent. This amount included expenses with 1) cleaning of the land; 2) removal of vegetation; 3) removal of the first 30 cm of soil to avoid the accumulation of organic material in the base of the mud; 4) ground leveling of dams/slopes; 5) adaptation of the nursery bottom to the ideal slope; 6) construction of the supply system; 7) construction of the drainage system and 8) protection of the slopes.

Disinfection of the bottom of each nursery consumed 90 kg of calcium oxide (CaO). This product was applied to eliminate possible pathogens, given the capacity of the calcium oxide to reduce the acidity of the soil in contact with it, from the unexpected rise in pH and the rapid release of heat caused by an exothermic reaction. For the liming of the nurseries, 6.03 t of dolomitic limestone (PRNT 92%) was applied to neutralize the sediment superficial layer at the bottom of the nurseries and to increase total alkalinity and total water hardness (QUEIROZ and BOEIRA, 2006). Fifteen days after limestone application, when pH of the water in the nurseries ranged from 6.5 and 8.5, and total alkalinity and hardness was higher than 30 mg of CaCO₃, fertilization based on urea (60 kg ha⁻¹) and triple superphosphate (30 kg ha⁻¹) were carried out to stimulate the primary production of zooplankton and phytoplankton in the nurseries.

After the process of acidity correction and fertilization of the nurseries - observed by the presence of clear green water and with a transparency of approximately 40 cm of the surface - the fingerlings were received to the nurseries. The animals were received at times of day with mild temperature (usually in the morning or late afternoon) to avoid further stress to the animals. Held in plastic bags with water, the fingerlings were removed from the transport vehicle and placed on the water surface of the tank, where they remained between 10 and 20 minutes, depending on the degree of oxygenation and temperature observed in the plastic bags, so that there was a balance between the temperature of the containers and that of the tank. After the stipulated

period, the plastic bags were opened and, without abrupt movements, with one of the hands opened in the form of a seashell, the water was mixed by putting water from the nursery in the plastic bags. Then, in a local with clear water, fingerlings were released in a slow and gradual manner. Similarly, the same procedures were adopted for the reception of juveniles in the finishing phase. Tanks were stocked with 20 thousand of fingerlings were used. For daily control of pH, dissolved oxygen levels and level of non-ionized ammonia ($\text{NH}_3\text{-N}$), colorimetric kits were used. As a prophylactic measure to reduce the risk of infections caused by bacteria and funguses, about 4 to 5 kg m^{-3} of sodium chloride (NaCl) were diluted in the nurseries. Sodium chloride stimulates the secretion of mucus on the gill epithelium, helping to cover injured areas, reducing the chances of infections caused by these microorganisms, and it has a stress-reducing activity by triggering physiological reactions that culminate in the rise of levels of cortisol in the fish blood (DINIZ and HONORATO, 2012). Over the entire cycle, 900 kg of this product was consumed (Table 2).

In addition to the items previously mentioned, there were also expenses for the preparation of the technical project and issue of the permits

(Table 2). Permit issue (Preliminary, Installation, and Operation) is a requirement of the municipal executive power to those enterprises focused on the fishing activity. The General Register of the Fishing Activity is an instrument of the federal executive power that allows legalizing the users through the approval of a private individual or a legal entity for the exercise of the fishing activity. As the information was collected in August 2015, it was the responsibility of the former Ministry of Fisheries and Aquaculture (MPA) to issue such a registration. Because that ministry was extinct, the attributions for issuance were in charge of the Ministry of Agriculture, Livestock, and Supply (MAPA). The license to grant water use is issued by the State Secretariat for Environmental Development of the state of Rondônia and it is intended for all who wish to use surface water (river, stream, stream, lake, mine or spring) or groundwater (tubular wells) for the most diverse purposes, among them fish farming.

Seven types of diets were used in the feed management, according to specification, quantities, and values shown in Table 3. Given the animal characteristics and their different growth phase, feeding was carried out using compounds with different sizes, consistence, and levels of crude protein (CP).

