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Economic and financial determination of mango cultivation under different Irrigation Management, in the Curaçá Project, in Juazeiro - BA

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***Abstract*— *Mango production is one of the world's main agricultural activities. In Brazil it is among the most produced and exported fruits, generating employment and raising millions every year, being the São Francisco Valley the main center of production of this fruit. Through a case study this work aims to characterize and analyze the cost of production and determine the economic and financial efficiency of mango cultivation worked with the irrigation system by surface furrow and located by micro sprinkling, in the Curaçá Project, municipality of Juazeiro - BA. Regarding the cost of production, it showed that from the sixth year, the most expensive segment is the cultural tracts. It was found that mango cultivation is viable and profitable in both systems, but the irrigation system located by micro aspersion, in addition to providing greater water savings, has better indicators of efficiency and economic viability, compared to the surface groove irrigation system. Thus, the use of the irrigation system located by micro sprinkling will provide water savings in times of water scarcity and future scenarios of climate change, as well as greater profitability to producers, thus creating better acceptance of this technology.*

I. INTRODUCTION

Accelerated population growth is a reality. The world population has already reached about 7.8 billion inhabitants [1]. And that's no different in the area of study. The Curaçá Project is part of the district of Itamotinga, which is located in the municipality of Juazeiro - BA, where it has 15,158 residents, but it is estimated that this population is already approximately 20,000 inhabitants [2].

As the population increases, there is a need to produce more food. Brazil is the second largest supplier of food and agricultural products in the world, and has been consolidating more and more with the possibility of reaching the first place, due to the growing demand, mainly from Asia [3].

It is also noteworthy that food production in Brazil can happen in a sustainable way with the improvement of technologies to obtain gains in productivity, without necessarily expanding the planting of new areas and without the extraction of more natural resources. Within this perspective is also the production of tropical fruits, which is increasing gradually.

In this context, it deserves attention and emphasis to carry out research studies, the fruit production pole of the Submedio do Vale do São Francisco, since it is the largest center of production and export of fresh fruit in the country. In this pole the fruit crop is exploited in more than a dozen irrigated perimeters, which are settled in the North of the state of Bahia and West of the state of Pernambuco, most of which is located in the municipalities of Juazeiro - BA and Petrolina - PE.

The Curaçá Project, which is one of the largest irrigation perimeters of this region, is located in Juazeiro - BA, and its main plantation is mango cultivation. Mango is the fruit that Brazil exports the most, and it has shown significant growth over the years. Its consumption is mainly in natura, but it is also used for the production of pulps and later the processing of juices [4]. The municipality of Juazeiro - BA, is the third largest mango producer in the country, in which the Curaçá Project is part and contributes directly to this highlight in the national scenario [5].

Given the economic and social importance of mango production for the Brazilian semiarid, and especially for the São Francisco Valley Submedio, where together with the grape are the crops that most generate jobs and income in the region. Thus it is important to carry out studies that seek to analyze the profitability and economic and financial viability, as well as the characterization of the cost of production for producers, contributing to their potentiation of their production and consequently profits, increasing employment and income generation in the region, associated with the correct use and management of natural resources.

Within this context, have already been developed with this theme applied to fruit growing, especially on mango and grape [6], [7], [8], [9]. But it is observed that there is a gap of research that will address the economic and financial issue of fruit production associated with environmental issues, such as water saving, which is one of the essential natural resources for agricultural production. Thus, this work will present the scientific community with a new source of research, which makes the link between economy and sustainability, also opening a range for the realization of new works.

Therefore, the objective of this research is to characterize the production cost and analyze the economic and financial efficiency of mango production under different types of irrigation management, in Project Curaçá, in Juazeiro - BA, emphasising that the choice of appropriate irrigation management will provide not only financial but also environmental gains, aligning the producer's objective of making profits from his investment with the need for environmental measures, given the projections of scenarios of temperature increases and water scarcity.

II. THEORETICAL REFERENCE

2.1 Panorama of mango cultivation

The cultivation of mango (Mangifera indica L.), is one of the world's leading agricultural activities. The mango is classified into three segments: red, yellow and green varieties. The main cultivated varieties are Tommy Atkins, Palmer, Keitt, Haden, Kent, Rose and Sword [10]. Increasingly this fruitful has gained ground on the international stage, helping to meet the food needs of the world's population. The main mango producing countries are India, China, Thailand, Mexico, Indonesia, Pakistan and Brazil [3].

The cultivation of fruit in Brazil has been producing significant growth, both for the domestic market and for the external market, due to favorable climate and soil conditions in relation to other countries, associated to investments in training, technology, infrastructure and logistics, which are determining factors for the sector's growth and competitiveness [11]. The production of mango has been contributing directly to this growth, since it is one of the main fruits cultivated at the national level.

