Comunicata Scientiae
Horticultural Journal

ORIGINAL ARTICLE
published: 31 October 2022
https://doi.org/10.14295/CS.v13.3884

Production cost of creeping fresh market tomatoes in different soil covers

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Abstract

The aim of this study was to determine the production cost and analyze the economic factors of two creeping fresh market tomato cultivars (Thaíse and Fascínio) grown using different soil covers. The tomato cultivars were evaluated for *in natura* consumption using a predetermined cycle. The treatments (soil cover types) used in this study were: I) uncovered soil, II) plastic mulching, III) sorghum, IV) Sudan grass, and V) pearl millet. For profitability calculations, the costs and revenues of the study area were accounted for and converted to values per hectare. The effective operating cost, total operating cost, gross revenue, operating profit, profitability index, gross margin, price, and productivity leveling point were considered. The costs of manual operations, tomato seed, fertilization, plastic canvas (double-sided black and white canvas), and irrigation were the highest expenses observed in the production of creeping fresh market tomatoes in relation to the total operating cost. For the Thaíse and Fascínio tomato cultivars, the highest operating profit was Brazilian R$ 143,194.03 and R$ 134,604.53 per hectare, respectively, which was obtained with the soil cover with plastic mulching. The cultivation of creeping fresh-market tomatoes has high economic profitability, especially when using plastic mulching as the soil cover. The two tomato cultivars (Thaíse and Fascínio), when grown on plastic mulching, showed the highest gross margin.

Keywords: commercialization, economic analysis, profitability, *Solanum lycopersicum* L.

Introduction

Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family and is the most consumed and cultivated fruit vegetable globally. It has great economic importance worldwide, as well as a growing demand, particularly when fresh (Gerszberg et al., 2015; Machado Neto et al., 2018).

Cultivars with a determined growth habit are under development for fresh market cultivation with the aim of reducing labor and intensifying large-scale production. Soil cover brings several benefits to the production process by improving fruit and soil quality (Almeida et al., 2018).

Tomato cultivation has a high financial cost, manifests a series of pests and diseases that cause damage to plants and fruits, and presents a high sensitivity to factors such as climatic anomalies because of its considerable nutritional requirements (Negrisoli et al., 2015). These factors incur sizable expenses for fertilization operations, cultural treatments, pesticides, and labor, while high productivity is often difficult to achieve (Almeida et al., 2015).

The production cost of a culture comprises all expenses related to the production process, including those involved in farm inputs, services, and operations. The minimum cost per unit produced is then determined from these expenses (Maciel et al., 2016). Tomato crops can be highly viable, both economically and socially, and with appropriate solutions to productivity and production cost management challenges, the sustainability of the cultivation system can be guaranteed (Van Loon et al., 2018).

By accurately surveying production costs, the commercial profitability can be determined based on the gross revenue earned less the production costs, including the expenses arising from manual operations

Received: 19 December 2021
Accepted: 24 January 2022

and irrigation, which are essential inputs in tomato farming (Van Loon et al., 2018; Krohling et al., 2018).

For effective tomato cultivation, understanding the production costs, revenue generated by the culture, and break-even point are important to verify economic viability for those considering entering the commercial tomato farming industry (Negrisoli et al., 2015), or for the rural producer to make informed decisions for positive economic results (Iotti & Bonazzi, 2018).

As the control of costs is necessary in tomato cultivation, the aim of this study was to calculate the production costs and prepare an economic analysis on the production of two cultivars of creeping fresh market tomatoes cultivated in different soil covers.

Material and Methods

The experiment was conducted in the plant production field of the experimental area of the State University of Mato Grosso (UNEMAT), Tangará da Serra, Mato Grosso, Brazil (14°39’00’’S, 57°25’54’’ W, 440.01 m above sea level).

