IMPACTOS DA MELEIRA DO MAMOEIRO NA RENTABILIDADE DA PRODUÇÃO DE MAMÃO NO EXTREMO SUL DA BAHIA

Papaya sticky disease impacts in the profitability of papaya production in the extreme south of Bahia

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Resumo: Este trabalho avaliou os prejuízos provocados pela meleira do mamoeiro na rentabilidade da produção de mamão no Extremo Sul da Bahia. A avaliação tomou por base os coeficientes técnicos do sistema de produção integrada do mamoeiro, da Empresa Brasileira de Pesquisa Agropecuária (Embrapa), para todo o Sul da Bahia, e informações obtidas de produtores e consultores técnicos nos municípios baianos de Eunápolis, Itabela e Porto Seguro. Os coeficientes técnicos considerados apresentam o quantitativo necessário para um hectare de mamão, dos grupos Solo e Formosa sob condições irrigadas. Com base nesses coeficientes foi realizada a análise de rentabilidade, a partir do cálculo dos indicadores VPL, TIR e Relação B/C. Para os cálculos dos danos causados pela meleira do mamoeiro foram consideradas perdas referentes a 5%, 10%, 20%, 30%, 40%, 50% e 60% de plantas, erradicadas. Os indicadores de rentabilidade utilizados foram o VPL, a TIR e a Relação B/C. Considerando-se o levantamento dos preços médios pagos ao produtor nos últimos três anos (outubro 2017 a setembro 2020), os indicadores de rentabilidade para a variedade de mamão Havaí foram positivos para até 50% de perdas, enquanto os do 'Tainung Nº 1' foram em até 60% de perdas.

Palavras-chave: PMeV; viabilidade econômica; custo de produção.

Abstract: This study evaluated the losses caused by papaya sticky disease in the profitability of papaya production in the extreme South of Bahia. The evaluation was based on the technical coefficients of the integrated production system of papaya, from the Brazilian Agricultural Research Corporation (Embrapa), for the entire South of Bahia, and information obtained from producers and technical consultants in the municipalities of Eunápolis, Itabela and Porto Seguro. The technical coefficients considered presented the quantitative needed for one hectare of papaya, from the Solo and Formosa groups under irrigated conditions. Based on these coefficients, the profitability analysis was performed. For calculations of the damage caused by papaya sticky disease, losses of 5%, 10%, 20%, 30%, 40%, 50%, and 60% of eradicated plants, were considered. The profitability indicators used were NPV, IRR and BCR. Considering the survey of average prices paid to the producer (October 2017 to September 2020), the profitability indicators for the Hawaii papaya variety were positive for up to 50% of losses, while those for the 'Tainung 1', were up to 60% of losses.

Keywords: PMeV; economic viability; production cost.

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1 INTRODUCTION

Papaya (*Carica papaya* L.) is one of the most important cultures for Brazil. Its relevance is reasoned in the fact that it is one of the few fruitful cultures capable of producing throughout the entire year. In 2019, the Brazilian production of papaya was approximately 1.17 million tons in an area of 28.1 thousand hectares (IBGE, 2019). Among the productive regions, the Northeast region stands out with approximately 55% of the national production, followed by the Southeast (40%), the North (3%), the Central-West (1%), and the South (0.3%) (IBGE, 2019). Brazil is the second largest exporter of papaya in the world, exporting the fruit to countries of Europe and mainly to the United States of America. In 2019, about 39 thousand tons of the fruit were shipped (Brasil, 2019).

Bahia is the second largest producer, with about 390 thousand tons and an average productivity of 40.5 t ha^{-1}, staying behind Espírito Santo with 403 thousand tons and an average productivity of 58.7 t ha^{-1} (IBGE, 2019). The municipalities that integrate the extreme South of Bahia region contributes with about 50% of the production of papaya in Bahia (IBGE, 2019). Among these, Prado, Mucuri, Porto Seguro, Itamaraju and Eunápolis, stands out, respectively (IBGE, 2019). Despite its prominent position, the State of Bahia has its production and economical income mainly compromised by phytosanitary problems. The main diseases that affect the culture are virus infections, such as Papaya ringspot disease (*Papaya ringspot virus*, PRSV-p) and Papaya sticky disease (*Papaya meleira* virus, PMeV) (Dantas; Oliveira, 2009).

Papaya sticky disease was first reported in orchards in the North of Espírito Santo and extreme South of Bahia in the 1980's and spreading to the main papaya productive regions of the country (Kitajima et al., 1993; Abreu et al., 2015). The major symptom of Papaya sticky disease is the spontaneous exudation of latex on the fruits, that oxidate, giving a sticky aspect to the fruit. The fruit surface becomes stained, sticky, and dark due oxidation, which makes it difficult to sell. For exportation it doesn't attend the standard size and form. Papaya sticky disease is caused by PMeV and an associated virus denominated *papaya meleira* virus 2 (PMeV2) (Daltro et al., 2014; Abreu et al., 2015; Antunes et al., 2016). In this context, papaya sticky disease has caused large losses in production and drop in yield of the main national productive areas (Lima; Lima, 2002; Vidal et al., 2004).

Until now, the identification of symptoms and the removal of infected plants (roguing[1]) has been the most efficient disease control strategy in the field (Ventura et al., 2003). Papaya sticky disease affects at least 20% of the plants along the economic cycle of the culture. In some orchards, in which roguing is not performed, the incidence of the disease may reach up to 100% (Ventura et al., 2003; Abreu et al., 2015). According to the phytosanitary legislation of the State of Bahia, the papaya sticky disease control on orchards is obligatory to avoid dissemination to nearby areas.