Table 2. Spending on tambaqui farming system implementation in excavated nurseries in Ariquemes, RO, 2015

Items	Unit	Quantity	Unit value (R\$)	Total value (R\$)
Nursery implementation and construction	ha	5	50,000.00	250,000.00
Tambaqui fingerlings	1,000	20	100.00	2,000.00
Triple superphosphate	kg	150	2.10	315.00
Urea	kg	300	1.90	570.00
Dolomitic limestone	ton	6.03	220.00	1,326.60
Lime	kg	90	1.00	90.00
Colorimetric Kit	un.	1	440.00	440.00
Salt	kg	900	0.56	504.00
Previous permit	un.	1	1,000.00	1,000.00
Installation permit	un.	1	1,000.00	1,000.00
Operation permit	un.	1	800.00	800.00
General Register of Fishing Activity - MPA	un.	1	137.00	137.00
Grant License	un.	1	1,000.00	1,000.00
Technical design plan	un.	1	5,000.00	5,000.00

The aquaculture business used a versatile employee to carry out the activities. The employee was hired by considering the value of two minimum wages added to a rate of 45.6% of that amount related to social charges (INSS, FGTS, additional for

vacation, work accident insurance, education salary, contract cancellation fine, INCRA, Christmas bonus salary and prior notice and the proportional amounts on those last two items). It should be highlighted that the minimum wage at the time of data collection was

R\$ 788.00. In addition to the expenses inherent to this employee, payments of six monthly daily rates with an average value of R\$ 41.66 were recorded for the services of fish harvest from tanks from the rearing

phase to the finishing phase, as well as final expenses. Since the activity management is the responsibility of the producer, a monthly withdrawal of R\$ 1,200.00 was also considered as pro-labor (Table 4)

Table 3. Different types of diet, quantities consumed and values used (Control values for 25-kg bag) in excavated nurseries in Ariquemes, RO, 2015

Types of diet	Qty/Plot	R\$/Unit	R\$/Plot
Extruded diet 45% CP, 0.8 to 1 mm	1	230.00	230.00
Extruded diet 45% CP, 1 to 1.7 mm	4	200.00	800.00
Extruded diet 45% CP, 2.6 mm	8	100.00	800.00
Extruded diet 36% CP, 2.6 mm	56	72.00	4,032.00
Extruded diet 32% CP 6 to 8 mm	129	51.00	6,579.00
Extruded diet 28% CP, 6 to 8 mm	1.290	35.00	45,150.00
Extruded diet 28% CP, 8 to 10 mm	1.008	35.00	35,280.00

Table 4. Monthly expenses with labor hired for tambaqui cultivation systems implementation in excavated nurseries in Ariquemes, RO, 2015

Labor	Quantity	Unit Value (R\$)	Annual total value (R\$)
Employee	01	2,294.34	27,532.08
Harvest day employee	06	41.66	3,000.00

The farm is a family-owned business focused on fishing. It has a total area of 100 ha, of which 74 ha are occupied by pastures, 5 ha for tambaqui farming, 20 ha for the permanent preservation area and 1 ha for improvements. Among the improvements, there is a 100 m² house and a masonry feed storage barn of 50 m². It has implements such as a feed broadcaster and carts, which can be coupled to a 50-hp tractor and a 150-cc motorcycle used to assist in the performance of daily activities. The enterprise also has a small utility vehicle for family use and material transportation. In relation to fish management, the following were used: 25 kg hook scale, eight 1,000 L water storage tanks, out of which three were used for management and five for food packaging, 100 m of a net for fishing (4-mm mesh) and 5,000 m of an anti-bird screen (100 mm thick). As equipment items, cabling was used to install electricity for nurseries (Table 5).

The depreciation of the assets used for construction and maintenance of the nurseries, as well as machines, implements and equipment used was estimated by the linear method, considering the term of ten years for the equipment and twenty-five years for the buildings and facilities (RECEITA FEDERAL, 1998).

Table 6 shows the management costs spent in the implanted system. The following were considered expenses: telephone bill, electric power bill, Rural Territorial Tax (ITR) and Motor Vehicle Property

Tax (IPVA), annual renewals of general registration of the fishing activity, renewals of environmental, operation and water analysis permits and bi-annual environmental report for operation of the activity. Also included in the management costs was the annual payment of R\$ 180,000.00 loans contracted with the National Program for Strengthening Family Agriculture (PRONAF) in the fund (R\$ 100,000.00) and investment (R\$ 80,000.00) modalities.

