Comunicata Scientiae
Horticultural Journal

ORIGINAL ARTICLE
published: 30 June 2025
https://doi.org/10.14295/CS.v16.4315

Cost and profitability of tomato cultivation in a protected environment with different spacings

Max José Festl[1], Franciely da Silva Ponce[2], Josiane Marlise Theis de Aguirre[2]*, Paulo Henrique de Oliveira Velozo[3], Márcio Roggia Zanuzo[4], Ana Karina Rodrigues Abadio de Paula[3], Silvia Graciele Hülse de Souza[2], Santino Seabra Júnior[5]

[1]Universidade Estadual do Mato Grosso, Nova Mutum-MT, Brasil
[2]Universidade Paranaense, Umuarama – PR, Brasil
[3]Universidade Estadual Do Mato Grosso, Alta Floresta – MT, Brasil
[4]Universidade Federal de Mato Grosso, Sinop – MT, Brasil
[5]Universidade Estadual Paulista, Botucatu – SP, Brasil
*Corresponding author, e-mail: josiane.aguirre@edu.unipar.br

Abstract

The tomato (*Solanum lycopersicum* L.) is a crop of significant global economic importance due to its extensive cultivation area and its role in generating employment and income. Climatic conditions pose a major challenge to production, necessitating the use of protected environments to produce quality fruits. Therefore, this study aimed to evaluate the cost and profitability of tomato cultivation in a traditional cultivation environment covered with plastic film and in a cultivation environment covered with polycarbonate and water film, using different spacings as a decision-making criterion. The experiment was conducted in the experimental area of Embrapa Agrosilvopastoral in Sinop - MT. Different environments were used: a greenhouse covered with 150-micron agricultural film and a greenhouse covered with polycarbonate with the application of a water film for cooling and five spacings: 0.2, 0.3, 0.4, 0.5, and 0.6 m. Commercial fruit yield, total operating cost, and profitability were evaluated. For both environments, the 0.2 and 0.3 m spacings showed greater fruit yield and, consequently, gross revenue, reflected in profitability parameters such as operating profit, gross margin, profitability index, breakeven point, and price. The other spacings assessed did not show economic viability.

Keywords: costs, dense spacing, economic viability, polycarbonate greenhouse, *Solanum lycopersicum L.*

Introduction

The tomato (*Solanum lycopersicum* L.) is one of the most economically important vegetables in Brazil. Rodrigues (2023) mentions that some factors hinder production due to the tropical and subtropical climate, hence the need to invest in new biotechnologies and bioinputs that facilitate its cultivation on a large scale. Tomatoes are grown in all Brazilian states, with Goiás standing out in first place in 2024 and São Paulo in second. It still stands out as one of the most productive vegetables in the world, reaching a production of approximately 186 million tons in 2020. Brazil stands out as the tenth largest producer in the world, with 4.2 million tons, according to the Brazilian Institute of Geography and Statistics (IBGE, 2024).

Modern agriculture faces annual challenges, including biotic and abiotic stresses, extreme temperatures, droughts on one hand, and floods on the other. Consequently, it is essential to adopt cropping systems that ensure high yields, minimize losses, and maintain product competitiveness and the economic viability of the production chain. Dos Santos et al. (2022) state that modern agriculture is highly dependent on climate changes, hence the need for changes, adaptation, and mitigation in agricultural systems. One of the most prominent problems is abiotic stresses, such as drought, extreme temperatures, poor soil nutrition, and salinity, among others. One of the concerns is properly using new biotechnologies, such as issues involving discoveries in genomics.

The use of protected cultivation in tomato farming brings important advances, such as the use of agricultural film, which is becoming increasingly important, as it is a technique that allows producing fruits with better yield and quality regardless of climatic conditions (Chahidi & Mechaqrane, 2022). Advances

Received: 30 September 2024
Accepted: 01 November 2024

in protected cultivation technologies combined with methods of controlling environmental variables boost tomato production, especially in periods adverse to its cultivation (Pataraico Junior *et al*., 2023). In addition to the agricultural film, other coverings can be used in tomato cultivation, mainly to reduce the temperature inside the environment (Santiago *et al.,* 2018). Therefore, the use of polycarbonate sheets with the application of a thin layer of water has been assessed to reduce the temperature and modify the wavelength of sunlight inside the cultivation environment (Velozo, 2022).