According to the Köppen climate classification system, the climate of the region is megathermic or tropical with dry winters and rainy summers (Aw) (Souza et al., 2013). The average annual air temperature, precipitation, and relative humidity are 24.4 °C, 1,830 mm and 70–80%, respectively (Dallacort et al., 2011). The soil in the experimental area is classified as dystroferric Red Latosol with a clayey texture (Santos et al., 2018).

The experiment was conducted in a creeping fresh market tomato production system under different soil covers. The production costs and profitability of the tomato crop were estimated from prices from October and November 2019.

The chemical and physical analyses of the soil collected prior to the implementation of the experiments are shown in Table 1. Planting fertilization was incorporated into the furrow, using urea (300 kg ha^{-1} of N), potassium chloride (600 kg ha^{-1} of K_2O), and simple superphosphate (1,200 kg ha^{-1} of P_2O_5), with 10% of urea, 100% of simple superphosphate, and 10% of the dose of potassium chloride used at planting. The remaining fertilizer was applied via fertigation (drip system every five days), along with ammonium sulfate, potassium nitrate, boric acid, and zinc sulfate (Ribeiro et al., 1999).

Table 1. Chemical and physical characteristics of the Red Latosol in the layer from 0 to 0.20 m prior to the experiment . Tangará da Serra, MT, 2019.

Sample	Chemical characteristic											
	pH		P	K	S	Ca	Mg	Al	H	SB	OM	V
	H_2O	$CaCl_2$	------ mg dm^{-3} ------			----------- $cmol_c$ dm^{-3} -----------					g dm^{-3}	%
1	5.8	4.8	1.0	93.7	18.5	1.5	0.9	0.0	6.0	2.6	38.79	30

Sample	Micronutrient					Physical characteristic		
	Zn	Cu	Fe	Mn	B	Sand	Silt	Clay
	------------------- mg dm^{-3} -------------------					-------------------- g kg^{-1} --------------------		
1	3.1	4.1	17.1	47.1	0.3	287	149	564

The soil was prepared 30 days before the implementation of the experiment, by mowing liming the soil and raising the base saturation to 70%, followed by incorporating with a leveling harrow, and lifting the beds using a mechanized embankment .

The plots consisted of four beds (5.0 × 1.2 m) divided between the Thaíse (salad type) and Fascínio (Italian type) cultivars, both of which have a determined growth habit (creeping), for *in natura* consumption. The distribution of plots within each block was randomized with a factorial arrangement consisting of five soil covers and two tomato cultivars with four replications, totaling 40 experimental units. The treatments were as follows: I) uncovered soil (conventional planting); II) plastic mulching (double-sided canvas, black and white, 25 μm); III) sorghum straw (cv. JB 1330); IV) Sudan grass straw (cv. ANsf 306); and V) pearl millet straw (cv. ANm 17).

Cover crops were sown with a spacing of 0.3 m between rows, using 20.0 kg ha^{-1} of pearl millet seeds, 15.0 kg ha^{-1} of sorghum seeds, and 25.0 kg ha^{-1} of Sudan grass seeds on the beds where the tomato cultivars would subsequently be planted. The cover crops were sown on May 20, 2019, and on Jul 19, 2019 at the beginning of flowering (60 days after sowing), they were mowed, leaving only the straw on the surface of the beds.

Twenty-two days after sowing in the trays, the tomato seedlings were transplanted to the definitive beds at a spacing of 0.5 m between plants and 1.2 m between rows, with an interval of 0.3 m between beds, totaling 13,333.33 plants ha^{-1}. Irrigation was performed daily by a drip system, with drippers spaced at 0.3 m and a working pressure of 10 mca.

When the tomato fruits reached a ripe red color, they were harvested, counted, and weighed on a semi-analytical balance to determine the yield (t ha^{-1}) of the marketable fruits (total fruits less damaged fruits), and the weight of the discarded fruits (non-commercial fruits, with damage and defects) was also determined (MAPA, 2002; PBMH, 2003).