Brazil produced an average of 1,132,802 tons of mango per year in the period from 2008 to 2017 [5]. Several states produce mango in Brazil, but the Northeast region is prominent in this fruit tree, driven mainly by the cultivation of the fruit in the São Francisco Valley, which produced an average of 467,325 tons of mango annually. This average production represents a percentage of 41.2% in relation to the national production in the same mentioned sample period.

Mango production has been growing in recent years, both in terms of production of tons and in terms of revenues [4]. In addition to not needing to import this type of fruit, Brazil is also one of the largest exporters, with about 179,000 tons shipped abroad in 2017. These exports represented revenue of more than US$ 205 million, an increase of about 13.99% over the previous year. The main buyers are the European Union with 132,820 tons and the United States with 33,095 tons.

2.2 Area and localised irrigation

Irrigation is an activity that provides the cultivation of various crops and boosts agriculture around the world.

Irrigation can be defined as the techniques, forms or means adopted to apply water to the soil and favor the plants, satisfying their needs and seeking to achieve the ideal production for each species. This way irrigation has over the years provided food production in various regions of Brazil and the world [12].

Irrigated areas in Brazil have been growing over the years. The number of hectares has increased since 1960 and in 2015 there are already approximately 7 million irrigated hectares, a growth of about 600% to that of fifty-five years [13].

Area irrigation is still used to grow various crops. One of the main types of surface irrigation is furrow irrigation, which consists of the direct application of water to the soil. Is one of the oldest irrigation methods in the world, where the farmer lets the water flow through the soil, causing the water to seep as it moves along. The water is distributed in the furrows mainly by the use of siphon, and requires favorable topographical conditions for efficiency in this type of irrigation [12].

Although furrow irrigation is widely used, it leaves the soil more susceptible to erosion and salinization processes, due to the accumulation of water and the need for soil slope for runoff. This way other irrigation management are more recommended, so that the use of water is more efficient and uniform, and does not cause future problems in the soil and consequently significant losses of productivity [14].

On the other hand, localized irrigation is one of the most efficient and least loss in water use, only 10% of losses [13], essential factor for the production of food potentiating the use of water. In times of water scarcity there is a great need to invest in irrigation systems that provide greater efficiency, so that more can be produced with less water use. One of the main advantages, besides reducing water consumption, is the uniformity that localized irrigation provides, where the soil profile is with well-distributed water quantities thus improving the performance of various crops [14].

2.3 Studies of economic analysis of fruit trees

On the economic issue of the yellow passion fruit culture in the region of Marília - SP, it was identified that the total cost of production per hectare was R$ 37,751.67 or R$ 1.89 per kilogram of fruit. Among the items that most influenced operating costs were those with machines and labor, which represented 31.1% and 23.5%, respectively. The average production shown is 12 to 15 tons per hectare, with the potential to produce up to 35 tons [7].

By analysing the production of the same fruit in six different production poles, they observed that production is viable when it exceeds 19 tons per hectare. In both studies it was proven that one of the biggest difficulties for the viability of the culture is the high price of inputs [15]. The studies showed profitability, especially when grown on a large scale, with a return of R$ 0.21 per kg of the fruit produced [16].

Analyzing the production of table grapes in regions of the state of São Paulo, viability was observed for fruit cultivation, where the region of Campinas had a total cost of US$ 0.81/Kg with a total net revenue of US$ 0.23/kg. In Itapetininga, the total cost was US$ 0.68/Kg with a total net revenue of US$ 0,32/kg. In this way, grape production in these regions of the state of São Paulo is profitable and has a positive return for farmers who cultivate this type of crop [8].

With economic viability analysis also on grapes, but in the municipality of Petrolina - PE, viability for fruit cultivation has been identified, and there is a return on investment from the third year onwards. It was observed that for each R$ 1,00 invested there is a net return of R$ 0,65 [9].

A survey on the cost of organic banana production in the São Francisco Submedio in the State of Bahia, was observed that the cost with inputs corresponds to 58% of the operating costs, being the main expense in this item. The total cost per hectare was R$ 8,364.00, the average annual production is 35 tons per hectare, giving a gross revenue of R$ 15,750.00, resulting in a net margin of R$ 7,386.00 [17].

Analyzing the economic viability of the strawberry crop in Paraná, verified that the size of the cultivated area influences the results, where when the area is very small ends up not recovering the investment in the long term and becoming unviable, highlighting the need for a minimum standard of cultivated hectare for the business to be profitable, with a minimum of one hectare [22]. These same authors also showed the need to market the fruit at a minimum of US$ 1.97 so that negative balances do not occur [18].