Growing tomatoes in a protected environment helps reduce crop risks and improves fruit quality. However, few studies address the costs involved in this type of management, which is a key factor in estimating the costs and profitability of the crop, such as that conducted by Nascimento et al. (2021), highlighting the importance of this type of work. Pataraico Junior et al. (2023) studied tomato cultivation under the same conditions as the present study; however, they only explored the fruit yield and physiology of the plant, which answers some questions regarding the use of the protected environment covered with polycarbonate but does not address how much the technology will cost the producer. The profitability index is an important profitability parameter, and it is estimated that in the off-season period of tomato plants in a protected environment, it can represent 49.15% (Nascimento et al., 2021). However, this index can vary depending on the type of environment and the cost of the system.

Among the cultivation of the most diverse vegetables, tomato cultivation is considered a highly complex and risky activity due to the environmental conditions in which it is cultivated, susceptible to pests and diseases, high demand for qualified labor, in addition to inputs and services; therefore, there is a need for excessive investment of financial resources to obtain good levels of fruit yield and quality (Clemente, 2018).

Given this context, this study aimed to analyze the cost and profitability of tomato cultivation in a traditional cultivation environment covered with plastic film and in a cultivation environment covered with polycarbonate and water film using different spacings as a decision-making criterion.

Material and Methods

2.1 Location of the experimental area and characterization

The experiment was conducted in the experimental area of Embrapa Agrosilvopastoral in Sinop - MT, at 11°52'12.62" S, 55°35'54.61" N, and an altitude of 370 meters. The climate of the region is classified as Am-type - tropical monsoon climate (Köppen; Geiger, 1928), with rainfall concentrated in the summer (October to April). The average annual precipitation is 1900 mm, and the average temperature is 26°C (Alvares et al., 2013).

2.2 Spacing

In the present study, five spacings between plants were used: 0.20, 0.30, 0.40, 0.50, and 0.60 m, and 1.25 m was used between rows. Each spacing corresponds to a population of plants in the 128 m² area of the protected environment: 550, 333, 250, 200, and 167.

2.3 Description of the environments

Both cultivation environments had gable roofs, measuring 6.40 x 20 m with a ceiling height of 3.5 m and a central height of 4.8 m, with side windows covered with heat-reflective screens and Aluminet ® with 30% light blocking.

Environment 1 was covered with a 150 μm transparent polyethylene agricultural film. Environment 2 was covered with 10 mm transparent double alveolar polycarbonate sheets. Both polymers have UV-A and UV-B treatment.

In the polycarbonate-covered environment, a sheet of water was applied that circulated inside the alveolar polycarbonate sheets and returned to the water tanks located in front of the structure used as a reservoir. The system was automatically activated by a timer programmed to start the pump every 15 minutes, continuously restarting the water cycle through the sheets from dawn to dusk.

2.4 Implementation and management of tomato cultivation

The Fascínio (Feltrin®) tomato hybrid with determinate growth and saladette fruit type (intermediate size, elongated shape, and suitability for fresh consumption and processing), with a cycle ranging from 80 to 110 days, was used. The seedlings were produced in 128-cell polystyrene trays in an inverted pyramid shape filled with commercial substrate. The trays were kept in a seedling nursery covered with 150 μm agricultural film with anti-UV-A and UV-B treatment. At 30 days after sowing, the seedlings were transplanted into 5-liter pots containing a mixture of 50% commercial substrate Carolina® and 50% carbonized rice husk. The pots were installed on bricks inside sloping canvas gutters to capture and direct the excess nutrient solution outside the protected environment.