The technical production coefficients of the production cost consist of the amount of farm inputs and materials consumed per hectare for the crop used, which can be presented in kilograms, tons, or liters (fertilizers, correctives, seedlings, and pesticides), labor (man-day = md), and machine hours (mh) (Ponciano et al., 2006). For the calculation of production costs, a working day was considered eight hours (1 md (man-day) = 8 hours of work).

A financial analysis was developed, initially noting and spreadsheeting all technical coefficients and activity costs for the tomato production level obtained in this study to obtain information on the production system of the culture studied.

The production cost calculation methodology used was that defined by Matsunaga et al. (1976) and described by Martin et al. (1998), which considers the total operating cost (TOC) and has been used in several previous studies (Rambo et al., 2015; Guimarães et al., 2017; Daniel et al., 2019; Robusti et al., 2020).

The structure of the total production operating cost is determined using the following components:

a) Expenses for mechanized operations: These are the costs of agricultural operations used in the production system, represented in reals with hour/machine (mh) based on the hectare/hour ratio for clearing, plowing, and harrowing the area to prepare the soil for tomato cultivation. To calculate the production costs, a machine hour value of R$ 160.00 was used, which is the average price used for services in mechanized operations in the region;

b) Expenses for manual operations: A survey of the labor needs was conducted for the different stages of the tomato production cycle, to determine the number of man-days (md) required for each operation, and multiplying the technical labor coefficient by the average daily rate in the region (R$ 80.00 per day for 8 hours of work). The value of a man-day for manual spraying services was R$ 140.00 per day for this region at the time of the experiment;

c) Expenses for consumables: Expenditures on consumables were obtained according to the products and the amount of materials used in the study and their respective prices paid in the local market;

d) Effective operating cost (EOC): the sum of items a, b, and c, representing the expenses to produce one hectare of low-growing tomatoes. This cost can be based on the production of the activity (t ha^{-1}) and the unit selling price of the product (R$ t^{-1});

e) Other operating costs: Martin et al. (1998) proposed that additional costs for the agricultural enterprise can be estimated at 5% of the EOC. Other studies have also cited other operating costs of 5% of the EOC (Guimarães et al., 2017; Vendruscolo et al., 2017; Daniel et al., 2019); and

f) Total operating cost (TOC): sum of items d and e. Represents the effective operating cost (EOC) plus other operating costs (5% of the EOC).

Similar to Guimarães et al. (2017) and Daniel et al. (2019), the opportunity costs related to the fixed capital of land, facilities, and machines were not considered, which, if added to the TOC, would correspond to the total cost of production (TCP).

Subsequently, an economic analysis of the activity was conducted to determine the economic indicators of rural activity proposed by Martin et al. (1998) and used in other studies (Guimarães et al., 2017; Vendruscolo et al., 2017; Daniel et al., 2019), which consist of the following parameters:

I) Gross revenue (GR): revenue from the activity and the respective yield per hectare at the average selling price. Gross revenue, GR = y × sp, where y = yield of the activity (t ha^{-1}), and sp = unit sales price of the product (R$ t^{-1});

II) Operating profit (OP): the difference between the gross revenue (GR) and the total operating cost (TOC) per hectare (OP = GR-TOC);

III) Profitability index (PI): the relationship between operating profit (OP) and gross revenue (GR) in percentage (PI = (OP/GR) × 100). This index shows the available rate (%) of revenue from the activity after all operational costs have been deducted;

IV) Gross margin (GM): the amount remaining to cover other fixed costs, risk, and the entrepreneurial capacity of the rural producer. It is calculated as the ratio of gross income to total operating cost (GM = (GR-TOC) / TOC × 100);

V) Leveling point (Production): the production cost data of the tomato relative to the selling price (sp) of the product, and the quantity of product required to pay the total operating costs (Leveling point (Production) = TOC/sp); and

VI) Leveling point (Price): the total operating costs of the tomato relative to the yield (y) of the production system, or the marketing price of the tomato required to cover the production costs (Leveling point (Price) = TOC/y).

