

Costs, viability and risks of organic tomato production in a protected environment¹

Custos, viabilidade e riscos da produção de tomate orgânico em ambiente protegido

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ABSTRACT - The aim of this research was to evaluate the agro-economic performance of two table-tomato cultivars (Santa Clara and Siluet), under organic cultivation and in a protected environment. Through the analysis of production costs, economic viability and project risk, it was sought to generate a proposal for agricultural profitability having less socio-environmental impact on family farming. To achieve that, the Operating and Total Production Costs, Net Present Value (NPV) and Internal Rate of Return (IRR) were calculated. A sensitivity analysis and economic risk analysis were then carried out. Both cultivars under consideration presented satisfactory economic indicators for the period being analysed. Judging by the criterion of Net Present Value, almost all discount rates (except for the rates of 10 and 12% for the Santa Clara cultivar) were found to be economically viable, with internal rates of return higher than the annual rate of 6%, the minimum rate of financial attractiveness considered. The sensitivity analysis revealed that price received and productivity have the greatest interference on project profitability, followed by packaging and labour costs. The estimated economic risk was relatively low, with a probability of obtaining a negative NPV of 30.31% in the case of the 'Santa Clara', and 4.48% for the 'Siluet'. It is therefore concluded that the organic production of 'Siluet' and 'Santa Clara' tomatoes under protected cultivation is an economically viable activity, with emphasis on the agro-economic superiority of the Siluet cultivar.

Key words: *Solanum lycopersicum*. Management. Economy. Sustainability.

RESUMO - A pesquisa teve como objetivo avaliar o desempenho agroeconômico de duas cultivares de tomate de 'mesa' ('Santa Clara' e 'Siluet'), sob cultivo orgânico e em ambiente protegido. Mediante análise dos custos de produção, da viabilidade econômica e dos riscos do projeto, buscou-se gerar uma proposta agrícola de rentabilidade e com menor impacto socioambiental, visando à agricultura familiar. Para isso, foram calculados os Custos Operacionais e Totais da Produção, o Valor Presente Líquido (VPL) e a Taxa Interna de Retorno (TIR). Em seguida, procedeu-se as análises de sensibilidade e de risco econômico. Ambas as cultivares consideradas apresentaram indicadores econômicos satisfatórios para o período analisado. Pelo critério do valor presente líquido, constatou-se viabilidade econômica para quase todas as taxas de desconto (exceto para as taxas de 10 e 12%, no caso da c.v. Santa Clara) e taxas internas de retorno superiores à taxa anual de 6% p.a., a taxa mínima de atratividade considerada. A análise de sensibilidade revelou que o preço recebido e a produtividade são as variáveis de maior interferência sobre a rentabilidade dos projetos, seguidas por custos com embalagens e mão-de-obra. Os riscos econômicos estimados foram relativamente baixos, com probabilidades de 30,31%, no caso do cultivo da 'Santa Clara', e 4,48%, no cultivo da 'Siluet', de serem obtidos VPLs negativos. Assim, conclui-se que a produção orgânica sob cultivo protegido dos tomateiros Siluet e Santa Clara são atividades economicamente viáveis, com destaque para a superioridade agroeconômica da cultivar Siluet.

Palavras-chave: *Solanum lycopersicum*. Manejo. Economia. Sustentabilidade.

DOI: 10.5935/1806-6690.20180066

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Received for publication in 21/10/2015; approved in 17/11/2017

¹Parte da Tese de Doutorado da primeira autora apresentada no Programa de Pós-Graduação em Produção Vegetal/Laboratório de Engenharia e Economia Agrícola/CCTA/UENF

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INTRODUCTION

Present on the table of most Brazilians, the tomato (*Solanum lycopersicum*) stands out in economic importance among cultivated vegetables. It is seen as a great challenge to organic production, due to being a demanding crop in terms of nutrition and handling, and especially to its high susceptibility to pests and diseases.

An important characteristic of the market is irregular product availability and supply throughout the year. Under unfavourable climate conditions, especially under high levels of temperature and humidity, there is a fall in productivity and fruit quality (REIS *et al.*, 2013), which exposes producers to production and price risks.