Ventura et al. (2015), in comparative studies concerning the adoption of roguing as a control strategy of papaya sticky and ringspot[2] diseases, found very satisfactory results. Even though it is an efficient strategy, it must be associated to other management techniques, aiming for the premature identification of infected plants in field, as management of spontaneous plants; disinfestation of thinning material and fruit harvesting (Abreu et al., 2015). With the joint adoption of these measures, it is expected to reduce the dissemination rates of the disease in field and its economic losses. The papaya producers for export must follow protocols established in contracts by the import market. This means the obligation to adopt rouging strategy for controlling papaya orchards from papaya sticky disease.

Despite the importance of the disease and the studies and management adopted by its control, the possible economic impacts of papaya sticky disease in the productive chain of papaya

1 Systematic identification and eradication of infected papaya plants with the papaya meleira virus.

2 Term which designates the disease caused by *Papaya ringspot virus* in papaya plants. It refers to the observed symptons on papaya fruits affected by this disease.

in the Extreme South of Bahia are still unknown. Therefore, the objective of this study is to determinate the losses caused by papaya sticky disease in the profitability of the productive chain of papaya in the extreme South of Bahia.

2 MATERIAL AND METHODS

The choice of the study area was motivated by the fact that the extreme South of Bahia is responsible for a major part of the papaya production in the state (more than 185 thousand tons) (IBGE, 2019). The losses surveys and corresponding problems in the production occurred through the performance of 14 directed interviews (with the method face to face) with the technical supervisors and the papaya producers of the municipalities of Eunápolis, Itabela and Porto Seguro. Nine technical supervisors that consult around 30 producers, as well as five papaya orchards owners from the extreme South of Bahia, were interviewed. The interviews were carried out between March of 2016 and May of 2017, whose script included 12 open-ended questions about the main problems of papaya culture, monoculture/intercropped systems, price and Market, pests and diseases, disease inspectors' costs, losses due papaya sticky disease and future expectations for the papaya culture.

The technical coefficients considered in this study were based on the integrated production system of papaya for the entire South of Bahia (Embrapa, 2019), applied and adapted considering the information gathered from producers, consulters, and technical supervisors located at the extreme South of Bahia, where the main papaya production is concentrated (about 50%). The technical coefficients express the amount of input necessary by hectare of the culture, in tons, kilogram or liters (correctives, fertilizers, seedlings and pesticides), in hours (machines and equipment), and in day of labor (man/day).

The profitability analysis of the culture of Hawaii papaya, as well as for 'Tainung 1' papaya, was based on the technical coefficients of the system of production, and the information gathered from the producers, consulters, and technical supervisors interviewed.

The profitability indexes used were NPV (Net Present Value), IRR (Internal Rate of Return), and BCR (Benefit-Cost Relation). The Net Present Value (or Net Current Value) consists in transferring to the current moment all the expected cash variations (inflow minus outflow or revenue minus costs), discounted at a determined interest rate (Minimum Attractiveness Rate or MAR) and their algebraic sum. In this case, all the values referring to the years 2 and 3 were "carried" to year 1. The IRR of a project is the rate that writes off the NPV of the cash flow of the investment (in this case, the culture of papaya). The base rate of discount considered was 8% per year, corresponding to the Long-Term Interest Rate (LTIR) of the specified period. The average prices paid to the producer were considered from the average of the last 3 years for the region South of Bahia, from October 2017 to September 2020 (Cepea, 2020).

The equations for the Net Present Value (1) and Internal Rate of Return (2) are (Ponciano et al., 2004):

$$NPV = \sum_{n=0}^{N} \frac{CF_n}{(1 + MAR)^n} \quad (1)$$

$$0 = \sum_{n=0}^{N} \frac{CF_n}{(1 + ITR)^n} \quad (2)$$

Whereas:

CF = Cash flow (Cost minus Revenue, or Inflow minus Outflow)

MAR = Minimum Attractiveness Rate

For the calculations of the damage caused by the papaya sticky disease, the indexes of 5%, 10%, 20%, 30%, 40%, 50% and 60% from eradicated plants used values that were cited by the producers and technical supervisors contacted.

3 RESULTS AND DISCUSSION

According to the survey performed by the interviews with the producers of papaya in the extreme South of Bahia, the major problems that affect the culture are, for 71% of the respondents, Papaya sticky disease – responsible for large losses on farming, ringspot (according to half of the respondents), and the presence of mites, for 21% of the responses. Still in this context, 14% of the producers and consultants interviewed cited that the constant variation of price paid for the fruit is limiting for the sustainability of the production. In the visited areas, the papaya orchards are intercropped with coffee because the latter has greater price stability and lower cost in management of pests and diseases. In this scenario, the culture of papaya has been losing cultivation area for the coffee culture, becoming secondary in the region of study. Still according to the survey performed, the type of papaya mostly produced among the interviewed producers (90%) is Hawaii (Solo Group).

Despite the prominent position of the extreme South region of Bahia regarding the production of papaya, there is a constant reduction in both areas intended for planting and in the quantity produced. The current efficient method of controlling the disease is the use of disease inspectors[3] with the ability to identify the symptoms in an early stage. Thus, it was noted that in 80% of the farms hire permanent disease inspectors. As to the losses in the farms caused by papaya sticky disease, in 65%, cutting of plants with symptoms of papaya sticky disease, was prominent.