Irrigation and fertilization were performed using self-compensating drip hoses. Initially, 1 L of solution was used per pot, gradually increasing the volume to 2.7 L at the full fruiting stage. The solution used was based on the recommendation of Furlani (1998) with adaptations according to the stage of plant development. Pest and disease control was performed according to conventional recommendations for the crop.

The tutoring was conducted using the so-called "Mexican" method, in which the plants are trained vertically between horizontally arranged twines on both sides of the rows and raised as the stems grow. Harvests began 96 days after sowing and were conducted weekly for 59 days, ending on October 22, 2021.

2.5 Fruit yield evaluation

The tomato fruits were harvested at full maturity stage VI (intense red color), and the total and commercial fruit yield and percentage of losses were evaluated.

2.6 Cost analysis

The production cost was calculated using an adapted methodology based on that defined by Matsunaga et al. (1976) regarding the Total Operating Cost (TOC), as described by Martin *et al*. (1998). In which the Total Operating Cost of production is formed by the following components:

Expenses with manual operations - constitute the costs of activities conducted by the environment: sowing, soil preparation (planting substrate, transplanting, fertilization, harvesting).

Expenses with consumed material - composed of substrate, trays, seeds, fertilizer, and parasitoids - are expenses with consumable material multiplied by the purchase price.

Effective operating cost (EOC) - constitutes the sum of expenses and represents the disbursement per environment;

Other operating costs - estimated at 5% of the EOC percentage (Martin, *et al.* 1998).

Total Operating Cost (TOC) - comprises the sum of the EOC and other operating costs, representing the cost that the farmer incurs in the short term to produce and to replace other expenses by area/crop.

2.7 Profitability analysis

For the economic analysis of the activity, the following economic indicators were determined, as described by Martin *et al.* (1998).

Gross Revenue (GR): revenue obtained for the activity and the respective yield per environment according to the sales price of the growing season;

Operating Profit (OP): consists of the difference between the gross revenue (GR) and total operating cost (TOC) values per cultivation environment.

Profitability Index (PI): is the relationship between OP and GR, in percentage (PI = (OP/GR) x 100), being a measure that demonstrates the available rate (%) of revenue from the activity after payment of all operating costs;

Gross Margin (GM): indicates the margin of the relationship between GR and TOC (GM= (GR- TOC)/ TOCx100)), characterizing the availability (%) to cover the other fixed costs, the risk, and the capacity of the activity.

Breakeven Point (Production): The quantity of product required to cover total operating costs, calculated as Production = TOC/pv, where TOC represents Total Operating Costs and pv represents the price per unit;

Breakeven Point (Price): minimum marketing price of the product required to cover production costs (Price=TOC/p).

Results and Discussion

The costs of manual operations, inputs, irrigation, tutoring, and environment were used to estimate the effective and total operational costs (**Table 1**). Inputs represented an average of 39% of the TOC, representing the highest costs of the project.

Costs varied depending on the cultivation environment and the spacing adopted. The lowest operational cost was observed with a spacing of 0.6 m between plants in both environments. In this context, the agricultural film environment had a total operational cost (TOC) R$ 82.68 lower than that of the polycarbonate environment at the same spacing.

The TOC increased as the spacing between plants was reduced, obtaining the highest values at a spacing of 0.2 m between plants for both environments.

The project's TOC in both environments presented values higher than R$ 5,000.00 (**Figure 1**). The cost of labor, plant training, and irrigation were the same for both environments and all tested spacings, differing in terms of the cost of the environment and inputs. The costs of inputs were more expressive in the 0.2-meter spacing, regardless of the environment.

The production costs represented 12.18% and 13.44% in denser spacing (0.2 m) in the agricultural film and polycarbonate environments, respectively. When using smaller spacing between plants, there is a higher operational cost due to the increase in inputs for cultivation; however, there is greater use of the area. In addition, plant density usually increases yield; however, there may be negative impacts on quality, given that each crop presents different adaptations.

Table 1. Costs of mechanized operations, manual operations, inputs, irrigation and tutoring of tomato plants in a greenhouse covered with agricultural film and a greenhouse covered with polycarbonate with five spacings between plants (0.2; 0.3; 0.4; 0.5 and 0.6 meters).