Verifying the economic and financial situation of mango cultivation in the municipality of Mauriti - CE, the gross revenue obtained per hectare/year was R$ 25,000.00, with a net income of approximately R$ 18,000.00 [6]. Among the fixed costs that had more relevance was the expenditure on capital goods depreciation, maintenance and water expenditure for irrigation, giving a total of R$ 3.157,67. Among the fixed costs that had more relevance was the expenditure on capital goods depreciation, maintenance and water expenditure for irrigation, giving a total of R$ 3.157,67.

Studies on the characterization of the Tommy Atkins manga, observed that the cost of production is R$ 0,58 per kg in the first year of harvest (fourth year), from the sixth year the cost is around R$ 0,48 per kg, having a gross revenue per hectare of R$ 20,800.00, obtaining a net revenue of R$ 13,197,91 per hectare, representing a profitability rate of 63.45% [19]. The equilibrium point of kilograms per hectare remained at 5,847.76 from the sixth year which is the year of full production. In this way, the production of mango was economically profitable.

In studies on fruit growing in the Northern Region of the State of Rio de Janeiro, it was found that mango cultivation is recommended, since the result of the Internal Rate of Return was higher than the highest minimum attractiveness rate of 12%, leaving Tommy mango for consumption in natura with a rate of 14.52% [20]. The Net Present Value was calculated with variables from 2% to 12%, and with 2% obtained the return value of R$ 51,675.92 and with 12% the value of 4,886.04, thus obtaining profitability in both NPV rates. Regarding expenses, the items that generated the greatest impact were labor and fertilizer expenditures.

Analyzing the production of organic and conventional mango in the state of Baja California, South - Mexico, satisfactory results were obtained for both productions, and organic production had better rates, with IRR of 91.35% in organic production and 83.02% in conventional production, and the Benefit/Cost ratio was 8.31 and 7.42 respectively [21]. On the production and marketing of the mango in Nariño - Colombia and Guayas - Ecuador, showed 22.75% for IRR and 1.54 for Benefit/Cost. In both works the results found presentation viability and profitability for production of marketing of the mango [22].

III. METHODOLOGY

The units of analysis of this study were four family farms in the Submedio do Vale do São Francisco, located in the municipality of Juazeiro - BA, in the Project of Irrigation Curaçá, which has in the exploitation of the mango its main economic activity. The methodological tool used was the case study, which is a research method that resides in a thorough analysis of one or a few samples, providing a comprehensive and detailed knowledge about the units analyzed [23], [24]. The targets of this study were two production units that irrigate the mango in the form of a surface groove and two other units that perform irrigation in a localized manner (micro sprinkler). These farms work exclusively with the cultivation of mango.

The procedure used to obtain the data was performed in four stages. First, several technical visits were carried out to the production areas in order to follow the various phases of crop management, under the two irrigation systems, as well as the marketing process. This stage was developed during approximately one year, emphasizing that in the properties there are mango areas planted in different years, which facilitates the follow-up of several simultaneous phases, from Year 1 to Year 6 (full production) and subsequent years. In these visits, besides the direct observation of the target phenomenon of the study, information was collected with the technical assistance responsible for conducting the crops, in order to have an identification and quantification of the activities performed by them in the mango production process.

In the second stage, a survey of the water consumption used in the properties targeted by the study was carried out, near the Irrigation district of the Curaçá Project. The third stage consisted of researching the prices of inputs in the areas of crops and in the companies that market inputs of this nature in the district. In the fourth stage, we obtained the sales prices of the product from the properties, district of the Company of Development of the Valleys of São Francisco and Parnaíba (CODEVASF), in the region, and specialized websites in fruit sales.

3.1 Studies of economic analysis of fruit trees

The model developed by the Institute of Agricultural Economics (IEA), an economic arm of the São Paulo Agribusiness Technology Agency (APTA), of the Department of Agriculture and Supply of the State of São Paulo, was used to analyze the production costs of the crop. With this method the costs are inserted in two large groups: the Effective Operating Costs (COE), which are the direct expenses from the preparation of the land to the harvest and the Indirect Costs (IC) that are spent as rent of the land, taxes and others. Total Cost (TC) is the sum of COE + CI expenses.

To determine the economic efficiency of the fruit production system under analysis in this study, the following economic performance indicators were used: Net Income (RL), Total Factor Productivity (PTF), Entrepreneur Return Rate (TRE) and the Levelling Point (PN) [25], [26], [9].

The Net Income corresponds to the total revenue obtained from the sale of the products generated in the enterprise less the sum of all the expenses generated for the production of the same [27].

$$\textit{Net Income} = \textit{Total Revenue} - \textit{Total Cost}$$

Total Factor Productivity must be measured by the ratio between Total Revenue and Total Cost, where the production system will only be able to sustain itself when the index result is at least 1 [26].