Around 65% of the interviewers responded that they do not intend to increase the cultivation area due to the low average market prices for the papaya fruit and its constant oscillations, which leads them to think about prioritizing planting coffee. Furthermore, 80% of the producers reported that do not intend to expand the planted area due to the recent history of unfavorable prices. In the interviews, the question if the producers have ever thought about giving up the farming of papaya, was also approached, from which half of them responded “Yes” (only one affirmed that intend to increase the planting area, because of market export).

Based on the information obtained (in the interviews) with the technical supervisors and papaya producers, papaya sticky disease causes, in the region, losses in papaya farms ranging from 5% to 60%. For comparison, it was reported 78% of cutting the plants affected by papaya sticky disease in Mexico (Magaña-Alvarez et al., 2013). In Brazil, when management strategies are not adopted, losses may reach up to 100% of the plants (Ventura et al., 2003; 2004). The interviews confirmed that in more technified farms, the losses are reduced to 5%, if the use of combative practice for virus infections (roguing), is used. For the moderately or little technified farms, the losses increase up to, respectively, 10-20% and 20-30%. In contrast, the use of these practices, mainly hiring of disease inspectors, tend to make the final product – papaya fruit – more expensive.

The average prices referring to the profitability of Hawaii and ‘Tainung 1’ papayas were R$ 0.99 a kg of Hawaii papaya, and R$ 0,85 a kg of ‘Tainung 1’ papaya. Based on the technical coefficients estimated and priced for one hectare from the systems of integrated production for papaya

3 Field worker responsible for identifying infected plants with Papaya meleira virus (PMeV) and *Papaya ringspot virus (PRSV-p)*.

in the South of Bahia – Hawaii and 'Tainung 1', along with the expected productivity (Embrapa, 2019), tables were drawn up for the production coefficients in 1 ha of Hawaii and 'Tainung 1' papayas (Tables 1 and 3, respectively), as well as profitability indexes calculated for Hawaii and 'Tainung 1' (Tables 2 and 4, respectively). Finally, tables for the profitability indexes with the presence of papaya sticky disease under different incidence rates (Tables 5 and 6, for Hawaii and Formosa respectively) are presented, according to information obtained from the producers, agricultural consulters and technical supervisors hired.

For Hawaii papaya, in the first year of planting, the total operating cost (TOC) was R$ 32,409.73, in the second year R$ 21,261.50, and R$ 10,437.61 in the last cycle (Table 1). The major expenses were with the production input, representing 27.90% of this value, followed by the expenses with cultural/phytosanitary treatments and irrigation, around 22.26% and 15.64%, respectively, in the first year of planting, were noted. This percentage is expected for the first year, because it is when the deploymental process of the farming occurs. In the second year the positions change, and the major expenses are with cultural and phytosanitary treatments (R$ 8,011.00), representing around 37.68% of the total. This scenario repeats itself also for the third year: costs with cultural and phytosanitary treatments represent around 36% of the total. The total operating expense (TOE), that represents the sum of TOC plus the finance charges (interest costs) and the land cost, is also presented in Table 1.

Regarding the papaya from the 'Tainung 1' (Formosa group), the major expenses were noted for input (31.29%), followed by costs with cultural and phytosanitary treatments (20.09%) (Table 3). As for the second and third years, the major expenses are represented by harvesting and cultural and phytosanitary treatments. Harvesting of papaya is performed manually through the entire year, being more expressive in the second year of production. The TOE for Formosa papaya, considering three years (October 2017 to September 2020) at an interest rate of 8% (p.a.), is presented on Table 4.

The profitability indexes are presented in Tables 2 and 4. The indicator of Net Present Value (NPV), considering a MAR of 8%, was positive for both Hawaii and 'Tainung 1' (R$ 35,361.21 and R$ 66,819.08, respectively). The Internal Rates of Return (IRR) of 159.28% and 380.64%, respectively, express the satisfactory economic viability of both groups cultivated in the extreme South of Bahia (Tables 2 and 4), if the recommendations presented on Tables 1 and 3 are observed. For each R$ 1.00 invested in Hawaii papaya culture, there is a gross return of R$ 1.55, while for 'Tainung 1' this value is R$ 1.91 (Tables 2 and 4). A relation below 1.0 is an indicator of venture unviability since the current value of cash inflow (revenue) is lower than the cash outflow (cost). Similar results were found by Feitosa et al. (2018), in papaya irrigated orchards in the State of Ceará, which presented a maximum BCR of 1.58.

For the calculation of damages caused by papaya sticky disease, percentages of losses reported by the producers and technical supervisors were used, ranging from 5% to 60% (Tables 5 and 6). For each percentage loss due papaya sticky disease considered (production per plant), both expected productivity and the amount of input were adjusted. These change according to the quantity of plants per hectare, for both years 2 and 3 of the orchard, except for the first year of production because there are no reports of losses due papaya sticky disease in young orchards.

For Hawaii papaya, the profitability indicators were positive for up to 50% of the losses; afterwards, they are negative (Table 5). Therefore, the losses of plants higher than 50%, due the incidence of papaya sticky disease indicate that the continuity of the farming is not recommended, in which the profitability indicators were negative (Table 5). The unit cost per ton of Hawaii papaya under different scenarios of the disease is the main threshold (limit) for this decision against the prices expected to the producers for the fruit. The variety 'Tainung 1' remained positive until 60% of the losses of plants calculated. Thus, the profitability indicators (NPV, BCR, and IRR) for this cultivar, in all scenarios of losses due papaya sticky disease, were positive (Table 6).