ENVIRONMENTS				Agricultural film Value 128 m² (R$)					Polycarbonate Value 128 m² (R$)				
Plant population				500	333	250	200	167	500	333	250	200	167
Plant spacing/ population	Items	Items	Unit Value- R$	0.2	0.3	0.4	0.5	0.6	0.2	0.3	0.4	0.5	0.6
A- Manual operations													
Preparation of planting substrate	Hm	Hm	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Planting fertilization	Dh	Dh	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Transplant seedlings	Dh	Dh	100	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fitillage	Dh	Dh	100	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
Top dressing fertilization	Hh	Hh	15	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0	90.0
Sprays	Dh	Dh	50	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0	150.0
Harvest	Dh	Dh	100	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0	600.0
Total operations				1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0	1,440.0
B - INPUTS													
Seed	Items		0.41	227.3	151.4	113.7	90.9	75.9	227.3	151.4	113.7	90.9	75.9
Seedling trays	Items		29.00	2.1	1.5	1.3	1.1	1.0	2.1	1.5	1.3	1.1	1.0
Substrate	kg		2.25	27.2	18.1	13.6	10.9	9.1	27.2	18.1	13.6	10.9	9.1
Super simple planting	kg	1,652	12.00	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0	249.0
Urea planting	kg	67	13.98	456.3	456.3	456.3	456.3	456.3	456.3	456.3	456.3	456.3	456.3
Potassium chloride	kg	69	9.77	684.3	684.3	684.3	684.3	684.3	684.3	684.3	684.3	684.3	684.3
Ammonium Sulfate	kg	700	6.70	12.0	8.0	6.0	4.8	4.0	12.0	8.0	6.0	4.8	4.0
Potassium Nitrate	kg	1,000	9.28	42.8	28.5	21.4	17.1	14.3	42.8	28.5	21.4	17.1	14.3
Ca nitrate	kg	7	3.30	71.3	47.5	35.6	28.5	23.8	71.3	47.5	35.6	28.5	23.8
Engeo Pleno ®	mL	220	0.39	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8	85.8
Tiger 100 EC®	mL	100	0.18	17.85	17.85	17.85	17.85	17.85	17.85	17.85	17.85	17.85	17.85
Applaud 250®	g	100	0.12	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75
Evidence ®	g	300	0.42	124.50	24.50	124.50	24.50	124.50	124.50	124.50	124.50	124.50	124.50
Cuprozeb ®	g	200	0.07	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Ridomil Gold®	g	300	0.30	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4	89.4
Total inputs				2,115.1	1,987.4	1,924.0	1,885.8	1,860.5	2,115.1	1,987.4	1,924.0	1,885.8	1,860.5
C - Irrigation													
Drip hoses	m	200	0.50	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2	29.2
PVC pipes	m	20	26.00	78.9	78.9	78.9	78.9	78.9	78.9	78.9	78.9	78.9	78.9
Irrigation accessories	Items	10	0.25	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Water tank	Items	1	1,500.00	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Pump	Items	1	500.00	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Registration	Items	2	2.00	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Total Irrigation				246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1	246.1
D- Tutoring													
Wooden beams	kg	24	11.36	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8	39.8
Wire	m	200	6.00	131.5	131.5	131.5	131.5	131.5	131.5	131.5	131.5	131.5	131.5
String	kg	5	13:00	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Support piles	Items	250	11:00	401.8	401.8	401.8	401.8	401.8	401.8	401.8	401.8	401.8	401.8
Turnstile	Items	12	3.00	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Total tutoring				643.4	643.4	643.4	643.4	643.4	643.4	643.4	643.4	643.4	643.4
Structure cost													
Agricultural film greenhouse	Items	1	22,000.00	651.85	651.85	651.85	651.85	651.85	730.59	730.59	730.59	730.59	730.59
Polycarbonate greenhouse	Items	1	25,000.00										
COE R$				**5,096.5**	**4,968.9**	**4,905.4**	**4,867.2**	**4,841.9**	**5,175.3**	**5,047.6**	**4,984.1**	**4,945.9**	**4,920.7**
COT R$				**5,351.4**	**5,217.3**	**5,150.7**	**5,110.5**	**5,084.0**	**5,434.0**	**5,299.9**	**5,233.4**	**5,193.2**	5,166.7