The tomato crop is an important income generator for small producers. From the socio-economic point of view, almost all table-tomato production comes from family farmers, providing them with employment and income. In 2016, Brazil produced 3.47 million tons of tomatoes; the Southeast of the country participated with 48.2% of domestic production, including São Paulo with 20.2%, Minas Gerais with 18.8%, Rio de Janeiro with 5.1% and Espírito Santo with 4.1% (IBGE, 2016).

According to Castro Neto *et al.* (2010), organic agriculture can be advantageous for the small producer who cultivates small areas. Among other advantages, this type of crop creates more jobs due to the high demand for labour, has less dependence on external inputs such as pesticides and chemical fertilisers, and generates a product of greater commercial value.

Production under protected cultivation is one of the alternatives for overcoming environmental limitations, as it allows total or partial control of wind speed, relative humidity and ambient temperature, as well as protection against heavy rainfall (CHANG *et al.*, 2013). In addition, it is seen as a management tool that is compatible with the techniques of organic production, and which tends to strengthen the concepts of total quality, competitiveness for better products on the market, programmed supply and product differentiation.

In view of the above, the aim of this study was to evaluate the agronomic performance of two table-tomato cultivars under organic management in a protected environment, as well as the production costs, economic viability and risks associated with each of these alternatives in the context of a small production unit.

MATERIAL AND METHODS

Characterisation of the experiment

Two table-tomato cultivars were grown under organic management in a protected environment (144 m²

greenhouse), at the Research Support Unit (UAP) of the Darcy Ribeiro North Fluminense State University (UENF), in the district of Campos dos Goytacazes in the State of Rio de Janeiro (RJ), from July to November of 2011.

According to the respective seed-producing companies, the main characteristics of the cultivars under consideration are:

‘Siluet’ (Syngenta Seeds): a hybrid of the salad group, of determinate growth; a vigorous plant, good vegetative growth, with intermediate leaf cover, round fruit, slightly flattened, multilocular, firm and of long life, destined for *in natura* consumption, harvested around 90 days after sowing, resistant to *Verticillium albo-atrum* race 1, *Fusarium oxysporum* f. sp. *lycopersici* races 1 and 2, *Fusarium oxysporum* f. sp. *radicis-lycopersici*, *Cladosporium fulvum* races a, b, c, d, and e, *Stemphylium solani*, *Pseudomonas syringae* pv. *tomato* (bacterial spot), *Clavibacter michiganensis* subsp. *michiganensis* (bacterial canker), tobacco mosaic virus (TMV), tomato spotted wilt virus (TSWV), *Meloidogyne incognita*, *M. arenaria* and *M. javanica*.

‘Santa Clara’ (Feltrin Seeds): a hybrid of the Santa Cruz group, tall, of indeterminate growth with globular fruits destined for *in natura* consumption, harvested around 110 days after sowing and resistant to *Verticillium dahlia*, *Fusarium oxysporum* 1 and 2 and *Stemphylium*.

The seeds were planted in Styrofoam trays of 128 pyramidal cells (Plantágio) containing substrate (60% organic compost + 40% sand), and were transplanted 20 days after germination, when the seedlings had reached a height of 15 cm.

The experimental design was of randomised blocks with six replications and two plots per block. Each plot corresponded to one cultivar (C1-Siluet and C2-Santa Clara), and comprised 12 pots of 22 L distributed randomly in six rows (replications), with one plant per pot. The resulting stand comprised (12 x 6 x 2) 144 plants, distributed over 72 m² of the greenhouse; the ten central plants of each plot was considered the working area, giving a total of 120 working plants (60 plants of each cultivar), which were evaluated for their agronomic performance.