Results and Discussion

The cultivation period was 109 days after transplanting the seedlings (DAT), the temperature and the median relative humidity during this period were 26.36 °C and 65.10%, respectively, and the total applied water (irrigation + precipitation) was 778.7 mm.

The cultivation of creeping market tomatoes for fresh consumption should be performed in the seasons with low rainfall, when phytosanitary management is required due to the high occurrence of pests and incidence of diseases. The temperature limits for tomato development are between 12 and 32 °C (Schmidt et al., 2017), and water demand is approximately 450.0 mm (Silva et al., 2018). During the duration of the experiment, there were no periods of thermal or water stress, considering the meteorological conditions and the ideal ecophysiology for the tomato plant.

The Thaíse and Fascínio tomato cultivars showed high yields in all treatments, similar to the national average of 63.60 t ha^{-1} (IBGE, 2018). Thaíse showed a higher yield for the treatment with mulching plastic, totaling 75.93 t ha^{-1}, which was 10.94% higher than that of the uncovered soil (67.62 t ha^{-1}) treatment. For the Fascínio cultivar, mulching plastic also provided a higher yield (72.96 t ha^{-1}), with a 20.38% higher yield than that of the uncovered soil treatment (58.09 t ha^{-1}) (Figure 1).

The treatments with mulching plastic and uncovered soil had bigger losses in terms of discarded fruits for the two cultivars in relation to the other treatments. The mulching plastic presented 34.78 t ha^{-1} for the Thaíse cultivar and 37.40 t ha^{-1} for the Fascínio cultivar, representing losses of 33.70 and 29.39%, respectively, which were greater than those for the sorghum coverage treatment (Figure 2).

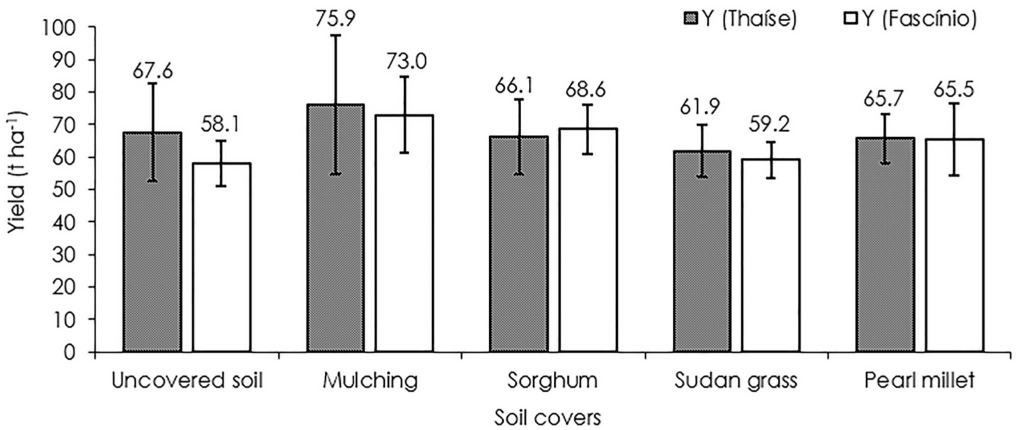

Figure 1. Yield (Y) in t ha^{-1} and standard deviation for two creeping fresh market tomatoes cultivars (Thaíse and Fascínio), grown in different soil covers.