The 0.2 m spacing provided a 35% increase in marketable fruits in tomatoes for fresh consumption (Amare & Gebremedhin, 2020), which reflects the profitability of the crop. However, the ideal spacing may vary according to the plant training system, cultivar, and cultivation environment (Zhang et al., 2022; Nascimento et al., 2022; Amare & Gebremedhin, 2020).

The economic analysis indicators demonstrated that the 0.2 and 0.3 m spacings provided positive results regarding operating profit, profitability index, and gross margin for both environments. These arrangements presented economic viability for implementation (**Table 2**).

Total fruit yield ranged according to both the environment and the spacing, and it was observed that the greater the spacing between plants, the lower the fruit yield per environment. This was reflected in the gross revenue, with lower fruit yield and gross revenue observed in the cultivation in the greenhouse with polycarbonate

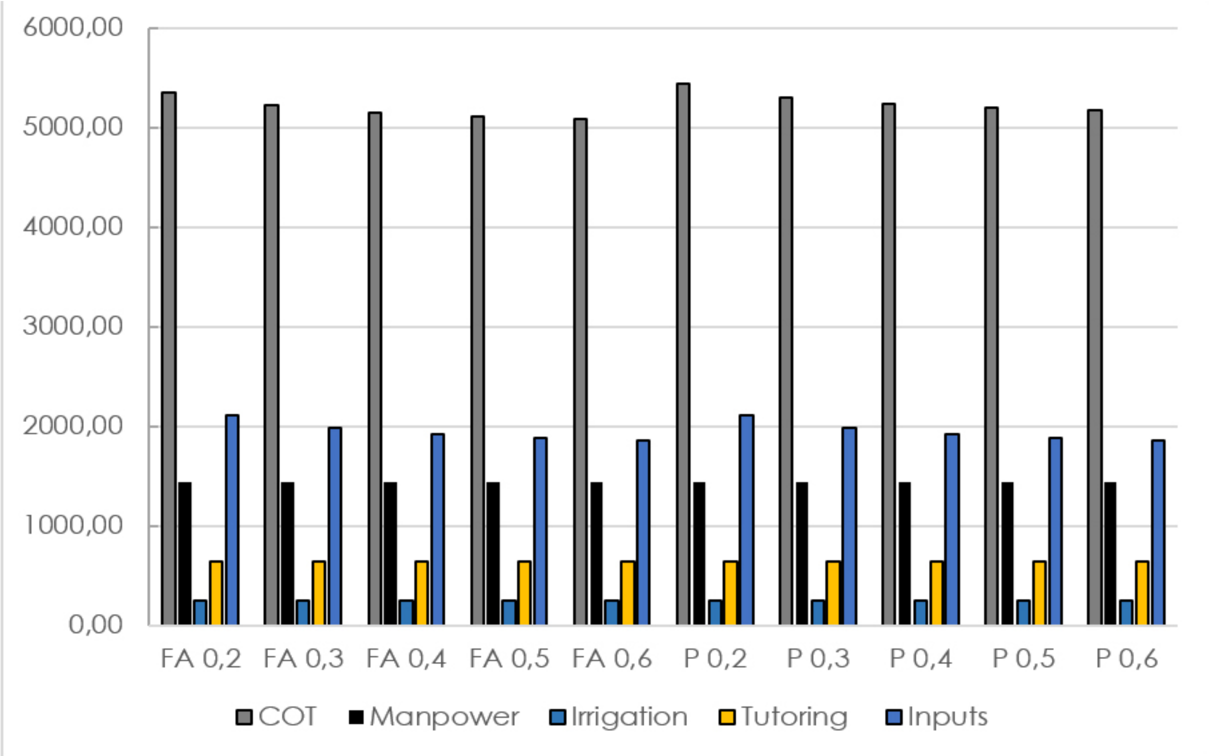

Figure 1. Total operating cost (COT), labor, irrigation, tutoring and inputs of tomato plants in a greenhouse covered with agricultural film and a greenhouse covered with polycarbonate with five spacings between plants (0.2; 0.3; 0.4; 0.5 and 0.6 meters).