PTF = (Total Revenue) / (Total Cost)

The Entrepreneur's Rate of Return has as main objective to analyze how much the entrepreneur will have of Net Income, per monetary unit spent on the enterprise [27]. The rate is obtained by dividing Net Income by Total Cost or Total Revenue by Total Cost minus one.

Rate of Return = (Total Revenue) / (Total Cost) = PTF - 1

The Leveling Point aims to inform the amount of production needed to equalize and cover the total expenses used to obtain the product. The Leveling Point is acquired by dividing the Total Cost by the Product Price.

Leveling Point = (Total Cost) / (Product Price)

3.2 Economic viability indicators and risk and uncertainty analysis

The following indicators were used to determine economic viability: Net Present Value (NPV), Internal Rate of Return (IRR), Modified Internal Rate of Return (IRR), Profitability Index (IL), Rate of Return (TR) and Discounted Payback [28], [29], [30], [16].

The Net Present Value (NPV) is the sum of the expected income flows in each period (n= 1, 2,..., N), brought to zero period values, at a discount rate equivalent to the Minimum Market Attractiveness Rate, minus the value of the initial investment carried out in period 0 [31].

$$VPL = \sum_{t=0}^{N} \frac{FC_t}{(1+i)^t}$$

Where:
Fct = expected cash flow for each period;
i = minimum attractiveness rate;
t = time period.

The minimum attractiveness rate is understood as the best rate available on the market for application, with the lowest associated risk [32]. Internal Rate of Return (IRR) is the discount rate that equals the sum of cash flows to the value of the investment. I n this way the discount rate equals the inflow flows to the outflow flows of cash, producing a NPV equal to zero.

$$0 = \sum_{t=0}^{N} \frac{FCt}{(1+IRR)^t}$$

Where:
Fct = expected cash flow for each period;
IRR = Internal Rate of Return;
t = Period of time.

The investment that presents an Internal Rate of Return higher than the Minimum Rate of Attractiveness will be considered viable. But when the calculated IRR is very different from the market rate, the interpretation may be compromised [31].

This can be corrected using the Modified Internal Rate of Return (TIRM). The Modified Internal Rate of Return (IRR) differs from the traditional IRR in that it presents a more realistic cash flow, as the financing and reinvestment rates are compatible with market interest.

((1 + TIRM)) / ((1 + TMA)) - 1

The Profitability Index, indicates the calculated return for each invested monetary unit and is given by the relationship between the net present value of positive cash flows (inflows) and the sum of investments, using as a discount rate the minimum rate of attractiveness of the project. Thus the investment will be profitable where the IL is greater than or equal to 1 [33].

IL = (VP (revenue)) / (sum of investments)

Rate of Return that is determined from the ratio of the NPV of positive cash flows to the NPV of negative cash flows minus 1. The investment in the venture will be considered attractive when RT is greater than or equal to zero; Negative TR will indicate unworkability in business.

TR (%) = (NPV (positive cash flows)) / (NPV (negative cash flows)) - 1

The Discounted Payback is the period of time required for the recovery of an investment. Is the time necessary for negative cash flows (investments) to be written off by positive cash flows (profits) [34].

$$I = \sum_{t=0}^{N} \frac{FC_t}{(1+i)^t}$$

Where:
Fc_t = expected cash flow for each period;
I = total investment;
i = minimum attractiveness rate;
t = Period of time.

Due to the characterization of the study object, a risk and uncertainty analysis was performed through the free version MODELRISK Software, worked through Microsoft Office Excel 2016. For this purpose, the Monte Carlo simulation method was used, using probability distributions of input variables (input variables), to generate output variables (output variables). In this way it will be possible to measure the risk associated with the project and determine investment alternatives, and not be restricted to a single value as absolute certainty.

The Monte Carlo simulation method makes it possible to generate random samples in terms of cost or time, which will undergo tests from statistical models, which will allow the distribution of probabilities for a given project risk [35].

Each sample corresponds to a repetition of the method, so the higher the number of repetitions, the lower the error. This method is fundamental for projects that have few samples in the study object, such as the project developed in this research that has only four.

The Monte Carlos simulation can be developed in two basic stages. The first step is the choice of risk variables of the project, based on their relevance in terms of costs and revenues. This stage is important because some of the items that make up the characterization of production cost and revenue, suffer price variations over time. Thus, the items with the greatest influence should be selected to determine the final result [36].

Based on these criteria, the input variables (inputs variables) of this project were considered: manual operations (cultural tracts), water, growth regulator (Paclobutrazol), mechanical operations (cultural tracts), price and productivity. In the second stage, the probability distribution was chosen, and the triangular probability distribution was chosen, where the minimum, maximum and mean values are inserted, which is considered more likely by the variable.

For the variables manual operations (cultural tracts), water, growth regulator (Paclobutrazol), mechanical operations (cultural tracts) were used values with 10% less and more in relation to the average for minimum and maximum values, taking into account that prices may vary over time.