A sensitive analysis of the papaya production was carried out by applying different total cost increment (25%, 50% and 100%) from no plants lost to papaya sticky disease till 60% of losses (Tables 7 and 8). Each calculated unit cost per ton for both papaya varieties means the minimum price to be paid for one ton of papaya, in each scenario. Prices must be equal or above the unit cost per ton to be profitable for producers. The lowest price for Hawaii papaya, in the period from October 2017 to September 2020, was R$ 250.00 per ton, and the highest, R$ 6,230.00 per ton. The 1st quartile, 2nd quartile, 3rd quartile (median) and 4th quartile were, respectively, R$ 250.00 per ton, R$ 487.50 per ton, R$ 760.00 per ton, and R$ 1,303.00 per ton. For the 'Tainung 1' papaya, the lowest price for the same period was R$ 280.00 per ton, and the highest, R$ 2,340.00 per ton. The prices in the 1st quartile, 2nd quartile, 3rd quartile (median) and 4th quartile were, respectively, R$ 280.00 per ton, R$ 507.50 per ton, R$ 795.00 per ton, and R$ 1,105.00 per ton.

As aforementioned, it is possible to affirm that the production of both Hawaii and Formosa papayas irrigated in the perimeter of the extreme South of Bahia is profitable when following the technician´s recommendations for the respective production systems, even considering the losses due papaya sticky disease. The information regarding the economic damages of papaya sticky disease in the productive chain of papaya in the extreme South of Bahia raised in this study in different scenarios may be useful to re-enforce public-private actions aiming to control this virus infection in the papaya agribusiness.

Table 1 – Technical coefficients to produce 1 hectare of Hawaii papaya (Solo Group) irrigated through dripping and microaspersion, with spacing in simple row 3.0m x 2.0m (1666 plants) and expected productivity of 15 ton/ha on the first year, 65 ton/ha on the second year, and 30 ton/ha for the third year

SPECIFICATION		UnitPrice (R$)	Year1		Year2		Year3	
			Qty	Price (R$)	Qty	Price (R$)	Qty	Price (R$)
1. Input								
Seedling production	unit	0.25	5.000	1,250.00	0.00	0.00	0.00	0.00
Seeds	kg	100.00	0.15	15.00	0.00	0.00	0.00	0.00
Dolomitic limestone	ton	158.00	3.20	505.60	0.00	0.00	0.00	0.00
Corral manure	ton	150.00	4.60	690.00	0.00	0.00	0.00	0.00
Super Simples Fertilizer (1)	sck.50kg	56.35	19.00	1,070.65	10.00	563.50	5.00	281.75
Potassium chloride (1)	sck.50kg	100.00	12.00	1,200.00	10.00	1,000.00	4.00	400.00
Urea (1)	sck.50kg	110.00	13.00	1,430.00	9.00	990.00	4.00	440.00
Micronutrients (FTE)	sck.50kg	76.00	2.00	152.00	1.00	76.00	0.00	0.00
Legume seeds	kg	20.00	60.00	1,200.00	0.00	0.00	0.00	0.00
Spreader sticker	l	125.00	3.00	375.00	3.50	437.50	3.00	375.00
Ant bait (powder and granular)	kg	10.00	8.00	80.00	0.00	0.00	0.00	0.00
Fungicide	kg	49.00	10.00	490.00	14.00	686.00	5.00	245.00
Insecticide	kg	70.00	3.00	210.00	3.00	210.00	2.00	140.00
Acaricide	l	90.00	3.00	270.00	3.00	270.00	2.00	180.00
Herbicide	l	17.50	6.00	105.00	4.00	70.00	2.00	35.00
Subtotal (R$)				**9,043.25**		**4,303.00**		**2,096.75**
Percentual participation				**27.90**		**20.24**		**20.09**
2. Soil preparation, fertilization and planting								
Stump removal and mowing	hr/wrk	160.00	7.00	1,120.00	0.00	0.00	0.00	0.00
Plowing	hr/wrk	103.00	4.00	412.00	0.00	0.00	0.00	0.00
Lime application	hr/wrk	103.00	1.00	103.00	0.00	0.00	0.00	0.00
Harrowing	hr/wrk	103.00	2.00	206.00	0.00	0.00	0.00	0.00