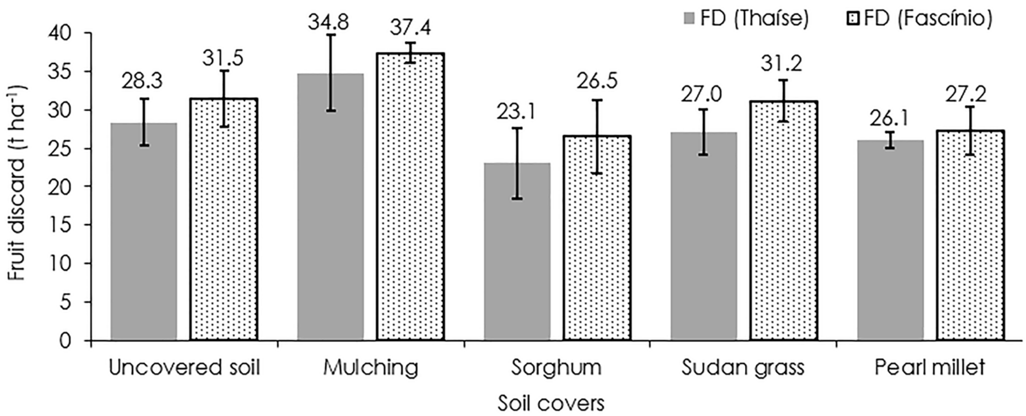

Figure 2. Fruit discard (FD) in t ha^{-1} and standard deviation for two creeping fresh market tomatoes cultivars (Thaíse and Fascínio), grown in different soil covers.

Despite the mulching treatment showing a high yield, damage to the environment can occur in the long term from the disposal of waste, evidencing the importance of using plant covers for environmental preservation and soil conservation. Soil treatment without cover would cause soil degradation and wear over time, which negatively affects soil properties causing a decrease in yield (Almeida et al., 2018).

The type of soil cover directly influences the productivity of tomato plants, and several covering techniques can be used that can be adapted to intensify the productivity of tomato plants. These covers can also reduce production costs, increase quality, and add value to the *in natura* product, thus maintaining the viability of the business (Li et al., 2014).

Based on the technical coefficients presented in the methodology, the costs of operations and farm inputs for the cultivation of creeping fresh market tomatoes are shown in Table 2.

Table 2. Estimated total operating cost (TOC) per hectare of creeping fresh market tomato cultivated in different soil covers.

Operation	Specification	Unit value (R$)	Uncovered soil		Plastic mulching		Sorghum		Sudan grass		Pearl millet	
			Quantity	Value (R$)	Quantity	Value (R$)	Quantity	Value (R$)	Quantity	Value (R$)	Quantity	Value (R$)
A - Mechanized operations												
A.1. Soil preparation												
Harrowing	mh*	160	5.3	1,696	5.3	1,696	5.3	1,696	5.3	1,696	5.3	1,696
Rotary hoeing	mh	160	10	1,600	10	1,600	10	1,600	10	1,600	10	1,600
Subtotal A				3,296		3,296		3,296		3,296		3,296
B - Manual operations												
B.1. Seedling production												
Sanitizating trays	md**	80	0.5	40	0.5	40	0.5	40	0.5	40	0.5	40
Preparing substrate + fertilizer	md	80	0.5	40	0.5	40	0.5	40	0.5	40	0.5	40
Filling trays with substrate	md	80	1.5	120	1.5	120	1.5	120	1.5	120	1.5	120
Seeding the trays	md	80	1.5	120	1.5	120	1.5	120	1.5	120	1.5	120
B.2. Implantation, management, and conduction of crop												
Manual liming	md	80	2	160	2	160	2	160	2	160	2	160
Grass sowing	md	80	-	-	-	-	4	320	4	320	4	320
Grass mowing	md	80	-	-	-	-	3	240	3	240	3	240
Desiccating	md	140	2	280	2	280	2	280	2	280	2	280
Furrow opening - planting	md	80	5	400	5	400	5	400	5	400	5	400
Furrow fertilizing - tomato	md	80	5	400	5	400	5	400	5	400	5	400
Installing irrigation/dripping	md	80	10	800	10	800	10	800	10	800	10	800
Installing plastic canvas	md	80	-	-	8	640	-	-	-	-	-	-
Transplanting tomato seedlings	md	80	12	960	12	960	12	960	12	960	12	960
Irrigating/fertigating	md	80	15	1,200	15	1,200	15	1,200	15	1,200	15	1,200
Spraying	md	140	25	3,500	25	3,500	25	3,500	25	3,500	25	3,500
Weeding	md	80	15	1,200	-	-	15	1,200	15	1,200	15	1,200
Harvesting	md	80	48	3,840	48	3,840	48	3,840	48	3,840	48	3,840
Classifying tomatoes	md	80	24	1,920	24	1,920	24	1,920	24	1,920	24	1,920
Subtotal B				14,980		14,420		15,540		15,540		15,540
C - Expenses for consumables – Farm inputs												
C.1. Crop management												
Seed - Sorghum	R$ kg^{-1}	14.00	-	-	-	-	15	210	-	-	-	-
Seed - Sudan grass	R$ kg^{-1}	4.50	-	-	-	-	-	-	25	113	-	-
Seed - Pearl millet	R$ kg^{-1}	3.20	-	-	-	-	-	-	-	-	20	64
Seed - Tomato	R$ $Unit^{-1}$	0.5	13,746	6,873	13,746	6,873	13,746	6,873	13,746	6,873	13,746	6,873
Trays for seedlings	R$ $Unit^{-1}$	18.00	108	1,944	108	1,944	108	1,944	108	1,944	108	1,944
Substrate	R$ kg^{-1}	1.00	360	360	360	360	360	360	360	360	360	360
Organic fertilizer	R$ kg^{-1}	5.00	12	60	12	60	12	60	12	60	12	60
Limestone	R$ t^{-1}	54.00	6.4	346	6.4	346	6.4	346	6.4	346	6.4	346