For the variables price and productivity, 60% and 30% were used, respectively, less and more in relation to the average for minimum and maximum. These two items are directly linked and can be affected by pest situations in the crop, higher or lower supply of fruit, as well as consumer demand, climatic situations, among other factors. Table 1 shows the distribution of the risk variables of Manga.

Table 1: Probability distribution of variables to perform the simulations

Variable	Distribution	Parameters
Manual operations (cultural tractors)	Triangular	RiskTriang (45,50,55)
Water	Triangular	RiskTriang (117,130,143)
Growth regulator (Paclobutrazol)	Triangular	RiskTriang (90,100,110)
Mechanical operations (cultural tracts)	Triangular	RiskTriang (117,130,143)
Manga price	Triangular	RiskTriang (0.512,1.280,2.048)
Year productivity 4	Triangular	RiskTriang (16800,24000,31200)
Year productivity 5	Triangular	RiskTriang (22400,32000,41600)
Year productivity 6	Triangular	RiskTriang (28000,40000,52000)
Year productivity 27	Triangular	RiskTriang (25900,37000,48100)
Year productivity 28	Triangular	RiskTriang (23800,34000,44200)
Year productivity 29	Triangular	RiskTriang (21700,31000,40300)
Year productivity 30	Triangular	RiskTriang (19600,28000,36400)

Source: *Own elaboration, based on research data (2021).*

The simulations were performed through stratified sampling, for being more efficient and having greater accuracy. To perform these analyses, the MODELRISK software was used, where 10,000 (ten thousand) interactions (process repetitions) were performed. The number of iterations is the largest available in the program, and was chosen to provide greater certainty in the data found, and to favor convergence to the result.

In these steps, the output variables (output variables) used were NPV, IRR and Cost Benefit analysis, which were widely used in this type of analysis. The minimum attractiveness rate chosen was 6.5%, Selic yield, and 33%, internal rate of grape return, extracted through the average [37], [9], [38].

IV. RESULTS AND DISCUSSIONS

4.1 Analysis of production costs

Analyzing the costs of implantation and maintenance of one hectare with 500 mango plants Tommy Atkins, with cultivation system with irrigation by surface groove (system 1) and with cultivation system with irrigation located by micro sprinkler (system 2), it was observed that in Year 1 the costs with systematization and preparation of the soil represented 13.61% for system 1 (Table 2) and 14.80% in system 2 (Table 3), which presented a lower real cost because there was no need to furrow the soil for the planting of mango seedlings, as it does not need this procedure for irrigation.

Still in Year 1 it is worth noting that the spending on planting was R$ 3.912,00 in the system 1 and R$ 3.820,50 in the system 2, which represents 27,66% and 31,50% respectively, being the most expensive expense for the system 2. in Year 2, the expenses with soil correction were

R$ 460,00 and spending on PPE and soil analysis were R$ 263.00, values found in both systems. In relation to Years 3 and 4, the largest expenses were with cultural tracts, where in Year 3 it was R$ 7,879.00 in system 1 and R$ 5,521.34 in system 2, representing 73.71% and 65.77% respectively of the total expenses. In Year 4, the value was R$ 14,493.00 in system 1 and R$ 11,987.08 in system 2, giving a percentage of 77.60% and 73.88% respectively in relation to total expenses (Tables 2 and 3).

Table 2 - Cost of implantation and maintenance of one hectare of mango (Irrigation system by surface furrow)

Segment	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Value	Value	Value	Value	Value	Value
Systematization and soil preparation	1925	-	-	-	-	-
Soil correction	460	460	460	460	460	460
Planting	3912	-	-	-	-	-
Cultural tracts	5298	7482	7879	14493	16154	17815
Harvest	-	-	-	920	920	920
PPE and Soil Analysis	263	263	263	263	263	263
Depreciation	409.90	409.90	409.90	409.90	409.90	409.90
Administration and Technical Assistance	600	600	600	600	600	600
Actual operational cost	**12867.90**	**9214.90**	**9611.90**	**17145.90**	**18806.90**	**20467.90**
Earth's opportunity cost	500	500	500	500	500	500
Opportunity cost of Costing	772.07	552.89	576.71	1028.75	1128.41	1228.07
Indirect cost	**1272.07**	**1052.89**	**1076.71**	**1528.75**	**1628.41**	**1728.07**
Total cost	**14139.97**	**10267.79**	**10688.61**	**18674.65**	**20435.31**	**22195.97**

Source: *Own elaboration, based on research data (2019)*

Table 3 - Cost of implantation and maintenance of one hectare of mango (Irrigation system located by micro sprinklers)