Table 5. Expenditure related to improvements, machinery, implements and equipment for implementation of tambaqui farming system in excavated nurseries in Ariquemes, RO, 2015

Items	Quantity	Total value (R\$)
Farm house	1	60,000.00
Feed storage barn	1	15,000.00
50-hp tractor	1	20,000.00
Tractor-cart	1	2,000.00
Motorcycle cart	1	2,000.00
Feed broadcaster	1	6,000.00
Hook scale (25 kg)	3	100.00
Water storage tank (1000 L)	3	350.00
Feed box (1000 L)	5	350.00
Electrical installation	1	7,000.00
Fishing trawl net	1	3,000.00
Anti-bird screen	1	2,000.00

Table 6. Annual management costs for the implantation of tambaqui farming system in excavated nurseries in Ariquemes, RO, 2015

Items	TotalValue (R\$)
Telephone	480.00
Electric power	288.00
ITR	2.00
IPVA	240.00
RGAP Renewals	137.00
Environmental Reports	1,000.00
Water operation and analysis environmental permit	300.00
PRONAF - Fund	2,000.00
PRONAF - Investment	3,200.00

Calculations for production costs and economic indicators allow the farmer to establish priorities, to identify the possibility of new investments and to evaluate the viability of the business (GOUVEIA *et al.*, 2006). The calculation methodology for estimating the economic viability of tambaqui farming was based on the following indicators: Effective Operational Cost (EOC), Total Operational Cost (TOC), Total Cost (TC), Gross Income (GI), Net Income (NI), Gross Margin (GM) and Net Margin (NM) (MATSUNAGA *et al.*, 1976; GOUVEIA *et al.*, 2006; GUIDUCCI *et al.*, 2012).

The Effective Operational Cost implies in the payments made by the farmer to operate the activity during a certain period of time. The following expenses of the farming activity are counted: feed, labor, fertilizers, medicines, energy, fuel, maintenance, taxes and technical assistance, etc. Total Operational Costs are the sum of the EOC combined with the costs corresponding to the labor of the owner (pro-labor), depreciation of improvements, machines, implements, and equipment. Total Cost includes the TOC plus the interest remuneration mobilized in improvements, machinery and equipment and the land opportunity cost. Gross Income is determined by the price of the product multiplied by the respective quantity produced. The analysis of GI alone is not conclusive since the production systems with the highest gross income are not always the best from the economic point of view. It is necessary to compare it with the associated costs, that is, with the amount invested in production. Net Income is obtained after the remuneration of all expenses incurred in production. It is the result of the deduction between Total Cost and Gross Revenue. If this remuneration is not competitive, the business will not be economically sustainable in the long term. If NI is greater than or

equal to zero, this will indicate that the activity is stable and profitable. If NI is negative, but the generated revenue covers the operating cost, at least, the business will present long-term decapitalization problems, although the activity may be maintained for some time. However, if this situation of negative NI persists, the payment to be received by the farmer will not be enough to cover the costs of depreciation of improvements and machinery, which may cause impoverishment and, in the long term, make the activity unsustainable from the economic point of view (GUIDUCCI *et al.*, 2012).

Gross Margin is the result from the difference between GI and EOC. If the GM value is positive, i.e. if it is higher than the effective operating costs, this indicates that the activity, at least in the short term, is able to compensate the production costs. If GM is negative, it is a sign that the activity is uneconomical and not more sustainable in the short term. NM is the difference between GI and TOC. If the NM of the activity is positive, it can be concluded that the activity is stable, with the possibility of expanding and sustain itself in the long term. If the value of NM is equal to zero, the activity will be at the equilibrium point and in conditions of redoing, in the long run, its fixed capital. However, when NM is negative, the farmer will have an increasing problem of decapitalization, although he or she is still able to remain in the activity for a certain period.

To estimate the percentage of each item in the composition of the effective operational cost, the division of the total payment of certain expenses by the effective operating cost was considered. To group the data and perform the economic indicator calculations, MS Excel® software was used.

RESULTS

Tambaqui was commercialized at R\$ 4.50 per kilogram, generating an annual revenue of R\$ 236,250.00. In addition to this amount, R\$ 1,388.34 came from the sale of empty feed bags, materials that are made of linen and can be reusable for the packaging of similar products in sacks and agricultural products houses. Therefore, the annual Gross Revenue was R\$ 237,638.34. The annual Effective Operational Cost was R\$ 189,638.81, the Total Annual Operating Cost was R\$ 214,732.40 and the Annual Total Cost was R\$ 238,477.91 (Table 7)

Feed purchase and hiring of labor were the items added cost the most to the production process. The expenses related to feed purchase and hiring of labor corresponded to 58.9% and 12.9% of the Gross Income, respectively.