Fertilisation was carried out by incorporating organic compost into the pots at a ratio of 2:1 (Organic compost:soil). The mixture had the following chemical characteristics: pH 6.1, 50.2 g dm⁻³ OM, 410 mg dm⁻³ P, 242 mg dm⁻³ K, 9.6 cmol_c dm⁻³ Ca, 3.5 cmol_c dm⁻³ Mg, 0.0 cmol_c dm⁻³ Al, 4.0 cmol_c dm⁻³ H+Al and 0.25 cmol_c dm⁻³ Na. Phytosanitary management was performed as follows: the biological method was adopted to control the tomato moth (*Tuta absoluta*) through the release of *Trichogramma* spp. on cards containing 40,000 parasitoid

eggs. *Neoleucinodes elegantalis* and *Helicoverpa zea* were controlled by spraying with *Bacillus thuringiensis* (Bac-control®PM) as per the manufacturer's recommendation. As a control measure for disease, especially for late blight (*Phytophthora infestans*), 1% Bordeaux mixture was sprayed every fortnight.

The plants were trained using tape fixed onto a horizontal wire placed over the planting rows and supported by the greenhouse structure. The plants were spaced 1.0 m between rows and 0.5 m between plants, and were irrigated by hose.

Production was evaluated by collecting all the pink fruit (30 to 60% of the fruit surface coloured red) in the working plot and adopting the following parameters: Total Fruit Production (TFP), representing the mean fruit weight per plant; Commercial Fruit Production (CFP), the sum of all fruit classified as within commercial standards, expressed in grams per plant; Total Number of Fruit (TNF), the sum of all the harvested fruit; Number of Commercial Fruit (NCF), the sum of the fruit classified as within commercial standards; Longitudinal Diameter (LD) and Transverse Diameter (TD) of the fruit, expressed in cm, obtained with the aid of a digital calliper.

In addition, in order to verify the respective levels of quality, the fruit was classified according to the presence or absence of defects following the current legislative guidelines of the Technical Regulations for Organic Production Systems (BRAZIL, 2008). The data were analysed statistically by analysis of variance (ANOVA), followed by Tukey's test to compare the mean values of any variables that showed significant statistical differences (COSTA NETO, 1977), considering a level of 5% probability ($p < 0.05$). The SAEG 8.0 software was used in the analysis.

Economic and financial analysis

The indicators proposed by Matsunaga *et al.* (1976) were used in calculating the production costs of the production system: the Effective Operating Cost (EOC), which includes expenses incurred with labour, operations with machinery/equipment, and materials consumed throughout the production process; and Total Operating Cost (TOC), which is the effective operating cost plus additional expenses (taxes and charges), and including the depreciation of improvements (greenhouse) and equipment (irrigation system, sprayer and pots). Total production costs (TC), comprising the sum of the fixed and variable costs were also considered, as per Noronha (1987).

The following indicators were used to determine crop profitability (NORONHA, 1987): a) Gross Margin (GM): the margin in relation to the effective operating cost

(EOC), obtained by $GM = (GR - EOC)$, where (GR) is the Gross Revenue (production x price per unit); b) Operating Profit (OP): the difference between gross revenue and total operating cost, obtained by $OP = (GR - TOC)$, where TOC = total operating cost of production; and c) Net Profit or total net income (NP): obtained by subtracting the total cost (TC) incurred in production from the gross revenue ($NP = GR - TC$).

In order to analyse economic viability, the NPV (Net Present Value) and Internal Rate of Return (IRR) were determined for all the production systems, as per the methodology described by Woiler and Mathias (2008). To capture the opportunity cost of the invested capital, a Minimum Interest Rate (MIR) of 6% p.a., equivalent to the remuneration rate of savings accounts, was considered as an alternative investment option.

The NPV is a measure of the return on an investment that consists in comparing the future cash flows of the project, discounted at an interest rate corresponding to the opportunity cost of the capital (discount rate), with the initial investment. The activity is attractive if $NPV > 0$, i.e. when the sum of future investment flows, updated by the assumed discount rate, is greater than the initial investment. In the case of an NPV equal to zero, the return on the project is equal to the minimum rate of attractiveness, leaving the producer indifferent whether to continue with the investment or place the money in a fund with remuneration that follows the minimum rate of attractiveness. The activity is considered economically and financially unviable if it presents an $NPV < 0$ and IRR less than the opportunity cost of the capital (WOILER; MATHIAS, 2008).