SPECIFICATION		UnitPrice (R$)	Year1		Year2		Year3	
			Qty	Price (R$)	Qty	Price (R$)	Qty	Price (R$)
Subsoiling (1m)	hr/wrk	172.00	3.00	516.00	0.00	0.00	0.00	0.00
Area marking	hr/wrk	60.00	3.00	180.00	0.00	0.00	0.00	0.00
Furrowing	hr/wrk	103.00	4.00	412.00	0.00	0.00	0.00	0.00
Seedling production	m/d	60.00	3.00	180.00	0.00	0.00	0.00	0.00
Soil transport for seedling preparation	hr/wrk	103.00	1.00	103.00	0.00	0.00	0.00	0.00
Fertilization, opening and closing of furrows	m/d	60.00	7.00	420.00	0.00	0.00	0.00	0.00
Transport and distribution of seedlings	hr/wrk	103.00	4.00	412.00	0.00	0.00	0.00	0.00
Sexing	m/d	60.00	4.00	240.00	0.00	0.00	0.00	0.00
Planting (03 seedling/pit)	m/d	60.00	7.00	420.00	0.00	0.00	0.00	0.00
Legume planting	m/d	60.00	1.00	60.00	0.00	0.00	0.00	0.00
Subtotal (R$)				**4,784.00**		**0.00**		**0.00**
Percentual participation				**14.76**		**0.00**		**0.00**
3. Cultural and phytosanitary treatments								
Manual weeding	m/d	60.00	18.00	1,080.00	12.00	720.00	3.00	180.00
Mechanical weeding and mowing	hr/wrk	103.00	3.00	309.00	3.00	309.00	2.00	206.00
Getting soil to the papaya plant	hr/wrk	103.00	1.50	154.50	0.00	0.00	0.00	0.00
Mowing of legume	hr/wrk	103.00	1.00	103.00	1.00	103.00	1.00	103.00
Thinning of plants	m/d	60.00	4.00	240.00	0.00	0.00	0.00	0.00
Transport of input	hr/wrk	103.00	4.00	412.00	3.00	309.00	1.00	103.00
Transport of input	m/d	60.00	4.00	240.00	3.00	180.00	1.00	60.00
Sprout thinning	m/d	60.00	3.00	180.00	0.00	0.00	0.00	0.00
Fruits thinning	m/d	60.00	5.00	300.00	15.00	900.00	5.00	300.00
Eradication of mosaic and papaya sticky disease	m/d	60.00	5.00	300.00	15.00	900.00	10.00	600.00
Top dressing fertilization	m/d	60.00	10.00	600.00	10.00	600.00	6.00	360.00
Application of pesticides (man)	m/d	60.00	12.00	720.00	15.00	900.00	5.00	300.00
Application of pesticides (tractor)	hr/wrk	103.00	25.00	2,575.00	30.00	3,090.00	15.00	1,545.00
Subtotal (R$)				**7,213.50**		**8,011.00**		**3,757.00**
Percentual participation				**22.26**		**37.68**		**35.99**
4. Irrigation								
Irrigation - Microaspersion	unit	3,576.71	1.00	3,576.71	0.00	0.00	0.00	0.00
Operation	m/d	60.00	10.00	600.00	10.00	600.00	5.00	300.00
Electric energy	kwh	0.32	2,500.00	792.50	2,500.00	792.50	1,500.00	475.50
Maintenance	R$	-	-	100.00	-	200.00	-	150.00
Subtotal (R$)				**5,069.21**		**1,592.50**		**925.50**
Percentual participation				**15.64**		**7.49**		**8.87**
5. Harvesting								
Manual harvesting	m/d	60.00	24.00	1,440.00	60.00	3,600.00	30.00	1,800.00
Transport	hr/wrk	103.00	16.00	1,648.00	16.00	1,648.00	8.00	824.00
Subtotal (R$)				**3,088.00**		**5,248.00**		**2,624.00**
Percentual participation				**9.53**		**24.68**		**25.14**

SPECIFICATION		UnitPrice (R$)	Year1		Year2		Year3	
			Qty	Price (R$)	Qty	Price (R$)	Qty	Price (R$)
6. Other expenses (on the previous costs)								
Management / Certification	%	1	29,197.96	291.98	19,154.50	191.55	9,403.25	94.03
Administrative overall costs	%	2	29,197.96	583.96	19,154.50	383.09	9,403.25	188.07
Subtotal (R$)				**875.94**		**574.64**		**282.10**
Percentual participation				**2.70**		**2.70**		**2.70**
7. Financial charges (on the previous costs)								
Financial charges (8.00% p.a.)	%	8.00	29,197.96	2,335.84	19,154.50	1,532.36	9,403.25	752.26
Subtotal (R$)				**2,335.84**		**1,532.36**		**752.26**
Percentual participation				**7.21**		**7.21**		**7.21**
TOTAL OPERATING COST				**32,409.73**		**21,261.50**		**10,437.61**
TOTAL PERCENTAGE				**100.00**		**100.00**		**100.00**
8. LAND COST								
Rental/ equivalent cost	budget/ year	1,254.00	1	1,254.00	1	1,254.00	1	1,254.00
TOTAL OPERATING EXPENSE				**33,663.73**		**22,515.50**		**11,691.61**

Table 2 – Profitability indicators of one hectare of Hawaii papaya (Solo Group) irrigated through dripping or microaspersion, with spacing in simple row 3.0 m x 2.0 m (1666 plants), with expected productivity of 15 ton/ha for the first year, 65 ton/ha on the second year, and 30 ton/ha for the third year

Papaya period	Prod. (ton)	Price (R$)	Value of prod. (B)	TOE (C)	Gross margin (B-C)	Benefit-cost relation	Break-even point (in ton)	Safety margin (%)
1st year	15	990.00	14,850.00	33,663.73	-18,813.73	0.44	34.00	126.69
2nd year	65	990.00	64,350.00	22,515.50	41,834.51	2.86	22.74	-65.01
3rd year	30	990.00	29,700.00	11,691.61	18,008.39	2.54	11.81	-60.63
Total (R$)			**108,900.00**	**67,870.31**	**41,029.16**			
IRR = 159.28%					**Net present value (NPV) = R$35,361.21**			
BCR = 1.55					**Unitary cost per ton = R$ 639.56**			

Notes: The Net Present Value and Benefit-Cost Relation were calculated using a Discount Rate of 8% p.a.; Gross Margin = Value of Production – Operational Cost; BCR = Benefit-Cost Relation, which indicates how much was generated for each monetary unit invested. However, considering it is a three-year culture the most important Benefit-Cost Relation is the one for entire period flow of culture (BCR =1.55); break--even point (ton) = amount produced (annual) in which the Value of Production (column B) is equal to Total Operating Expense (column C); Safety Margin (%) = how much the value of production (column B) may vary in percentage (for more or less) to equal to the Total Operating Expense (column C).