In relation to the EOC, expenses with feed purchase accounted for 73.7%, while labor expenses accounted for 16.1% (Table 8). So, these two items, were responsible for almost 90% of the Effective Operational Cost.

Table 7. Economic indicators related to Tambaqui farming in excavated nurseries in Ariquemes, RO, 2015

Specification	Activity annual value (R\$)	Activity value per plot (R\$)	Unit value (R\$ kg ⁻¹ of fish per year)
GROSS INCOME - GI			
Fish sell revenue per cycle	236,250.00	157,500.00	4.50
Other revenues - empty feed bags	1,388.34	925.56	0.03
TOTAL GI	237,638.34	158,425.56	4.53
EFFECTIVE OPERATIONAL COST - EOC			
Fingerling	3,000.00	2,000.00	0.06
Feed	139,306.50	92,871.00	2.65
Fertilizers	1,327.50	885.00	0.03
Correctives	2,124.90	1,416.60	0.04
Management expenses, taxes and fees	7,359.00	4,906.00	0.14
Energy and fuel	537.75	358.50	0.01
Maintenance - machinery/equipment	759.10	506.70	0.01
Maintenance - improvements	3,275.97	2,183.98	0.06
Contract labor	30,532.09	20,354.73	0.58
Salt	756.00	504.00	0.01
TOTAL EOC	189,638.81	126,425.87	3.60
TOTAL OPERATIONAL COST - TOC			
Effective operational cost	189,638.81	126,425.87	3.60
Improvements depreciation	8,170.93	5,447.28	0.16
Depreciation machinery, implements, equipment and tools	2,522.67	1,681.78	0.05
Pro-labor	14,400.00	9,600.00	0.27
TOTAL TOC	214,732.40	143,154.93	4.08
TOTAL COST - TC			
Total operational cost	214,732.40	143,154.93	4.08
Return on capital - improvements	9,827.91	6,551.94	0.19
Return on capital - machinery, inputs, equipment and tools	1,917.60	1,278.40	0.04
Land opportunity cost	12,000.00	8,000.00	0.23
TOTAL TC	238,477.91	158,985.27	4.53

Table 8. Gross Income and Effective Operational Cost Composition for implementation of Tambaqui farming system in excavated nurseries in Ariquemes, RO, 2015

Items - Effective Operational Cost (EOC)	GI composition (%)	EOC Composition (%)
Fingerlings/juveniles	1.27	1.59
Feed	58.97	73.72
Fertilizers	0.56	0.70
Correctives	0.90	1.12
Management expenses, taxes, fees	3.11	3.89
Energy and fuel	0.23	0.28
Maintenance - machinery/equipment	0.32	0.40
Maintenance - improvements	1.39	1.73
Contract labor	12.92	16.16
Sanity	0.32	0.40

DISCUSSION

The results show that the venture is subject to long-term decapitalization and it becomes economically unviable since what is produced and commercialized is not able to cover all the expenses inherent in the activity.

Considering the annual values presented in Table 7, it is verified that fish farming was enough to pay EOC. The gross margin was R\$ 0.91 kg⁻¹ of fish. As GI was also higher than TOC, the unit net margin was positive and was R\$ 0.44 kg⁻¹ of fish. However, the NI obtained generated a negative value of R\$ 839.57 and the difference between GI and TC by the annual production presented a loss of R\$ 0.02 kg⁻¹. However, these results are much more promising than those found by MELO *et al.* (2001), who, when analyzing tambaqui farming in clay nurseries/dams in the state of Amazonas, found that GI amortized 51.3% of EOC and 60% of TOC. If one analyzes the results of the two models, it is verified that the production system in Amazonas presents higher cost and lower profitability when compared to the model implanted in Ariquemes.

According to the results in the studied venture, the revenue obtained, although it did not cover the total costs, was sufficient to amortize the operating cost, allowing the farmer to remain in the activity for some time. However, if the negative NI situation persists, the farmer will receive a lower payment than the one considered in the cost and this may lead to impoverishment, making the activity unsustainable from an economic point of view, which has been occurring, for example, in most tambaqui farming ventures in another municipality in the state of Rondônia, near Ariquemes. LOOSE *et al.* (2014), when evaluating the costs of tambaqui farming on farms in Cacoal, verified that only 40% of the evaluated farms had a high net margin. The others presented negative results attributed to lack of planning, adequate technical knowledge and control of production costs.

