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Financial Evaluation, Under Conditions of Risk, in a Family Dairy Production System

César Otaviano Penna Júnior[1*], Rogério Figueiredo Daher[2], Paulo Marcelo de Souza[2], Niraldo José Ponciano[2], Gercílio Alves de Almeida Júnior[3], Ismail Ramalho Haddade[4], Ivan Jannotti Wendling[3], Wanessa Francesconi Stida[2], Ana Kesia Faria Vidal[2] and Rafael Souza Freitas[2]

[1]General Education Office, Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo – Campus Alegre, Municipality of Alegre, State of Espírito Santo, Brazil.
[2]Agricultural Science and Technology Center, Universidade Estadual do Norte Fluminense Darcy Ribeiro – UENF, Municipality of Campos dos Goytacazes, State of Rio de Janeiro, Brazil.
[3]Department of Animal Science, Universidade Federal do Espírito Santo, Municipality of Alegre, State of Espírito Santo, Brazil.
[4]General Education Office, Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo – Campus Santa Tereza, Municipality of Santa Tereza, State of Espírito Santo, Brazil.

Authors' contributions

This work was conducted together among all the authors. Authors COPJ, RFD, PMS, NJP, GAAJ and IRH collected and manipulated the data and wrote the first draft of this manuscript. Authors COPJ, RFD, PMS, NJP, GAAJ, IRH, IJW, WFS, AKFV and RSF discussed the results, corrected and improved the writing of the manuscript in Portuguese and English versions. All the authors read and approved the final manuscript.

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**Corresponding author: E-mail: copenna@ifes.edu.br;*

ABSTRACT

Aims: This study analyzed, in comparative terms, the competitive potential of family farming using an intensive milk production system based on the intermittent stocking in irrigated tropical pasture; it also evaluated the financial results before and after the implementation of an appropriate technology in the intensification process.
Study Design: The article is based on an opinion about a subject of major interest aimed at generating discussion.
Place and Duration of the Study: The study was conducted based on data collected from a family farming property located at the municipality of Alegre, State of Espírito Santo, Brazil, between 2011 and 2013.
Methodology: Cash flow spreadsheets were organized, taken into consideration two deterministic scenarios (with and without the implementation of the proper technology), evaluated the net present value (NPV at 6%) and the internal rate of return (IRR). Subsequently, a sensitivity analysis was carried out, and, considering the items with the greatest contribution in the financial indicators, the Monte Carlo Simulation method was used, obtaining the risk in the decision to invest under each situation studied.
Results: The results of NPV6%, estimated according to the opportunity costs of capital, and the IRR would exceed the values of alternative investments with returns of 6% by US$ 1,830.71 and would return the capital by 6.25%, respectively.
Conclusion: It was concluded that the intensive pasture milk production system has potential to be an alternative for income generation for family farming.

Keywords: Competitiveness; intensification; internal rate of return; technology transition; net present value; Monte Carlo Simulation.

1. INTRODUCTION

The year 2014 has been declared by the United Nations as the International Year of Family Farming, and since then its goal has been to position the sector at the center of agricultural, environmental and social policies on national agendas, identifying challenges and opportunities for promote change that enables more equitable and balanced development [1].

In Brazil, the legal definition of family farming is contained in Decree No. 9,064 of May 31, 2017 [2]; In it, the property management is shared by the family and the agricultural production activity is the main source of income. Results of the 2017 agricultural census showed that 77% of farms were classified as family farms but representing only 23% of the area and 23% of the production value of all rural establishments in the country [3]. The high degree of vulnerability of this segment of the primary sector in Brazil can be measured by the 9.5% reduction in the number of establishments and 2.2 million jobs since the 2006 census [4].

Studies on the productivity behavior in an agricultural production system are considered of great relevance, given the significance of issues such as food security and the environment. Combining food production growth at rates compatible with population growth, with reduced resource use, especially soil, is an issue that has proven challenging for great part of the world according to Gasques et al. [5].

Pasture milk production by means of intermittent stocking technology in irrigated tropical forage is an available option for producers who aim at intensifying their production systems in search of competitive levels of land productivity, animals and labor force. Yet, planning goals that influence the technical efficiency of productive resources must necessarily be monitored by an evaluation of the economic viability of the activity, which is consistent with the expectations of the producer, his/her technical limitations, and market demands. The rural extensionist has a significant role to play in this context, especially in family farming (FF), both as a link between the market and farm and as a guide for farmers on the technical possibilities that make the economic and financial performance of the production system adopted, viable.