Table 3 – Technical coefficients to produce 1 hectare of papaya Formosa Group irrigated through dripping or microaspersion, with spacing in simple row of 4.0 m x 2.0 m (1250 plants), with expected productivity of 25 ton/ha for the first year, 100 ton/ha for the second year, and 55 ton/ha for the third year

Specification		Unit. Price (R$)	Year1		Year2		Year3	
			Qty	Price (R$)	Qty	Price (R$)	Qty	Price (R$)
1. INPUT								
Seeds	g	17.50	80.00	1,400.00	0.00	0.00	0.00	0.00
Seedling production	unit	0.25	1,250.00	312.50	0.00	0.00	0.00	0.00
Dolomitic limestone	ton	158.00	3.20	505.60	0.00	0.00	0.00	0.00
Corral manure	ton	150.00	4.60	690.00	2.30	345.00	0.00	0.00
Super Simples Fertilizer (1)	sck.50kg	56.35	20.00	1,127.00	10.00	563.50	5.00	281.75
Potassium chloride (1)	sck50kg	100.00	14.00	1,400.00	11.00	1,100.00	8.00	800.00
Urea (1)	sck50kg	110.00	15.00	1,650.00	12.00	1,320.00	8.00	880.00
Micronutrients (FTE)	sck50kg	76.00	3.00	228.00	2.00	152.00	1.00	76.00
Legume seeds	kg	20.00	80.00	1,600.00	0.00	0.00	0.00	0.00
Spreader sticker	l	125.00	3.00	375.00	3.50	437.50	3.00	375.00
Ant bait (powder and granular)	kg	10.00	8.00	80.00	0.00	0.00	0.00	0.00
Fungicide	l	44.00	10.00	440.00	14.00	616.00	5.00	220.00
Insecticide	kg	70.00	3.00	210.00	3.00	210.00	2.00	140.00
Acaricide	l	90.00	3.00	270.00	3.00	270.00	2.00	180.00
Herbicide	l	17.50	6.00	105.00	4.00	70.00	2.00	35.00
Subtotal (R$)				**10,393.10**		**5,084.00**		**2,987.75**
Percentual participation				**31.29**		**18.95**		**21.95**
2. Soil preparation, fertilization and planting								
Stump removal and mowing	hr/wrk	160.00	7.00	1,120.00	0.00	0.00	0.00	0.00
Plowing	hr/wrk	103.00	4.00	412.00	0.00	0.00	0.00	0.00
Lime application	hr/wrk	103.00	1.00	103.00	0.00	0.00	0.00	0.00
Harrowing	hr/wrk	103.00	2.00	206.00	0.00	0.00	0.00	0.00
Subsoiling (1m)	hr/wrk	172.00	3.00	516.00	0.00	0.00	0.00	0.00
Area marking	m/d	60.00	3.00	180.00	0.00	0.00	0.00	0.00
Furrowing	hr/wrk	103.00	4.00	412.00	0.00	0.00	0.00	0.00
Seedling production	m/d	60.00	3.00	180.00	0.00	0.00	0.00	0.00
Soil transport for seedling preparation	hr/wrk	90.00	1.00	90.00	0.00	0.00	0.00	0.00
Fertilization, opening and closing of furrows	m/d	60.00	7.00	420.00	0.00	0.00	0.00	0.00
Transport and distribution of seedlings	hr/wrk	103.00	4.00	412.00	0.00	0.00	0.00	0.00
Planting	m/d	60.00	7.00	420.00	0.00	0.00	0.00	0.00
Legume planting	m/d	60.00	1.00	60.00	0.00	0.00	0.00	0.00
Subtotal (R$)				**4,531.00**		**0.00**		**0.00**
Percentual participation				**13.64**		**0.00**		**0.00**
3. Cultural and phytosanitary treatments								
Manual weeding	m/d	60.00	18.00	1,080.00	12.00	720.00	3.00	180.00
Mechanical weeding and mowing	hr/wrk	103.00	3.00	309.00	3.00	270.00	2.00	206.00
Getting soil to the papaya plant	hr/wrk	103.00	1.50	154.50	0.00	0.00	0.00	0.00
Mowing of legume	hr/wrk	103.00	1.00	103.00	1.00	90.00	1.00	103.00
Transport of input	hr/wrk	103.00	4.00	412.00	3.00	270.00	1.00	103.00