Decision-making under risk conditions

Sensitivity analysis consists of estimating the impact that each of the items, whether revenue or expense, has on the financial result of the project. This procedure allows evaluation of how changes in each of the project variables may influence the profitability of the expected results (BUARQUE, 1991).

The procedure to carry out the sensitivity analysis initially consisted of establishing an expression that would relate the profitability indicators (NPV and IRR) with the parameters and variables of the project. Using the Excel® software, 10% variations were introduced in one or more parameters, with all the other parameters remaining constant, and the impact that these variations had on the financial results of the project were observed. In each of these cases, pessimistic scenarios were considered, characterised by a rise in the price of expense items and a reduction in the price of revenue items. Finally, the simulated results were compared with the economic indicators initially predicted for the activity in order to

identify and analyse which variables had the greatest interference in the feasibility indicators of the project.

To evaluate the risk involved in the various systems, the Monte Carlo simulation technique was used; this process can be summarised as follows: 1. A value was randomly selected for each of the variables within a pre-established probability distribution. In this case, it was assumed that the variables presented a triangular distribution, which is defined by the most probable mean level (m), a minimum level (a) and a maximum level (b). 2. A new cash flow was generated, corresponding to the values selected in the previous step. 3. A profitability indicator, the NPV, was then calculated for this new cash flow. 4. These procedures were repeated a sufficient number of times (10,000 times) to obtain the probability distribution of the indicator (NPV). 5. Finally, from the NPV probability distribution, the risk (probability of a negative NPV) associated with the tested activities was calculated.

Source of the data

For the economic analysis, the maximum capacity utilisation of the greenhouse was considered as 144 m², giving a total of 288 plants for each cultivar. To reflect the real economic potential of the alternatives under test relative to the period from 2011 to 2013, all the monetary values used in the economic analysis (products, inputs, equipment, and price received for the product) were obtained from the arithmetic mean of the North Fluminense region. A planning horizon of six months was considered in compiling the cash flow of each crop.

RESULTS AND DISCUSSION

After harvesting, selecting and classifying the fruit, all the production obtained in the present study had a commercial profile (CFP) classified as small fruit, the fruit not presenting a significant number of defects which would make commercialisation non-viable, and the mean transverse diameter of both cultivars (Santa Clara and Siluet) being between 40-60 mm (Table 1).

These results highlight the importance of protected cultivation, considered an efficient tool in protecting from inclement climates and phytopathological problems (SCHALLENBERGER *et al.*, 2011), and under which similar and even higher yields can be obtained than under cultivation in the field (REIS *et al.*, 2013).

Quantitatively, and still based on Table 1, productivity in the 'Santa Clara' tomato had a mean value of 2.9 kg plant⁻¹, higher than the mean value of 0.7 kg plant⁻¹ obtained by Toledo *et al.* (2011), but lower than the 3.3 kg plant⁻¹ found by Genuncio *et al.* (2010) employing hydroponic management.

It can be seen that the performance of the Siluet cultivar, with a tomato production of 3.56 kg plant⁻¹, was 22.7% higher than the productive performance of the 'Santa Clara'. This superiority was found in terms of both total fruit production (TFP) and number of fruit (NF), although no difference ($p > 0.05$) was seen in the parameter fruit weight (kg). These results show the potential of the cultivar in a protected organic production system, which until now has not been reported in the literature.

The cultivars under study have different morpho-agronomic characteristics, especially in relation to the requirement of the Santa Clara cultivar for regular thinning operations throughout the period of vegetative development. The economic impact of possible increases in the operational demand of the crops was therefore verified by the method of production costing and shown below.

In general, it was found that the thinning operations required by the Santa Clara cultivar deserved highlighting, since this demand resulted in an increase of 8.2% in the effective operating cost of the cultivar. It was also found that of all the labour employed on the crop, from planting to harvesting, 48% is due to expenses with thinning, which represented a 23% share of all the items that made up the circulating capital of the crop (Figure 1b).