Table 2. Total operating cost (COT), Productivity (Prod. 128 m^2), Gross revenue (RB), Operating profit (LO), Profitability index, Gross margin (MB), Break-even point (PN) and Break-even price (PN R$) of tomato plants in a greenhouse covered with agricultural film and a greenhouse covered with polycarbonate with five spacings between plants (0.2; 0.3; 0.4; 0.5 and 0.6 meters).

Indicators	Agricultural film					Polycarbonate				
	Esp. 0.2	Esp. 0.3	Esp. 0.4	Esp. 0.5	Esp. 0.6	Esp. 0.2	Esp. 0.3	Esp. 0.4	Esp. 0.5	Esp. 0.6
COT (R$)	5,351.4	5,217.3	5,150.7	5,110.5	5,084.0	5,434.0	5,299.9	5,233.7	5,193.2	5,166.7
Prod. 128 $^{m}2$	1,989.63	1,450.11	1,280.38	936.83	850.05	1,713.66	1,493.38	1,074.43	1,094.02	835.07
RB (R$)	7,958.53	5,800.45	5,121.54	3,747.33	3,400.19	6,854.66	5,973.50	4,297.73	4,376.06	3,340.29
LO (R$)	2,607.16	583.14	-29.14	-1,363.21	-1,683.86	1,420.61	673.52	-935.63	-817.16	-1,826.44
IL (%)	32.76	10.05	-0.57	-36.38	-49.52	20.72	11.28	-21.77	-18.67	-54.68
MB (%)	48.72	11.18	-0.57	-26.67	-33.12	26.14	12.71	-17.88	-15.74	-35.35
BW (kg)	1,783.79	1,739.10	1,716.89	1,703.51	1,694.68	1,811.35	1,766.66	1,744.45	1,731.07	1,722.24
PN (R$)	2.69	3.60	4.02	5.46	5.98	3.17	3.55	4.87	4.75	6.19

compared to the greenhouse with agricultural film, except for the spacings of 0.3 m and 0.6 m (Table 2).

Operating profit reflects the value available to the producer after paying all cultivation costs. Only the 0.2 and 0.3 m treatments in both environments provided positive OP.

The profitability index represents the available rate (%) of revenue from the activity after all operating costs have been paid and is an important indicator of the viability of the activity. At the same time, the gross margin is the availability (%) to cover the other fixed costs; the lower the gross margin, the greater the activity risk.

The profitability values were low, while there was a high cost for implementing and conducting the proposed treatments and low fruit yield, reflecting on the profitability parameters (Table 2).

The breakeven point represents how much product in kilograms will be needed to cover the cost of cultivation. It was observed that in both environments, the breakeven point for spacings of 0.4, 0.5, and 0.6 m was much higher than that produced; thus, the revenue generated by selling tomatoes at R$ 4.00 per kilo was insufficient to cover the costs.

The main disadvantage of production in protected environments is the increase in production costs (Mauria, Rajagopalan & Stöckle, 2022). The use of protected environments is a requirement for tomato cultivation during rainy seasons. In Brazil, there is no need to use artificial heating in these environments, and the search focuses on materials that attenuate excess temperature and light within the cultivation environments. Mauria, Rajagopalan & Stöckle (2022) obtained 6.4 times higher tomato fruit yield when using protected cultivation; however, they reported a high cost for heating these environments. The low insertion of technology is one of the main causes of losses in the field due to pests and diseases. Open-field tomato cultivation during periods of high rainfall is unfeasible, highlighting the necessity of protected cultivation in the studied region.

The breakeven price represents the market value per kilogram of tomatoes required to cover the total operating cost. The lowest marketing price was obtained for tomatoes grown in a plastic film environment with a spacing of 0.2 m, making it possible to sell them at R$ 2.69.