Segment	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
	Value	Value	Value	Value	Value	Value
Systematization and soil preparation	1795	-	-	-	-	-
Soil correction	460	460	460	460	460	460
Planting	3820.50	-	-	-	-	-
Cultural tracts	3424.92	5247.96	5521.34	11987.08	13522.2	15312.94
Harvest	-	-	-	920	920	920
PPE and Soil Analysis	263	263	263	263	263	263
Depreciation	603.51	603.51	603.51	603.51	603.51	603.61
Administration and Technical Assistance	600	600	600	600	600	600
Actual operational cost	**10966.93**	**7174.47**	**7447.85**	**14833.59**	**16368.70**	**18159.55**
Earth's opportunity cost	500	500	500	500	500	500
Opportunity cost of Costing	658.02	430.47	446.87	890.02	982.12	1089.57
Indirect cost	**1158.02**	**930.47**	**946.87**	**1390.02**	**1482.12**	**1589.57**
Total cost	**12124.95**	**8104.94**	**8394.72**	**16223.61**	**17850.81**	**19749.12**

Source: *Own elaboration, based on research data (2019)*

Analyzing the expenses of Year 5, the difference in value with cultural tracts is observed, one of the justifications is the fact that in the system by micro sprinkler the use of chemical fertilizers is less, because it is introduced directly into the water through fertigation, which also greatly reduces labor costs. In Year 6, where full production begins in mango cultivation, there is also a large difference in values in the same segment of cultural tracts, with the value of R$ 17,815.00 in system 1 (Table 2) and R$ 15,312.94 in system 2 (Table 3), this occurs mainly because in the second system the expenses with water and labor are much lower compared to the first system.

4.2 Analysis of economic viability

In the exploitation of a hectare of mango Tommy Atkins, in full production year, cultivated in the region of the Submedio of the Valley of San Francisco, in the municipality of Juazeiro - BA, in the Curaçá Project, the producers who work with irrigation system by surface furrow (system 1) and those who work with micro sprinkler irrigation (system 2) obtained a gross revenue of R$ 51,200.00 (Table 4). This value was acquired with a productivity of 40 tons per hectare/year carried out in two annual harvests and an average annual price of R$ 1.28 per kilogram during the research data collection period (March 2018 to February 2019).

The cost of production was different in relation to the two types of irrigation system, where in the system 1 was R$ 22,195.97 and in the system 2, R$ 19,749.02, thus decreasing these values of gross revenue obtained a net income of R$ 29,004.03 and R$ 31,450.98, respectively (Table 4). As discussed in the methodology, positive net income indicates the economic viability of both production systems, and system 2 presented better results.

Regarding the benefit/cost, the system 1 presented a result of R$ 2.30, lower than the system 2 that obtained R$ 2.59, but in both of them it can be observed that there is profitability and economic efficiency in these production systems. It can be confirmed by the result of the rate of return of the entrepreneur, which presents a measure of how much each monetary unit generates net income, this index showed that the cultivation of the mango generates in the system 1 R$ 1,30 net income for each R$ 1,00 applied (cost) and in the system 2 generates R$ 1.59 (Table 4).

The level point was 17,340 kg for system 1 and 15,428 kg for system 2 (Table 4), this index establishes the minimum annual production level necessary for the generated gross revenue to be equal to the total costs, thus obtaining net revenue equal to zero. Thus the properties that work with these systems, surface furrow and located by micro sprinkling, and have annual production below this level will make economically unviable the production system.

Table 4 - Economic efficiency indicators

Indicators	System 1 (Surface groove) Year full-production	System 1 (Surface groove) The whole enterprise	System 2 (Microspray) Year full-production	System 2 (Microspray) The whole venture
Productivity (Kg)	40.000	1.026.000	40.000	1.026.000
Gross Revenue (R$)	51.200,00	1.313.280,00	51.200,00	1.313.280,00
Net Income (R$)	29.004,03	684.174,42	31.450,98	756.855,47
B/C (R$)	2,30	2,08	2,59	2,36
TRE (R$)	1,30	1,08	1,59	1,36
PN (Kg)	17.340	491.488	15.428	434.706

Source: *Research data (2019)*

Analyzing all the investment, which has a useful life of thirty years, it was verified that the gross revenue was R$ 1,313,280.00 for both systems, with a total cost of R$ 629,105.58 in the system 1 and R$ 556,424.53 in the system 2, obtaining a net income of R$ 684,174,42 and R$ 756,855.47 respectively (Table 4). With regard to costs, the most expensive segment was that of cultural tracts for both systems.

The productivity during the whole useful life was of 1.026.000 tons in both systems, and the leveling point was of 491.488 tons in system 1 and of 434.706 in system 2. Regarding the benefit/cost the system 1 presented result of R$ 2,08 and system 2 the value of R $ 2,36, with return rate of entrepreneur of R$ 1,08 and R $ 1,36 respectively (Table 4). These indexes show that system 2 also has better results in the long term, but that both systems are economically viable.