The circulating capital comprised four groups, namely: 1 - Pesticides (hydrated lime, Agree®, Bovenat® and copper sulphate); 2 - Labour (phytosanitary control, training and cultivation, clearing and harvesting); 3 -

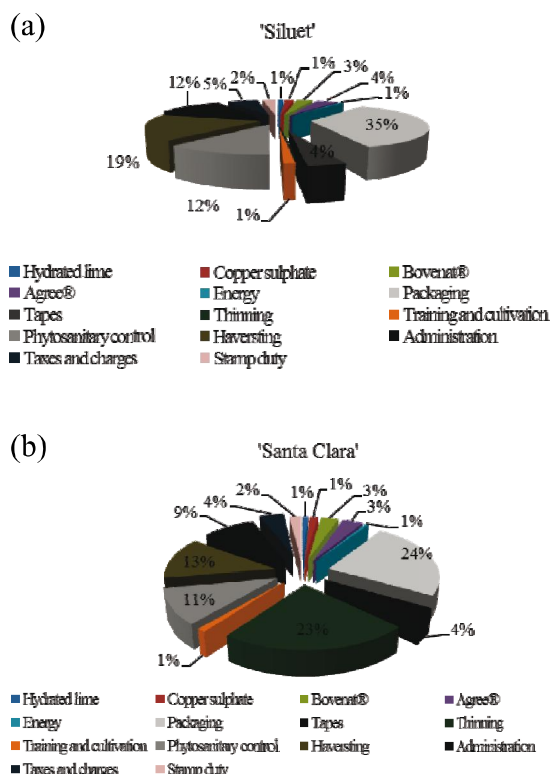
Table 1 - Mean values of the agronomic variables of two tomato cultivars, grown under organic management in a protected environment

Cultivar	TFP	TNF	FW	LD	TD
Siluet	3.56 a	27 a	0.133 a	42.15 b	45.88 a
Santa Clara	2.90 b	22 b	0.130 a	48.47 a	44.84 a
MSD	0.15	1.79	3.17	0.97	1.05

TFP - Total fruit production (kg plant⁻¹); TNF - Total number of fruit; FW- Fruit weight (kg); LD - Longitudinal diameter (mm); TD - Transverse diameter (mm); Mean values followed by the same letter in a column do not differ by Tukey's test at 5%. MSD = minimum significant difference

Other inputs and services (energy, packaging and tape for training); and 4 - Taxes and charges (stamp duty, administration). A breakdown of the circulating capital by item (Figure 1a and b) made possible a more detailed analysis, in which it was possible to verify the economic impact of each input and/or operation on the production costs of the tomatoes under study.

Figure 1 - Items that make up the circulating capital of the production cost of: a) 'Siluet' and b) 'Santa Clara', under organic cultivation in a protected environment



In order of importance, and still based on Figure 1, it can be seen that around 35% (Figure 1a) and 24% (Figure 1b) of the circulating capital consists of packaging costs for 'Siluet' and 'Santa Clara' respectively. In economic terms, this representation reveals the important role of packaging among the inputs used for the crops, since it was the item with the largest share of the costs within the circulating capital.

Generally, as found by Sousa *et al.* (2011) and Hens (2010), the organic production of vegetables is directed towards specific markets, where the standard packaging consists of expanded polystyrene trays and plastic polyethylene film, which in addition to being

pollutants increase production costs. This information is important, especially for small producers, who are also generally responsible for sales. For that reason, as with other short-cycle vegetables subject to seasonal scenarios, the profitability of the tomato grower is more vulnerable, requiring special attention to those items that have the greatest impact on production costs.

For the indicators of economic result (Table 2), the cultivation of 'Siluet' gave a Gross Margin of BRL 2,987.30, while the cultivation of 'Santa Clara' resulted in a Gross Margin of BRL 1860.70. However, these results demonstrate only that a residual value was generated after payment of all operating expenses.

Remuneration of all the production factors employed in the production process, including variable costs, depreciation and opportunity cost of the capital, is captured by the Net Profit indicator. From this indicator, it can be seen that it was possible to remunerate all the production factors and still generate a residual value of BRL 1,274.70 with the cultivation of 'Siluet'. In the case of 'Santa Clara', the production factors were remunerated, but the residual value was only BRL 76.50.