Transferring income to the most organized sectors of the supply chains has been demanding rural producers to overcome the efficiency in the use of productive resources and achieving scale to, at the very least, maintain the generation of income in their production systems. Such tendency has been excluding thousands of farmers from different agricultural activities, and family farmers have been experiencing these changes more intensely, as they have greater difficulty in adapting to changes, given that, in accordance with Pires et al. [6], small producers are characterized by a lack of organization, capital, information, and application of inadequate management.

When studying the creation and ending of jobs in the primary sector in Brazil, Fiuza-Moura et al. [7] stressed a positive variation in job generation when there is the application of appropriate technology to agricultural production systems. As such, the continuity and sustainability of production units in a vulnerable state depend directly on a process of innovation in their production systems, i.e., the technological variation that can reach innovation is the one with the best solutions for the pre-existing financial, environmental and social needs.

It becomes essential that research and rural extension institutions develop and disseminate intensification technologies, also accessible to FF, that enable the achievement of a production scale that can generate a sufficient number of results for the economic and social inclusion of this segment. This scenario, as described by Camargo & Novo [8], presents the intensive management of tropical pastures as an alternative for efficient land use, since it makes possible production with a high level of productivity, satisfactory nutritional value, low investment in non-productive resources, moderate risk level and that, with the appropriate technical monitoring, makes this type of production system to become competitive for the FF.

Based on this context, this paper aims at answering the following question: By means of adequate technical support, does the production system based on intensive tropical pasture management make it possible for FF to be competitive? Hence, a comparative analysis of a milk production system before and after the implementation of intensification technologies for production and use of pasture was made.

2. METHODOLOGY

This work was conducted on a rural property typical of family farming, led and managed by a married couple of farmers, who had dairy farming as their main activity. The research was developed based on data from a farm located in the municipality of Alegre, with the following geographical coordinates: 20º37'48.6" south latitude and 41º32'51.9" west longitude, mountainous region of the south of the state of Espírito Santo, Brazil.

2.1 Reason for Choosing the Study Site

This property was conveniently chosen for having been monitored for 42 months, and two production cycles during this time, from March 2011 to February 2012 and from January to December 2013, were selected to the evaluation. These periods include the time in which there was a technology transition from a production system considered traditional in the region to a production system intensified by the implementation of intermittent stocking technology in irrigated tropical pasture.

The goals established were focused on efficiency in the use of productive resources measured by indexes of land productivity, animal production response, and their respective economic effects. The process of intensification of the production system has resulted in a reduction of 50% of the total area allocated to dairy farming and an increase of 90% in milk production, leading to an increase of 280% in land productivity (Kg milk.ha^{-1}.$year^{-1}$).

2.2 Preparation of a Cash Flow Spreadsheet

The cash flow sheets were prepared during monthly routine visits to the farm, when costing items were determined by means of notes and invoices for purchases of inputs, as well as the hired labor. Family labor value was defined at a minimum wage for each person engaged in the operational activities of the property. Data on volume and price of milk sold were derived from the invoice of the company responsible for taking the product, while the volume of milk consumed by the family and fed to the calves was obtained by the zootechnical bookkeeping. The information on capital invested in animals, machinery, facilities, improvements, and land, and respective balance sheets, were collected at the beginning of each year. Their values were estimated according to the state of conservation, useful life and quoted market rate.

2.3 Financial Evaluation Indicators

With a view to deepening the technology transition analysis of the case under study, it has been necessary to examine the time effect and identify the items that could influence the economic results and the viability of the activity before and after the adoption of the proposed technologies. For this purpose, the financial viability evaluation was conducted considering the net present value (NPV) return indicator; the project risks were evaluated based on the internal rate of return (IRR) indicator; and the sensitivity analysis was made so as to measure how the prefixed change in project factors would affect the final result. It should be noted that the risks of a drop in productivity were not considered, only the ones related to fluctuations in prices of the several items of the projects.

As Guerreiros et al. [9] say, NPV is a cash flow indicator that permits analyzing the long-term economic viability of the project, and its purpose is to measure the impact several future situations involving the proposed investment may cause on the present value; also the IRR is a profitability indicator that helps the entrepreneur in decision making to determine investment values, process efficiency, and the selling price of products.

The definition of the discount rate for Souza & Clemente [10] may result from a policy defined by those leading the company. This concept was adopted in this work; as such, for the calculation of economic indicators for investment analysis, it was considered a planning horizon of 15 years and a discount rate of 6%.This scenario is supported by the time needed to amortize the main investments in machinery and equipment used in dairy activities. Regarding the discount rate, it is assumed that the chosen value is compatible with the main investment options in the financial market[1].