Regarding the economic-financial analysis, it is noted that investing in mango cultivation in the study area is feasible in both irrigation systems, because the Net Present Value of R$ 298.746,06 in the system 1 and R$ 336.113,33 in system 2, indicate that the enterprise generates a much higher return to the producer than the capital invested in the implantation and maintenance of the crop. These results are confirmed when the Annualized Present Value is also observed, indicating that in addition to remunerating the invested capital at a rate of 6.5% per year, the investment also provides a surplus to the producer of R$ 22,877.21 in system 1 and R$ 25,738.70 (Table 5).

Table 5 - Economic and financial analysis

Financial Indicator	System 1 30 years old lifespan	Sistema 2 30 years old lifespan
Net Gift Value (R$/ha)	298.746,06	336.113,33
Internal Rate of Return (%)	59,06	76,95
Modified Internal Rate of Return (%)	14,80	15,93
Index of Profitability	9,51	12,74
Rate of Return (%)	8,51	11,74
Annual Net Gift Value (R$/ha)	22.877,21	25.738,70
Discounted Pay Back (Years)	5 years and 3 months	4 years and 8 months

Source: *Research data (2019)*

The results of the Internal Rate of Return and the Modified Internal Rate of Return were also satisfactory in both systems, being 59.06% and 14.80% in system 1 and 76.95% and 15.93% in system 2, respectively, presenting values higher than the minimum attractiveness rate of 6,5%, value for the annual rate of Selic income. The Profitability Index was 9.51 in system 1 and 12.74 in system 2, the Profitability Rate was 8.51% and 11.74%, respectively (Table 5), also certifying the economic and financial viability of the mango exploration.

In relation to the discounted Pay Back it was observed that in system 1 there is the return on investment with 5 years and 3 months and in system 2 with 4 years and 8 months (Table 5), considerably short period leading tothe useful life of the 30-year enterprise according to the cash flow presented (Table 6).

Table 6 - Cash flow

Year:	System 1 (Surface groove) Cost (R$):	Recipe (R$):	Result (R$):	System 2 (Micro spray) Cost (R$):	Recipe (R$):	Result (R$):
1	14.139,97	0,00	-14.139,97	12.124,95	0,00	-12.124,95
2	10.267,79	0,00	-10.267,79	8.104,94	0,00	-8.104,94
3	10.688,61	0,00	-10.688,61	8.394,72	0,00	-8.394,72
Inv.			-35.096,37			-28.624,61
4	18.674,65	30.720,00	12.045,35	16.223,61	30.720,00	14.496,39
5	20.435,31	40.960,00	20.524,69	17.850,81	40.960,00	23.109,19
6	22.195,97	51.200,00	29.004,03	19.749,02	51.200,00	31.450,98
7	22.195,97	51.200,00	29.004,03	19.749,02	51.200,00	31.450,98
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
25	22.195,97	51.200,00	29.004,03	19.749,02	51.200,00	31.450,98
26	22.195,97	51.200,00	29.004,03	19.749,02	51.200,00	31.450,98
27	22.195,97	47.360,00	25.164,03	19.749,02	47.360,00	27.610,98
28	22.195,97	43.520,00	21.324,03	19.749,02	43.520,00	23.770,98
29	22.195,97	39.680,00	17.484,03	19.749,02	39.680,00	19.930,98
30	22.195,97	35.840,00	13.644,03	19.749,02	35.840,00	16.090,98
Total	629.105,58	1.313.280,00	684.174,42	556.424,53	1.313.280,00	756.855,47

Source: *Research data (2019)*

All the indexes and results found in this research show that mango farming is an economically viable agricultural activity, developed both by the irrigation system by surface furrow and also by irrigation located by micro sprinkler, but that the latter, besides presenting a considerable saving of water annually, keeping the soil less susceptible to erosion and salinization processes, also provides better economic and financial results for producers.

4.3 Risk and uncertainty analysis

With the elaboration of the cash flow it is possible to make simulations for the development of an analysis of risks and uncertainties of the obtained results. For this is used the Minimum Attractiveness Rate (TMA), which was 6.5%, Selic yield, and 33%, internal grape return rate, average of the results found [37], [9], [38]. The indicators analyzed were the Net Present Value, the Benefit/Cost ratio and the Internal Rate of Return.

The data found from NPV and B/C ratio to Minimum Attractiveness Rate of 6.5% show that both projects are profitable. However, the results found in system 2 are more satisfactory. The histograms were generated through the simulations, where it is observed that the NPV has a 90% probability of having values between 9,160.70 and 312,543.03 in the system 1 and between 31,375.18 and 335,479.01 in the system 2. On the other hand, the B/C ratio obtained a 90% probability of having values between 1,46 and 23.11 in system 1 and between 3.61 and 28.87 in system 2 (Figure 1).