The highest breakeven price was observed in tomato cultivation within a polycarbonate-covered environment at a spacing of 0.6 m, requiring a selling price of R$ 6.19 per kilogram to cover the costs. The breakeven price helps the producer estimate the price for the product, so there is a profit in the activity.

The use of a protected environment for growing table tomatoes, especially during rainy periods, is the most viable alternative for the crop. Nascimento et al. (2021) obtained a cost of R$ 10.05/m² for producing table tomatoes in a greenhouse. In the present study, this value reaches R$ 42.45, reflecting the low profitability of the proposed treatments.

The observed operating profit obtained in the present study, using a spacing of 0.2 m and a greenhouse covered with agricultural film, was 45.25% higher than the OP obtained by Nascimento et al. (2022). However, when the same spacing is observed under a polycarbonate greenhouse, the OP is 0.47% lower than described by these authors, reflecting the impact of environmental costs and fruit yield on crop profitability.

Evaluating profitability parameters is crucial, particularly in light of new technologies designed to enhance crop yield. A study assessing the cost and profitability of cabbage cultivated under low tunnels found that using organza-covered tunnels resulted in a 26% increase in yield compared to open-field cultivation. However, the material costs and limited durability equated the profitability of this method to that of tunnels covered with agrotextiles and shade screens (Ponce et al., 2022).

The use of innovative cultivation systems using a protected environment has been studied to improve efficiency and maximize plant production. Due to the increase in production costs, it is essential to conduct a cost analysis since the investment needs to pay for itself and generate profit. Mauria, Rajagopalan, and Stöckle (2022) report the high energy cost of maintaining the system in their studies on tomato cultivation in a climate-controlled greenhouse. In the protected environment proposed in our studies, the highest cost is related to acquiring materials and implementing the environment, with no high maintenance cost.

The use of polycarbonate covering is still a pilot project that will require some adjustments. However, it is an interesting initiative, especially regarding the temperature reduction within the cultivation environment. The treatments proposed in this study may present advantages, especially for cultivating crops with high added value, such as *grapes, tomatoes*, and strawberries, among others, representing an alternative for future studies.

Conclusion

The cost and profitability were affected by the cultivation environment and adopted spacings. Using spacings of 0.2 m and 0.3 m was economically viable for both environments. Spacings of 0.4 m, 0.5 m, and 0.6 m, in both agricultural film and polycarbonate environments, presented high TOC and, due to lower fruit yield, presented lower gross revenue, resulting in negative values of gross revenue, total operating profit, profitability index, and gross margin, indicating the unfeasibility of the activity.

While spacings of 0.2 and 0.3 m resulted in higher fruit yield and, consequently, greater revenue, they also provided positive profitability indicators, ensuring the viability of the activity with a lower breakeven point and market price.

References

Alvarenga, M. A. R. 2013. Origem, Botânica e descrição da planta. In: alvarenga, M.A.R. (Ed.). Tomate: produção em campo, casa de vegetação e hidroponia. *Editora Lavras, Lavras,* Brasil. p. 11-21.

Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.D.M., Sparovek, G. 2013. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift 22: 711-728.

Amare, G., Gebremedhin, H. 2020. Effect of plant spacing on yield and yield components of tomato (*Solanum lycopersicum* L.). *Scientifica*, in Shewarobit, Central Ethiopia 2020: e8357237

Chahidi, L.O., Mechaqrane, A. 2022. *Greenhouse Design Selection in Moroccan Climatic Conditions.* In: WITS 2020, Springer, Singapore. p. 639-648.

Clemente, F. M. V. T. 2018. Árvore do Conhecimento do Tomate: socioeconomia. *Embrapa*, Brasília, Brasil. Disponível em: <http://www.agencia.cnptia.embrapa.br/gestor/tomate/arvore/CONT000fa2qor2t02wx5eo01xezlsjcqvf7u.html>. Acesso em: 11 abr. 2018.