Specification		Unit. Price (R$)	Year1		Year2		Year3	
			Qty	Price (R$)	Qty	Price (R$)	Qty	Price (R$)
Transport of input	m/d	60.00	4.00	240.00	3.00	180.00	1.00	60.00
Sprout thinning	m/d	60.00	3.00	180.00	0.00	0.00	0.00	0.00
Eradication of mosaic and papaya sticky disease	m/d	60.00	5.00	300.00	15.00	900.00	10.00	600.00
Top dressing fertilization	m/d	60.00	10.00	600.00	10.00	600.00	6.00	360.00
Application of pesticides (man)	m/d	60.00	12.00	720.00	15.00	900.00	5.00	300.00
Application of pesticides (tractor)	hr/wrk	103.00	25.00	2,575.00	30.00	3,090.00	15.00	1,545.00
Subtotal (R$)				**6,673.50**		**7,111.00**		**3,457.00**
Percentual participation				**20.09**		**26.51**		**25.40**
4. Irrigation								
Irrigation - Microaspersion	unit	3,576.71	1.00	3,576.71	0.00	0.00	0.00	0.00
Operation	m/d	60.00	10.00	600.00	10.00	600.00	5.00	300.00
Electric energy	kwh	0.32	2,500.00	792.50	2,500.00	792.50	1,500.00	475.50
Maintenance	R$	-	-	100.00	-	200.00	-	150.00
Subtotal (R$)				**5,069.21**		**1,592.50**		**925.50**
Percentual participation				**15.26**		**5.94**		**6.80**
5. Harvesting								
Manual harvesting	m/d	60.00	20.00	1,200.00	70.00	4,200.00	30.00	1,800.00
Transport	hr/wrk	103.00	20.00	2,060.00	60.00	6,180.00	30.00	3,090.00
Subtotal (R$)				**3,260.00**		**10,380.00**		**4,890.00**
Percentual participation				**9.81**		**38.69**		**35.93**
6. Other expenses (on the previous costs)								
Management / Certification	%	1	29,926.81	299.27	24,167.50	241.68	12,260.25	122.60
Administrative overall costs	%	2	29,926.81	598.54	24,167.50	483.35	12,260.25	245.21
Subtotal (R$)				**897.80**		**725.03**		**367.81**
Percentual participation				**2.70**		**2.70**		**2.70**
7. Financial charges (on the previous costs)								
Financial charges (8.00% p.a.)	%	8	29,926.81	2,394.14	24,167.50	1,933.40	12,260.25	980.82
Subtotal (R$)				**2,394.14**		**1,933.40**		**980.82**
Percentual participation				**7.21**		**7.21**		**7.21**
Total operating cost				**33,218.76**		**26,825.93**		**13,608.88**
Total percentage				**100.00**		**100.00**		**100.00**
8. Land cost								
Rental/ equivalent cost	budget/ year	1,254.00	1	1,254.00	1	1,254.00	1	1,254.00
Total operating expense				**34,472.76**		**28,079.93**		**14,862.88**

Table 4 – Profitability indicators of one hectare of papaya Formosa Group irrigated through dripping or microaspersion with spacing in simple row 4.0 m x 2.0 m (1250 plants), expected productivity of 25 ton/ha for the first year, 100 ton/ha for the second year, and 55 ton/ha for the third year

Papaya period	Prod. (ton)	Price (R$)	Value of prod. (B)	TOE (C)	Gross margin (B-C)	Benefit-cost relation	Break-even point (in ton)	Safety margin (%)
1st year	25	850.00	21,250.00	34,472.76	-13,222.76	0.62	40.56	62.22
2nd year	100	850.00	85,000.00	28,079.93	56,920.08	3.03	33.04	-66.96
3rd year	55	850.00	46,750.00	14,862.88	31,887.12	3.15	17.49	-68.21
Total (R$)			**153,000.00**	**77,415.56**	**75,584.44**			
	IRR = 380.64%				**Net Present Value (NPV) = R$ 66,819.08**			
	BCR = 1.91				**Unitary cost per ton = R$ 444.41**			

Notes: The Net Present Value and Benefit-Cost Relation were calculated using a Discount Rate of 8% p.a.; Gross Margin = Value of Production – Operational Cost; BCR = Benefit-Cost Relation, which indicates how much was generated for each monetary unit invested. However, considering it is a three-year culture, the most important Benefit-Cost Relation is the one for entire period flow of culture (BCR =1.91); break-even point (ton) = amount produced (annual) in which the Value of Production (column B) is equal to Total Operating Expense (column C); Safety Margin (%) = how much the value of production (column B) may vary in percentage (for more or less) to equal to the Total Operating Expense (column C).

Table 5 – Profitability indicators of one hectare of Hawaii papaya (Solo Group) based on the indexes of eradicated plants of 5, 10, 20, 30, 40, 50, and 60% due to papaya sticky disease

Number of Eradicated Plants: 5%			
Period	**Year 1**	**Year 2**	**Year 3**
Number of Plants	1666	1583	1504
Productivity (t)	15	62	28.5
IRR= 146.50%			**NPV= R$ 32,295.21**
BCR= 1.51			**Unitary cost/ton =R$ 655.71**
Number of Eradicated Plants: 10%			
Period	Year 1	Year 2	Year 3
Number of Plants	1666	1499	1349
Productivity (t)	15	59	27
IRR= 133.70%			**NPV= R$ 29,231.89**
BCR= 1.47			**Unitary cost/ton = R$ 673.35**
Number of Eradicated Plants: 20%			
Period	Year 1	Year 2	Year 3
Number of Plants	1666	1333	1066
Productivity (t)	15	52	24
IRR= 107.96%			**NPV= R$ 23,102.56**
BCR= 1.39			**Unitary cost/ton = R$ 714.06**
Number of Eradicated Plants: 30%			
Period	Year 1	Year 2	Year 3
Number of Plants	1666	1166	816
Productivity (t)	15	46	21
IRR= 82.01%			**NPV= R$ 16,973.24**
BCR= 1.30			**Unitary cost/ton = R$ 764.09**
Number of Eradicated Plants: 40%			
Period	Year 1	Year 2	Year 3
Number of Plants	1666	1000	600
Productivity (t)	15	39	18
IRR= 55.76%			**NPV= R$ 10,843.91**
BCR= 1.20			**Unitary cost/ton =R$ 827.04**

Number of Eradicated Plants: 5%			
Period	**Year 1**	**Year 2**	**Year 3**
Number of Eradicated Plants: 50%			
Period	Year 1	Year 2	Year 3
Number of Plants	1666	833	417
Productivity (t)	15	33	15
IRR= 29.04%			**NPV= R$ 4,714.58**
BCR= 1.09			**Unitary cost/ton = R$ 908.65**
Number of Eradicated Plants: 60%			
Period	Year 1	Year 2	Year 3
Number of Plants	1666	666	266
Productivity (t)	15	26	12
IRR= **-** 2.07%			**NPV= R$ - 2,202.83**
BCR= 0.96			**Unitary cost/ton = R$ 1,034.65**

NPV: Net Present Value; BCR was calculated using a Discount Rate of 8% p.a.; IRR: Internal Rate of Return.