Considering the cash flows (CF) of the periods from April 2011 to March 2012 and January to December 2013, respectively before the adoption of technology and with economic and zootechnical effects from the technologies implemented, the purpose was to evaluate the effect of time on the results by calculating the NPV applying the formula below:

$$NPV = \sum_{t=0}^{n} VF/(1+r)^t$$

in which: NPV = net present value; FV = net flow value (difference between inputs and outputs); n = number of flows; r = discount rate; t = period of analysis (i = 1, 2, 3...).

In case of a positive result, the investment is considered economically viable.

For IRR, based on the acceptance criteria, the higher the result obtained in the project, the greater the incentive for its implementation. In this way, IRR is the value of r that equals zero the expression:

$$NPV = FV_0 + \frac{FV_1}{(1+r)^1} + \frac{FV_2}{(1+r)^2} + \frac{FV_3}{(1+r)^3} + \cdots + \frac{FV_n}{(1+r)^n}$$

in which: FV = net cash flows (0, 1, 2, 3,...,n); r = discount rate.

NPV at 6% discount (NPV6%) and IRR were calculated considering the total implementation of the system before the adoption of technologies and after its adoption. The monetary amounts were converted from the Brazilian currency, *real*, to the United States dollar at the exchange rate prevailing on August 21, 2019. Thus, it was considered that one US dollar was equivalent to 4.025 Brazilian *reais* [11].

2.4 Sensitivity Analysis and Risk Evaluation

Sensitivity analysis involves measuring the magnitude to which a prefixed alteration in one or more project factors changes the outcome. Hence, the sensitivity analysis was estimated from an unfavorable 1% variation in milk and input prices in the systems, before and after the technology transition, and assessed its effects on the IRR of production systems.

With a view to evaluating risks in financial appraisal decisions, a risk analysis was conducted to provide a quantitative estimate. Saggab and Costa [12] suggested that, to evaluate the risks of a production system, methods that consider probability distributions should be adopted, such as the Monte Carlo simulation method (MCS), as it can add relevant information to the decision-making process in situations of risk, and allow simultaneous analyses for different variables.

3. RESULTS AND DISCUSSION

3.1 Financial Analysis

Financial results of the milk production system before and after the process of intensification by technology adoption are depicted in Table 1.

[1] *As an example, the key interest rate of the Brazilian economy (Selic rate) is currently 6.5% per year. At current inflation rates, this would imply a real rate much lower than the 6% rate used in the study.*

Results of NPV6% and IRR show the current values for the production system before the technologies were adopted were not economically viable. On the other hand, for the system after the implementation of the production technologies, the results of the NPV6% calculated on the basis of the opportunity costs of capital and the IRR, which represents the rate of return on capital committed to the project during its useful life, showed that the implementation of the project was viable, since it remunerates the invested capital at a rate higher than the minimum rate of return defined in the project.

When it comes economic land use efficiency, comparing these results to two alternative cultures and common competitors for small farmers in the southern region of the state of Espírito Santo, it was verified that the cultivation of eucalyptus for the production of charcoal in the state of Minas Gerais led to IRR of up to 29.63% per year [13], and irrigated coffee growing in an area of five hectares in the state of Rondônia resulted in an NPV of 12% per year of US$ 58,350.99 and IRR of 45.60% [14]. As such, it proved to be necessary to identify the limiting factors of intensive milk production; investigate in detail the risk analysis of the technology adopted; and propose measures to increase the competitiveness of dairy farming in the face of alternative activities.

3.2 Sensitivity Analysis

Sensitivity analysis made it possible to enumerate the main items that influenced the indicators analyzed, before and after the intensification of the production system, established in order of importance (Table 2).

Milk price and production volume had the same importance in the sensitivity analysis and were the factors that most influenced the results in both production systems.

The value of land in the non-intensive system had significant importance in the outcome of the activity because of the lower capacity for animal support of this type of production system, which led to inefficiency in the use of the main productive resource of any agricultural company. In the intensive system, the value of land occupied just the seventh position in importance, explaining the search for productivity levels compatible with regional values of land.