Furlani, P.R. 1998. Instruções para o cultivo de hortaliças de folhas pela técnica de Hidroponia NFT. Instituto Agronômico, Campinas, Brasil. 30p. (*Boletim técnico, 168)*.

Instituto Brasileiro De Geografia E Estatística (IBGE). Agência IBGE Notícias. 2024. *Em setembro, IBGE prevê safra de 295,1 milhões de toneladas para 2024*. Rio de Janeiro: IBGE. Disponível em: https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/41594-em-setembro-ibge-preve-safra-de-295-1-milhoes-de-toneladas-para-2024. Acesso em 17 out. 2024.

Köppen, W., Geiger, R. 1928. Klimate der erde. gotha: Verlag justus perthes. Wall-map 150cmx200cm, p. 91-102.

Martin, N. B., Serra, R., Oliveira, M. D. M., Ângelo, J. A., Okawa, H. 1998. Sistema" Custagri": Sistema Integrado de Custo Agropecuário-versão 1, 0. *IEA/ASS/FUNDEPAG/* Campinas: São Paulo, Brasil. EMBRAPA-CNPT1A. Disponível em: http://www.iea.sp.gov.br/ftpiea/ie/1998/tec1-0198.pdf. Acesso em 29 Out. 2024.

Matsunaga, M. 1976. Metodologia de custo de produção utilizada pelo IEA. *Agricultura em São Paulo* 23: 123-39.

Mauria, F., Rajagopalan, K., Stöckle, C.O. 2022. Evaluating tomato production in open-field and high-tech greenhouse systems. Journal of Cleaner Production 337:130459.

Nascimento, A.S., Silva, R. M., Dipple, F.L., Casagrande, J.G., Trento, D.A., Ponce, F.S., Grzebieluckas, C., Seabra Júnior, S. 2021. Viabilidade agroeconômica do cultivo de híbridos tomateiro de hábito determinado no período de safra e entressafra na região central Matogrossense. *Revista Ibero-Americana de Ciências Ambientais* 12: 74-83.

Pataraico Junior, V., Fernandes Junior, F., Zanuzo, M.R., Silva Campos, R.A., da Silva Ponce, F., Botelho, S.D.C.C., Silva, V., Antunes, D.T., Nascimento, M.S.P., Seabra Junior, S. 2023. Yield performance and nutritional quality of tomato hybrids in response to protected environments during the Amazonian summer. Advances in Horticultural Science 37: 391-402.

Ponce, F. S., Lima Toledo, C.A., Casagrande, J.G., Grzebieluckas, C., Zanuzo, M. R., Seabra Júnior, S. 2022. Produtividade, custo e rentabilidade de couve produzida sob túnel baixo. *Comunicata Scientiae*, 13, e3876-e3876.

Rodrigues, A.R.S.P. 2023. Viabilidade do uso de diferentes técnicas agrícolas para a cultura de tomate (Solanum lycopersicum L.). *Revista Ambientale* 15: 17–29.

Santiago, E.J.P., de Oliveira, G.M., Ramos, M.D.M.V.B., de Carvalho Rocha, R., Silva, R.R. 2018. Condições microclimáticas proporcionadas por tela de sombreamento no cultivo do tomate cereja. *Agrometeoros* 25: 153-161

Santos, T. B., Ribas, A. F., de Souza, S.G.H., Budzinski I.G.F., Domingues D.S. 2022. Physiological Responses to Drought, Salinity, and Heat Stress in Plants: A Review. Stresses 2:113-135.

Velozo, P.H.O. 2022. *Modificações ambientais e sua influência na produção, qualidade e ecofisiologia de tomateiros na Amazônia Mato-Grossense*. Dissertação (Mestrado em Biodiversidade e Agroecossistemas Amazônicos) - Universidade do Estado de Mato Grosso.

Zhang, M. Z., Niu, W. Q., Lu, Z. G., Bai, Q. J., Li, Y., Wang, D. L., Wang, Z. Q. Zhang, Z. X. 2022. Yield and quality response of greenhouse tomato to different micropores

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.