Table 6 – Profitability indicators of one hectare of Formosa papaya based on the indexes of eradicated plants of 5, 10, 20, 30, 40, 50, and 60% due to papaya sticky disease

Number of Eradicated Plants: 5%			
Period	**Year 1**	**Year 2**	**Year 3**
Number of Plants	1250	1188	1129
Productivity (t)	25	95	52
IRR= 356.49%			**NPV = R$ 62,253.00**
BCR= 1.87			**Unitary cost/ton = R$ 454.85**
Number of Eradicated Plants: 10%			
Period	Year 1	Year 2	Year 3
Number of Plants	1250	1125	1013
Productivity (t)	25	90	50
IRR= 333.62%			**NPV = R$ 58,416.94**
BCR= 1.83			**Unitary cost/ton = R$ 463.65**
Number of Eradicated Plants: 20%			
Period	Year 1	Year 2	Year 3
Number of Plants	1250	1000	800
Productivity (t)	25	80	44
IRR= 285.13			**NPV = R$ 48,286.05**
BCR= 1.74			**Unitary cost/ton = R$ 489.71**
Number of Eradicated Plants: 30%			
Period	Year 1	Year 2	Year 3
Number of Plants	1250	875	613
Productivity (t)	25	70	39
IRR= 237.97%			**NPV = R$ 40,883.90**
BCR= 1.64			**Unitary cost/ton = R$ 518.29**
Number of Eradicated Plants: 40%			
Period	Year 1	Year 2	Year 3
Number of Plants	1250	750	450
Productivity (t)	25	60	33
IRR= 188.88%			**NPV = R$ 31,753.67**
BCR= 1.52			**Unitary cost/ton = R$ 558.28**

Number of Eradicated Plants: 5%			
Period	**Year 1**	**Year 2**	**Year 3**
Number of Eradicated Plants: 50%			
Period	Year 1	Year 2	Year 3
Number of Plants	1250	625	313
Productivity (t)	25	50	28
IRR= 141.37%			**NPV = R$ 23,350.87**
BCR= 1.41			**Unitary cost/ton = R$ 604.75**
Number of Eradicated Plants: 60%			
Period	Year 1	Year 2	Year 3
Number of Plants	1250	500	200
Productivity (t)	25	40	22
IRR= 90.98%			**NPV = R$ 14,219.98**
BCR= 1.26			**Unitary cost/ton = R$ 674.22**

NPV: Net Present Value; BCR was calculated using a Discount Rate of 8% p.a.; IRR: Internal Rate of Return.

Table 7 – Sensitivity analysis of unit cost (per ton) for total cost increment: 25%, 50% and 100% (Hawaii papaya)

Plant eradication	Unit cost (per ton)			
	Expected	**Increasing 25%**	**Increasing 50%**	**Increasing 100%**
None	639.56	799.45	959.34	1,279.12
5%	655.71	819.64	983.57	1,311.42
10%	673.35	841.69	1,010.03	1,346.70
20%	714.06	892.58	1,071.09	1,428.12
30%	764.09	955.11	1,146.14	1,528.18
40%	827.04	1,033.80	1,240.56	1,654.08
50%	908.65	1,135.81	1,362.98	1,817.30
60%	1,034.65	1,293.31	1,551.98	2,069.30

Source: Author's calculation based on Table 1

Table 8 – Sensitivity analysis of unit cost (per ton) for total cost increment: 25%, 50% and 100% ('Tainung 1' papaya)

Plant eradication	Unit cost (per ton)			
	Expected	**Increasing 25%**	**Increasing 50%**	**Increasing 100%**
None	444.41	555.52	666.62	888.82
5%	454.85	568.56	682.28	909.70
10%	463.65	579.56	695.48	927.30
20%	489.71	612.14	734.57	979.42
30%	518.29	647.86	777.44	1,036.58
40%	558.28	697.85	837.42	1,116.56
50%	604.98	756.23	907.47	1,209.96
60%	674.22	842.78	1,011.33	1,348.44

Source: Author's calculation based on Table 3

4 CONCLUSIONS

Hawaii and 'Tainung 1' papayas were economically viable for the region studied according to the profitability indicators evaluated, based on the coefficients of the integrated production system of papaya for the entire South of Bahia (EMBRAPA, 2019) and information obtained from producers and technical consultants from extreme South of Bahia.

The profitability indicators were positive for up to 50% and 60% of the losses due papaya sticky disease, for Hawaii and 'Tainung 1', respectively. When the production costs are 25% higher, the profitability indicators were positive for up to 30% and 60%, respectively. Considering a cost increment of 50%, the profitability indicators are positive for up to 5% and 40% of the losses due papaya sticky disease, for Hawaii and 'Tainung 1', respectively. In any case, the producer must take into consideration the unit cost per ton of papaya from its production and compare with the average market papaya prices.

Papaya sticky disease must undergo continuous control measures in papaya orchards, from the beginning of plantation until harvest. This is necessary due the fast plant-to-plant dissemination of the disease. In the Extreme South of Bahia, incidence is higher after the first year of cultivation.

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