Table 2. Continuation ...

Operation	Specification	Unit value (R$)	Uncovered soil		Plastic mulching		Sorghum		Sudan grass		Pearl millet	
			Quantity	Value (R$)	Quantity	Value (R$)	Quantity	Value (R$)	Quant.	Value (R$)	Quantity	Value (R$)
SSP – planting (100%)	R$ kg^{-1}	1.70	6,667	11,333	6,667	11,333	6,667	11,333	6,667	11,333	6,667	11,333
Urea - planting (10%)	R$ kg^{-1}	2.20	66.67	146.67	66.67	146.67	66.67	146.67	66.67	146.67	66.67	146.67
KCL – planting (10%)	R$ kg^{-1}	3.30	100	330	100	330	100	330	100	330	100	330
KCL – fertigation (90%)	R$ kg^{-1}	3.52	900	3,168	900	3,168	900	3.168	900	3,168	900	3,168
Calcium nitrate (90%) - fertigation	R$ kg^{-1}	3.60	1,742	6,271	1,742	6,271	1,742	6,271	1,742	6,271	1,742	6,271
Boric acid - fertigation	R$ kg^{-1}	12.50	1.94	24.19	1.94	24.19	1.94	24.19	1.94	24.19	1.94	24.19
Zinc sulfate - fertigation	R$ kg^{-1}	9	1.69	15.24	1.69	15.24	1.69	15.24	1.69	15.24	1.69	15.24
Foliar fertilizer	R$ L^{-1}	20	8.1	161	8.1	161	8.1	161	8.1	161	8.1	161
Ant bait	R$ kg^{-1}	14	16.13	226	16.13	226	16.13	226	16.13	226	16.13	226
Mancozeb - Fungicide	R$ kg^{-1}	50	25.60	1,280	25.60	1,280	25.60	1,280	25.60	1,280	25.60	1,280
Thiophanate-Methyl	R$ kg^{-1}	85	2.80	238	2.80	238	2.80	238	2.80	238	2.80	238
Azoxystrobin + Teboconazole	R$ L^{-1}	110	3.00	329	3.00	329	3.00	329	3.00	329	3.00	329
Deltamethrin - Insecticide	R$ L^{-1}	110	2.80	308	2.80	308	2.80	308	2.80	308	2.80	308
Pyriproxyfen - Insecticide	R$ L^{-1}	130	6.00	780	6.00	780	6.00	780	6.00	780	6.00	780
Chlorfernapyr - Insecticide	R$ L^{-1}	75	2.00	150	2.00	150	2.00	150	2.00	150	2.00	150
Plastic canvas - Mulching	R$ m^{-1}	0.82	-	-	6,667	5,467	-	-	-	-	-	-
C.2. Irrigation												
C.2.1. Tomato irrigation and fertigation												
Piping (PCV) - 6 m × 50 mm	R$ Unit^{-1}	56	22	1,232	22	1,232	22	1,232	22	1,232	22	1,232
Irrigation pump (7.5 hp)	R$ Unit^{-1}	3,924	1	3,924	1	3,924	1	3,924	1	3,924	1	3,924
Electricity	R$ kw^{-1}	0.17	3,000	510	3,000	510	3,000	510	3,000	510	3,000	510
Drip hoses	R$ m^{-1}	0.34	7,000	2,380	7,000	2,380	7,000	2,380	7,000	2,380	7,000	2,380
Irrigation accessories	R$ Unit^{-1}	27	35	950	35	950	35	950	35	950	35	950
Reservoir - fertigation (1,000 L)	R$ Unit^{-1}	350.00	1	350	1	350	1	350	1	350	1	350
Water reservoir (15,000 L)	R$ Unit^{-1}	5,752	1	5,752	1	5,752	1	5,752	1	5,752	1	5,752
Subtotal C				49,442		54,909		49,652		49,554		49,506
D - Effective Operating Cost (EOC) (R$ ha^{-1} year^{-1}) Subtotal A + Subtotal B + Subtotal C				67,718		72,625		68,488		68,390		68,342
E - Other Operating Costs (R$ ha^{-1} year^{-1}) Other Expenses (5% of EOC)				3,386		3,631		3,424		3,420		3,417
F - Total Operating Cost (TOC) (R$ ha^{-1} year^{-1}) EOC + Other Operating Costs (D + E)				71,104		76,256		71,912		71,810		71,759