According to the values shown at the end of Table 2, the Internal Rate of Return (IRR) and Net Present Value (NPV) for the organic production of table tomatoes under protected cultivation were favourable. Both cultivars had an IRR greater than zero, of the order of 4.21 and 0.66% p.m, for 'Siluet' and 'Santa Clara' respectively, and a positive NPV for almost all discount rates, except the rates of 10 and 12% p.a. in the 'Santa Clara'. In this case, comparing the rate of return of the 'Santa Clara' crop with the yield of the savings account, which was between 0.56% and 0.79% p.m. in 2012, the proposed investment can be questioned, since investing the capital in a savings account would be a less-costly and less-risky decision. On the other hand, if the producer needed to carry out all initial investment using third-party capital, credit from Pronaf [The National Program to Strengthen Family Farming] for example (3% p.a.), the viability of both cultivars would be attractive, especially Siluet.

These results show the economic viability of the proposals under evaluation, which can represent an important alternative to diversify crops and increase the financial result of family farming. Added to these results are the socio-environmental benefits, since the production obtained is free of agrochemicals, especially agrottoxins, which damage the health of the consumer and the rural worker.

Furthermore, another important factor distinguishes these two systems of production: the selling price of the products. The high volatility in the price of conventional tomatoes is reported by different

Table 2 - Economic indicators of the organic production of the ‘Santa Clara’ and ‘Siluet’ tomatoes under protected cultivation of 144 m²

Economic Indicator	Unit	Value	
		‘Santa Clara’	‘Siluet’
Effective Operating Cost	BRL	2,315.30	2,139.10
Total Operating Cost	BRL	3,978.80	3,815.40
Total Cost	BRL	4,099.50	3,851.70
Price Received	BRL/Kg	5.00	5.00
Gross Revenue	BRL	4,176.00	5,126.40
Gross Margin	BRL	1860.70	2,987.30
Operating Profit	BRL	197.20	1,311.00
Net Profit	BRL	76.50	1,274.70
NPV 2% p.a.(0.165% p.m.)	BRL	146.80	1,253.65
NPV 6% p.a.(0.487% p.m.)	BRL	50.05	1,143.45
NPV 8% p.a. (0.643% p.m.)	BRL	3.56	1,090.49
NPV 10% p.a.(0.797% p.m.)	BRL	-41.73	1,038.87
NPV 12% p.a.(0.949% p.m.)	BRL	-85.89	988.53
IRR p.m.	%	0.66	4.21
IRR p.a.	%	8.20	64.10

studies in the literature (CARVALHO *et al.*, 2014; LUZ; SHINZATO; SILVA, 2007; MAYORGA *et al.*, 2009; SILVA NETO, 2014). However, according to Lima and Campos (2014), the profitability of organic agriculture generally fluctuates less than that of conventional agriculture due to smaller variations in the price of organic products.

Although organic production differs from conventional production in various aspects, an analysis of the financial behaviour of the systems when they are subject to pessimistic variations in production factors and revenue is a technique that provides greater efficiency in the administrative management of these crops.

In the present study, according to the sensitivity analysis (Table 3), profitability can be seen to be more sensitive to revenue components than to cost components, with the price received and productivity having the greatest influence on the financial result of the project.

Within a sustainable proposal of organic-based cultivation, and despite the price received displaying less-fluctuating behaviour (LIMA; CAMPOS, 2014), this variable, together with productivity, is the most important factor for increasing profitability, as happens in conventional tomato farming (CARVALHO *et al.*, 2014) and in other conventional agricultural activities (ARÊDES; OLIVEIRA; RODRIGUES, 2010; MACHADO NETO;

JASMIM; PONCIANO, 2013; SIQUEIRA; SOUZA; PONCIANO, 2011).

In addition to price and productivity, three other expense variables (packaging, labour and taxes/charges) were identified that are important for having a stronger effect on the economic results of the activity. In short, the five variables with the greatest impact on the economic viability of both cultivars under test were, in decreasing order of importance, the price, productivity, packaging, labour, and taxes and charges.