Table 1. Comparative financial viability indicators of technology transition in two production cycles of 12 months, before and after technical intervention, between 2011 and 2013

Indicator	Values	
	Before	After
NPV at 6% discount (US$)	-76,871.56	1,830.71
IRR (%)	-3.93	6.25

NPV – Net Present Value; IRR – Internal Rate of Return
Source: Elaborated by the authors based on research data

Table 2. Items that most impacted the economic indicators in the technological transition identified by the sensitivity analysis, in decreasing order of importance

Item classification	Before	After
1º	Milk price and production volume	Milk price and production volume
2º	Value of land	Concentrated ration
3º	Concentrated ration	Family labor
4º	Family labor	Capital invested in cows
5º	Capital invested in cows	Capital invested in machinery, equipment, and facilities
6º	Capital invested in machinery, equipment, and facilities	Value of land
7º	Soil acidity correction and chemical fertilizers	Soil acidity correction and chemical fertilizers

Before: Without Technology Adoption after: With Technology Adoption
Source: Elaborated by the authors based on research data

Analyzing the importance of concentrated ration in the intensive system, this item had a higher relative weight than in the traditional system. The reason is that this input is characteristic of intensified production systems.

The evaluation of the efficiency of family labor showed that the intensive system allowed the same labor force to handle a larger production scale; in this way, the greater relative impact of the remuneration of family labor force in the intensive system can be justified by the nominal variation in the value of the minimum wage in the analyzed period.

With regard to the effects of the capital invested in cows in both production systems, it should be explained that, though the intensive system has fewer animals, they became more valuable after the genetic selection process. The representativeness in the economic evaluation of fixed capital in machinery, equipment and facilities is directly related to the level of intensification of production systems, i.e., technology transition frequently demands investment in resources for structuring the system that enable increased productivity. In the study in question, the investment made in milk cooling tanks, and watering equipment increased the importance of this item in the intensified system.

The combination of soil acidity correction and chemical fertilizers to intensify the intermittent stocking system, even though they are the main inputs, fundamental to maintaining the adopted system, had little effect on the viability of the proposal, which suggests that the correct use of productive resources can bring satisfactory returns to the rural producer even though they are significant nominal values.

3.3 Risk Evaluation

3.3.1 Estimate of variations of the most representative Items in the economic analysis

For the MCS to be executed, minimum and maximum variations of the most representative items in the economic analysis had to be estimated, using values of the period (Table 3). A pessimistic market context was considered, but possible for the estimates of milk, concentrated ration, and fertilizer prices. The estimated variation in productivity in the intensified system considered the stability provided by irrigation and genetic gains of the herd. Such as described by Lopes et al. [15], the remuneration of family labor is usually connected to the minimum wage. Despite being a sine qua non condition, it is not a financial expense, and as such, was not included in MCS.

3.3.2 Simulations of the NPV6%

Table 4 outlines the results of the MCS in ten thousand simulations of NPV6%. Before adopting the technology, there would be a 100% probability the NPV6% would be lower than zero;

Table 3. Maximum and minimum variations in the main items that affected the economic indexes before and after the intensification process

Before items	Minimum	Mean value	Maximum
Price of milk (US$/liter)	0.18	0.21	0.23
Milk production (liters/year)	40,000	45,881	50,000
Land (US$/ha)	1,987.38	2,484.23	2,981.07
Concentrated ration (US$/kg)	0.17	0.20	0.22
Animals (US$/head)	621.06	745.27	869.48
Machinery/facilities (US$)	16,147.46	17,613.90	18,631.69
After items	**Minimum**	**Mean value**	**Maximum**
Price of milk (US$/liter)	0.17	0.27	0.29
Milk production (liters/year)	80,000	87,193	145,000
Land (US$/ha)	1,987.38	2,484.23	2,981.07
Concentrated ration (US$/kg)	0.22	0.25	0.32
Animals (US$/head)	869.48	1,030.95	1,242.11
Manure (US$/kg)	0.20	0.25	0.50

Source: Elaborated by the authors based on research data

Table 4. MCS result for calculation of mean NPV in ten thousand simulations, standard deviation, and NPV probability to be lower than zero before and after the implementation of intensification technologies

	Before	After
Mean NPV (US$)	-1,169,686,458.16	13,911.27
Standard deviation (US$)	42,383,889.08	47,612.86
P (NPV) < 0 (%)	100.00	38.51

Source: Elaborated by the authors based on research data

in other words, in any scenario, the traditional production system with no implementation of technologies would be economically unviable. In simulations conducted for the intensified system, a mean NPV6% of US$ 13,911.27 was obtained, and the negative values for this indicator would be understood as a situation in which the system would present a lower return than that provided by the market. In this way, there would be a 38.51% probability the NPV6% would be lower than zero.

A significant importance in obtaining a production scale was evident, regardless of the relatively high probability the activity presented an unsatisfactory income. It was also made clear that the system has the flexibility to absorb negative variations in the price of milk and in the main inputs (concentrated ration and manure) utilized in the proposed system, in contrast to the system with no adoption of technologies, which, besides using twice the area, did not enable achieving a production scale that would allow an efficient use of available resources on the farm.