In relation to the price of kilogram of tambaqui commercialized in the municipality of Ariquemes, although the value used for calculation refers to the month of August 2015, it should be noted that this value remained unchanged until the second quarter of 2016, as shown by weekly price consultations carried out along with the website of Empresa Estadual de Assistência Técnica e Extensão Rural do Estado de Rondônia (EMATER, 2016). This price stagnation is due to the great offer of the

product and the lack of processes capable of adding value to production, such as: processing units and refrigeration plants suitable to make elaborate cuts and to provide differentiated products that meet the demands of consumers. This scenario of price stagnation, combined with the gradual increase in feed costs, continuously reduced profit margins of the farmer due to "economic burden" of these items in productive activity.

The percentage of 89.8%, resulting from the sum of the feed and labor items for the EOC composition (Table 8), is close to that observed by PEDROZA FILHO *et al.* (2016) when analyzing the dynamics of the tambaqui and other round fish farming in Brazil. These authors verified that costs related to the purchase of the feed and the hiring of labor in the central region of Tocantins were the items that had the greatest impact and accounted for 76% and 9.33%, respectively, in tambaqui farming. In relation to the feed, these same authors verified that, although the purchase of feed for tambaqui and tilapia have similar weight in the composition of the EOC, the greatest impact occurs in the final cost of tambaqui production due to the larger consumption and the lower feed conversion efficiency of this species since it is necessary 1.8 kg of diet for the production of 1 kg of tambaqui and 1.4 kg of feed produce 1 kg of tilapia (PEDROZA FILHO *et al.*, 2016).

Feed is the input that adds cost the most in tambaqui production (MELO *et al.* 2001; CASTRO *et al.*, 2002; IZEL e MELO, 2004; ANDRADE *et al.*, 2005; LOOSE *et al.*, 2014; SOUZA *et al.*, 2014). This is not only because of the price but also to technological issues. The great lack of nutritional studies on tambaqui, especially regarding the need for fatty acids, amino acids, vitamins and minerals, implies in nutritionally incomplete diets for the species in all the farming phases, causing low productivity and profitability (RODRIGUES, 2014). Actually, there is no diet formulation that meets all nutritional requirements and able of interacting with the different abiotic factors that affect the species (CYRINO *et al.*, 2010). And this is not just a problem in tambaqui production (SCORVO-FILHO *et al.*, 2010). Considering that the available knowledge about the more than 200 species of fish commercially produced in the world - at least 40 of them cataloged in Brazil - it is still emerging, and that there are fish farming systems under the most diverse exploitation regimes, implanted in all ecological conditions as possible, the task of producing diets fitted to

the needs of each species is not only other than unlikely but greatly demanding (BORGHETTI and OSTRENSKY, 2002; BUREAU and VIANA, 2003; CYRINO *et al.*, 2010). In short, problems related to the nutritional efficiency of fish feed will remain, for a long time, a productive challenge. For this reason, it is difficult to obtain greater productive efficiency and better economic yield.

Other factors influencing the high cost of feed purchase are concerned to logistic aspects: 1) lack of proximity to soybean and corn (essential ingredients in the composition of the product) producing centers, which ends up in increasing freight expenses for the transportation of this product from other states; 2) a small number of mills focused on fish diet production; 3) the lack of supply of specific diets for tambaqui farming; 4) the price paid for feed acquisition due to the recent exchange devaluation, which leads to the export of commodities - as is the case of soybean and corn, inputs used for the production of feed - since there will be an increase in international demand due to the fall in the prices of these domestic products in relation to the dollar. The increase in foreign demand stimulates commodity producers to export, given the greater profitability to be obtained with the exchange devaluation. However, this greater advantage, due to the external commercialization, brings with it effects that result in the reduction of the supply of these products domestically, thus raising its prices in the domestic market; 5) the commercial price itself of soybean and corn; 6) climatic factors, such as long periods of drought such as those caused by the El Niño phenomenon in the 2015/2016 harvest, which may affect the production of soybean and corn. Hence, SIDONIO *et al.* (2012) admitted that, because Brazil is the largest producer of soybean and corn, there should not be great technical difficulties for feed production. However, the problem is due to the difficulties inherent in certain production models. Fish industry companies are generally small and with large idle productive capacity, which does not justify the construction of feed mills. And because there are no feed mills, producers import this feed from other centers. As a result, they pay a higher value, since, in addition to the costs inherent to the purchase of the product itself, freight expenses are also computed to transport it to the farm (SIDONIO *et al.*, 2012). Whether there are no alternatives that allow the establishment of feed mills or that reduce the price of transportation of inputs, this type of situation will remain unchanged. The purchase of