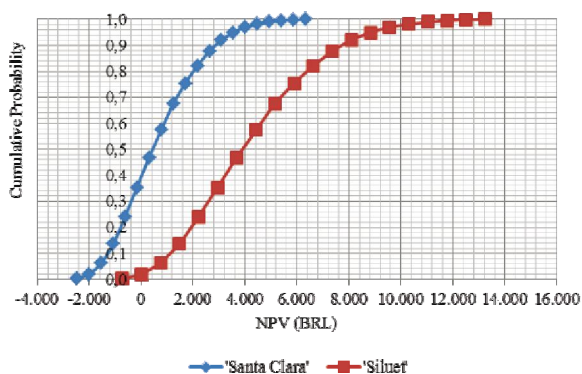
Once the variables with the greatest impact on the profitability of the projects were identified, the next step was to carry out the Monte Carlo simulation. The results of this simulation are summarised in Figure 2, which shows the cumulative probability distribution of the NPV for both cultivars. In this figure, the probability of the project becoming unfeasible (occurrence of negative values for NPV) corresponds to the value on the vertical axis associated with the intercept of this axis and the cumulative distribution curve.

The indicators presented so far show the economic viability of the alternatives under test, especially for the cultivation of ‘Siluet’, which obtained the highest profitability. However, according to the results of the Monte Carlo simulation, the proposed activities are not risk free, with a 30.31% probability of economic failure

Table 3 - Percentage-point reduction in the Internal Rate of Return (IRR) and Net Present Value (NPV) for the organic production of ‘Santa Clara’ and ‘Siluet’ under protected cultivation, due to an unfavourable 10% variation in the price of the product and inputs

Item	‘Santa Clara’		‘Siluet’	
	Variation in NPV (R\$)	Variation in IRR (%)	Variation in NPV (R\$)	Variation in IRR (%)
Seeds	-1.58	-0.01	-8.85	-0.03
Fertilizers	-14.00	-0.05	-14.00	-0.05
Pesticides	-22.34	-0.08	-22.34	-0.07
Other Inputs and Services	-164.42	-0.54	-182.92	-0.68
Labour	-143.51	-0.48	-93.99	-0.31
Irrigation Equipment	-12.52	-0.04	-12.52	-0.10
Land	-2.52	-0.01	-2.52	-0.07
Greenhouse	-10.19	-0.04	-10.19	-0.11
Taxes and Charges	-34.04	-0.11	-41.79	-0.13
Productivity	-376.08	-1.28	-461.67	-1.48
Price Received	-376.08	-1.28	-461.67	-1.48

Figure 2 - Cumulative probability distribution for Net Present Value (NPV), according to the cash flow of the organic production project for the ‘Santa Clara’ and ‘Siluet’ tomato under protected cultivation



(NPV <0) in the case of ‘Santa Clara’, and 4.48% in the case of ‘Siluet’. There is therefore a risk in this activity, which highlights the importance of the care that the producer should take in planning the choice of cultivars, methods of cultivation, management and definition of the production period, among others.

CONCLUSIONS

1. It was found that under a system of protected organic cultivation, the Siluet and Santa Clara cultivars were economically viable. This system of tomato cultivation can be an alternative for obtaining income, with

satisfactory economic indicators, in small growing areas;

2. It was concluded that the Siluet cultivar was agro-economically superior in relation to the Santa Clara cultivar, as the plants were more productive, with better economic results;
3. The sensitivity analysis revealed that the productivity and price of the tomato, followed by packaging and labour costs, had the greatest influence on the profitability of the activity. From the Monte Carlo simulation, it can be concluded that the probabilities of obtaining negative Net Present Values for both cultivars were relatively low;
4. One work limitation refers to risk assessment, since in addition to the economic risk, there is the inherent risk from biotic and abiotic factors, although in this system the climate risks of pests and diseases were minimised. It is therefore necessary to emphasise the need to evaluate other cultivars, as well as verify production functions that would clarify the productive potential of the systems for different combinations of inputs. Only then will the results of the research be effective for regional development.

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