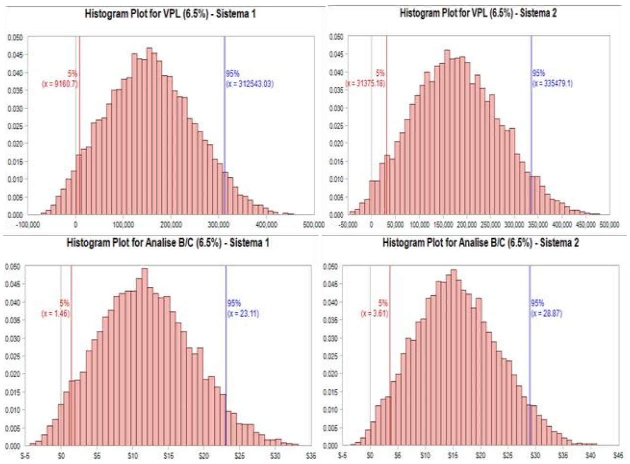

Fig.1 - Histograms of NPV and B/C at a rate of 6.5%

***Source:** Research data (2019)*

On the other hand, these same indicators, NPV and B/C, with TMA of 33% had lower values, but still satisfactory, and with system 2 presenting better results in both indicators (Figure 2).

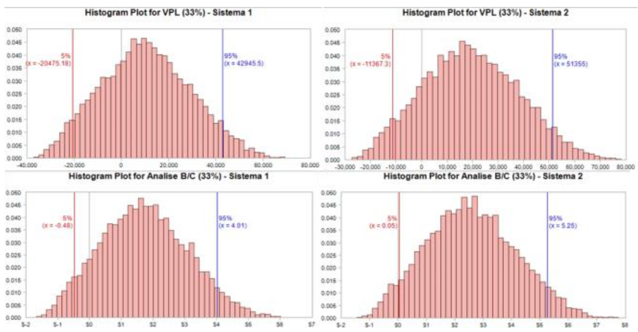

Fig.2 - Histograms of NPV and B/C at 33% rate

***Source:** Research data (2019)*

In relation to IRR, less than 5% of the probability of obtaining a value below 10.44 in system 1 and 19.32 in system 2, and 90% of the probability of the values being between 10.44 and 60.41 in system 1 and between 19.32 and 69.82 in system 2 (Figure 3). This indicator shows that the investment provides a return to the producer who works with mango production in both systems, and that system 2 has better results.

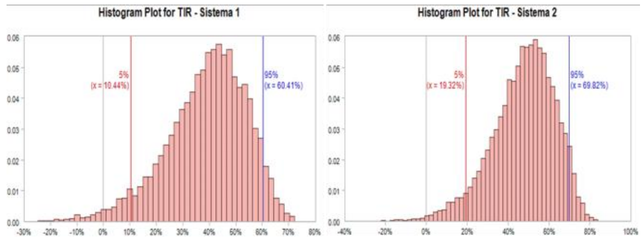

Fig.3 - Histograms of IRR

***Source:** Research data (2019)*

V. CONCLUSION

Considering the exploitation of mango culture in the Submedio do Vale do São Francisco, this research sought to characterize and analyze the production cost of this fruit tree, as well as determine the economic and financial viability, under different irrigation management. Regarding the cost of production, it was observed that year 1, year of crop implantation, has higher expenses than years 2 and 3, due to expenditure on the purchase of seedlings and systematization and preparation of the soil for planting. From the year 4, the segment of cultural tracts was the most expensive in both systems, highlighting expenditures on inputs and labor.

With regard to economic and financial viability, this research revealed that the exploitation of the mango is a profitable activity, where through the various indicators analyzed satisfactory results were obtained, presenting positive numbers. Through the analysis of risks and uncertainties, it was found that using percentages of 6.5% and 33% for the Minimum Attractiveness Rate, the results are still satisfactory providing a return to the producer, but that using the 33% rate the return is much lower compared to the 6.5% rate.

It was evidenced that the system 2, of irrigation located by microaspersion, presents better results in all the indicators analyzed in comparison to the system 1, of irrigation by surface furrow. These results were proven through risk and uncertainty analysis. It was found that system 2, in addition to providing environmental gains, such as water savings, also offers the producer greater income and profitability, thus being more attractive the choice for this irrigation system that makes the link between environmental and economic benefits.

Therefore, it is important to point out that new research needs to be developed in this theme, which associates the environmental and economic issue involving fruit farming in the Region of the Sub-Edict of the São Francisco Valley, given the gap that exists of works on this theme, since the research focuses on work developed on the environmental or economic issue separately, and given the importance and potential that there is in the production of fruit in the region at the national level for domestic consumption and also for export.

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