large volumes of ration by tambaqui farmers in the State of Rondônia is perhaps an alternative, since it will allow the reduction of the value of freight cost and, consequently, of the value of the cost to acquire this product, making it cheaper in the calculation of the total cost of production.

In relation to labor, MARTIN *et al.* (1995) evaluated the costs and returns under different technological levels of tambaqui farming and verified that this component is the second item, after feed purchase that pressures the costs of the activity the most, regardless of the technology adopted. MELO *et al.* (2001), in a study carried out with tambaqui farming in nurseries and dams in the State of Amazonas, also verified that the hiring of labor was the second item - behind feed purchase - that impacted the cost of production the most and accounted for 5.07% in the composition of the TOC. BRABO *et al.* (2015), when verifying the economic viability of tambaqui, curimatã and piaçu fingerlings in fish farms in northeastern Pará, demonstrated that labor cost is one of the most significant items on the operational costs of production and this is due to the social charges that affect the hiring of labor and the level of qualification required to carry out the activities.

As the results show, and by maintaining the current conditions of production, it is observed that the activity in question will become impracticable in the medium to long term. The alternatives to make the production feasible are the increase in the value paid for the kilogram of fish or the reduction of costs, especially for feed purchase, which is the input that impacts the costs of the activity the most. Although tambaqui has become one of the most important fish of the Brazilian fishery because of its gastronomic qualities and versatility in offering a series of by-products generated by evisceration and cutting operations, in addition to the capacity to compete equally with tilapia and other imported fish due to its great acceptability, even in non-traditional markets where there is no expressive consumption of the product, even though, what is perceived now is that the profit margins perhaps positive are conditioned mainly to the prices paid to the farmer than to the technological conditions (PEDROZA FILHO *et al.*, 2016). This relationship becomes even more fragile when it is analyzed under a scenario of an increased offer of the product and consequent fall in the prices paid to the farmer. This will fatally reduce the profit margins of fish farmers and will require alternatives that promote increase in the productivity.

By analyzing in relation productivity, it is observed that fish farming, and consequently its element related to tambaqui production in excavated nurseries, lacks technological innovations. Both fish farming and aquaculture did not experience the same advances that were widely obtained in other agricultural and livestock segments. And when the production of native species, as is the case of tambaqui, is evaluated, it can be seen that it is covered by an underdeveloped technological package. PEDROZA FILHO *et al.* (2016) mentioned that the seasonality in the offer of fingerlings, the low efficiency of feed conversion and growth rate, the presence of intramuscular spines in "Y" and the high cost of production in tank-net contribute to study actions focused on the improvement of breeding techniques, development of specific diets, selection and genetic improvement of the species, development of techniques and equipment for processing and improvement of management techniques. Only by solving such difficulties, the tambaqui will be able to express all its zootechnical potential and will be able to provide increases in the productivity and economic gains.

CONCLUSIONS

Tambaqui farming in excavated nurseries in the municipality of Ariquemes, State of Rondônia has not shown to be promising and economically feasible for this case and tends to become economically unsustainable in the long term. Although Net Margin was sufficient to amortize Total Operating Cost, the Net Income generated a negative amount of R\$ 839.57. Whether the farmer does not adopt measures that can reverse this continuous process of decapitalization, the venture will not be able to remunerate all the production factors and the activity will no longer be economically attractive. Feed purchase and labor were the items that most affected the production system, accounting for 73.7% and 16.1% of the composition of the Effective Operational Cost, respectively. The results indicate that whether the farmers do not have an in-depth knowledge of the profitability in their establishments, this may make it difficult to make decisions and compromise the strategies for the activity. Only a strict management control can contribute to reduce the risk of indebtedness and loss of productive capacity and guarantee economic efficiency in tambaqui farming.

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