The risk of the intensified system can be increased in proportion to the investments in fixed assets with a high specificity of dairy activity. This would restrict the choice of the producer to leave the activity in case of low profitability. Therefore, the use of simple and functional physical structures is essential for the activity to remain sustainable within the family model.

In studying the seasonality of the prices of milk, regarded as a result of natural, economic, social, and institutional causes, Marin et al. [16] associated this instability with heterogeneity in production systems, often crop systems, fluctuations in supply and demand of the product, and market imperfections. This was confirmed by the findings of this study, which indicated the price of milk as the main impact factor on the production system, although with low influence by the farmer on its formation, being essential to base the planning of the activity on reducing production costs.

The study also supports the research of Simionatto et al. [17], who, in analyzing performance indicators of milk production, considered this as a profitable activity, stressing the relevance of production volume as an essential factor to spread production costs and present better outcomes, being practiced mostly by the family members themselves, with low presence of hired labor force.

Sabbag and Costa [12] research results revealed that feed and labor costs were the most significant variables in milk production. However, this study proved that, even though they were representative among the items in the production cost, the significant maximum variations of manure and concentrate hardly impacted the viability of the activity. This suggests a high capacity of this production system to prove profitable, even in unfavorable scenarios in relation to the prices of its main production inputs.

The technology transition evaluated in this case study has nitrogen fertilization of the soil as an input of great importance in the increase of forage productivity and, consequently, in economic outcomes. Hence, in accordance with the statements of Reis et al. [18], the increase in revenues from intensification should be proportionally higher than the expenses with this input; however, variations in demand for food and oil may influence the result. In addition, the impact of intensification is more significant when observing the appreciation, often speculative, of land prices.

The value of animals was considered as the fourth factor with the greatest impact on the viability of the production system under study, which sheds light on the discussion about decision making regarding replacement strategies for cows in the herd, whether they are the search in the market for already formed animals, or the rearing of females on the farm itself. In the opinion of Santos and Beloni [19], for the decision to raise replacement animals on the property itself to be taken, it is necessary to pay attention to the number of animals in rearing and the delay in age at first delivery. As such, the considerations of these authors validate the decision, in this case study, to select a herd structure containing a smaller number of rearing animals, prioritizing animals in the production phase (cows).

Souza et al. [20] regarded technology inequality in the family segment in a way that it should be pointed out ways that allow acquiring new alternative technologies for maintenance and reproduction of FF. In this sense, this study is in line with findings by Mendonça and Camargo [21], who considered pasture irrigation an economically advantageous alternative to dairy farmers, with social and environmental benefits, for being a technology that fosters the increase and better distribution of milk production and income during the year, the reduction in animal feed costs, the increase in their labor force, and the optimization of the use of natural resources.

Likewise, the study conducted by Gawlak and Dalchiavon [22] on land use highlighted the effects caused by the devaluation of "commodities", areas with inflated prices and availability of land may be minimized by selecting more profitable activities and/or by implementing correct practices in the production system that raise land productivity levels. Hence, choosing intermittent stocking technology in irrigated tropical pasture, when conducted as part of a complex set of factors, in which their interactions should be in harmony, considering land fertility, management, animal genetics and health, and forage, as well as the operational and management capacity of human resources, may provide productions capable of competing with alternative activities.

The study case had an average annual productivity, considering only the module of the pasture system implemented, of 85.471 liters of milk per hectare per year. Comparing with conilon coffee, a traditional activity in the south of the state of Espírito Santo, which has its productivity, also by adopting technology, around 80 bags per hectare [23], and considering the quotations of US$ 0.36 per liter [24] and US$ 65.53 per bag [25], the results of US$ 31,076.50 and US$ 5,242.31 for dairy farming and coffee production, respectively, prove the competitive capacity of milk when the adoption of technology occurs in a careful, planned, and progressively occupies areas on the farm to provide maximum performance in productivity and economic and financial results.

4. CONCLUSION AND RECOMMENDATIONS

It was demonstrated that the adoption of intermittent stocking technology in irrigated tropical pasture in the family farm under study, performed with proper technical monitoring, was financially possible, when compared to alternative investments, with the potential to become an alternative to generate income for family farming.

Other studies about dairy family farming need to be carried out to better understand the aspects that can help the farmers to remain in this activity in an economic and sustainable way.

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COMPETING INTERESTS

The authors have declared that no competing interests exist.

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