Note: The predicted amounts of fertilizers cited are the results of this study, and are intended only to provide elements for estimating production costs. The amounts to be effectively applied for fertilization and liming will depend on each case and the results of the soil analysis. *mh = machine hour; **md = man-day. SSP, single superphosphate; KCL, potassium chloride; PVC, polyvinyl chloride. Source: Research data.

The cost of mechanized operations for the tomato crops grown with different soil covers were undifferentiated, with a value of R$ 3,296 per hectare, which represents 4.64% of the TOC of the activity. Harrowing corresponded to 51.46% of the mechanized operation costs, while the survey of construction sites using quarrying machines corresponded to 48.54% of the mechanized operations.

The manual operations were represented as 21.07% (uncovered soil), 18.91% (plastic mulching), 21.61% (sorghum), 21.64% (Sudan grass) and 21.66% (pearl millet) of the TOC for tomato cultivation. In the region of Marechal Floriano, Espírito Santo (ES), a study was conducted on the production costs of Italian table tomatoes, and manual operation costs were observed in the amount of R$ 12,385.00, representing 24.64% of the TOC (Krohling et al., 2018), which is similar to the values found in this study, despite the cultivation occurring in a different regions and using a tomato cultivar with different growth habits.

The authors of that study stated that 38.21% of the TOC related to expenses of manual operations, which is a difference that can be explained by the different production systems used in the studies, demonstrating a variability of costs within the same culture, depending on the type of system used (Souza & Garcia, 2013). Thus, the costs of manual operations in cropping systems without cover and with different soil covers are close to 20% of all costs related to the production of table tomatoes. This implies that the use of soil cover in tomato planting does not influence the costs of manual operations.

Within the activities of sowing and maintaining the culture, manual spraying activities cost R$ 3,500.00, regardless of the type of soil cover used, representing 4.92% (uncovered soil), 4.59% (plastic mulching), 4.87% (sorghum), 4.87% (Sudan grass) and 4.88% (pearl millet) of the TOC, respectively. Manual harvesting operation was another activity within the management and cultivation that presented higher values than the other activities, with a value of R$ 3,840.00, representing 5.40, 5.04, 5.34, 5.35, and 5.35% for tomatoes cultivated in uncovered soil or with plastic mulching, sorghum, Sudan grass, or pearl millet soil covers, respectively.

Consumables and agricultural inputs had the highest costs for the production of one hectare of creeping fresh market tomatoes under different soil covers, with values of 69.53, 72.01, 69.04, 69.01, and 68.99% for tomatoes grown in uncovered soil, or with plastic mulching, sorghum, sudan grass, or pearl millet soil covers, respectively.

Tomato seeds and fertilizers incurred the greatest costs of all materials consumed. The acquisition of seeds totaled R$ 6,872.00, corresponding to 9.66% of the TOC for the tomatoes with uncovered soil, 9.01% with plastic mulching, 9.56% with sorghum, 9.57% with Sudan grass, and 9.58% with pearl millet. In a study that used a tomato cultivar with indeterminate growth in uncovered soil in the region of Marechal Floriano, ES, the acquisition of tomato seeds cost R$ 5,963.00, which was 11.86% of the TOC (Krohling et al., 2018), and higher than the value found in this study due to the difference in the cost of the seed of the cultivar chosen. The high cost of seeds is explained by the advanced technology used and the quality of the seeds reflected in the field where the crop produces high yields (Maciel et al., 2012).

Fertilizers cost R$ 10,116.00 representing 14.23, 13.27, 14.07, 14.09, and 14.10% of the consumed materials for tomatoes grown in uncovered soil, or with mulching plastic, sorghum, Sudan grass, or pearl millet straw, respectively. Souza & Garcia (2013) indicated that materials consumed and agricultural inputs generate the highest costs for tomato cultivation, due to the price of fertilizer and the amount required by the crop, and this was corroborated by the high values observed with fertilizers in this study.

The effective operational cost (EOC) is represented by the sum of the costs of mechanized operations, manual operations, materials consumed, and other inputs. Soil cover with plastic mulching had the highest effective operational cost of R$ 72,625.00 (95.24% of the TOC). The other studied soil covers also presented EOCs of approximately 95% of the TOC.

In the cultivation of tomatoes with a plastic mulching soil cover, the other expenses (5% of the EOC) were R$ 3,631.00, representing 4.76% of the TOC, which corresponded to part of the general expenses of the cultivation, which were included to increase precision in the evaluation of production costs and economic indicators. For the other covers studied, the other expenses were approximately 4.76% of the TOC value for each type of soil cover.

The total operating costs (TOC) ranged from R$ 71,104.00 for tomato cultivation without ground cover to R$ 76,256.00 for cultivation with plastic mulching, and the other types of coverage showing TOCs between these values. Krohling et al. (2018) identified the TOC for three table-type tomato varieties (Fusion, Royale, and one of the Italian types, BS-20) of R$ 50,268.00 per hectare; therefore, even between study sites and cultivars of fresh tomato, the TOC varies since the the prices charged differ depending on the region.

To determine production costs, in addition to analyzing the profitability of the production sector, capitalization and decision-making in the rural sphere should also be considered as criteria (Almeida et al., 2018).

Financial indicators, such as gross revenue (GR), total operating cost (TOC), operating profit (OP), profitability index (PI), gross margin (GM), and leveling point (LP) (t ha^{-1} and R$ t^{-1}) for the two creeping fresh market tomato cultivars grown on different soil covers are shown in Table 3.

The average selling price for tomatoes in the studied region was determined as R$ 2,890.00 per ton for the two cultivars studied (SEAF-MT, 2019). For the Thaíse cultivar, the gross revenue ranged from R$ 178,919.00 to R$ 219,450.00 depending on the soil cover used, since the leveling point (price) ranged from R$ 1,004.00 to R$ 1,160.00 per ton based on the soil cover used (Table 3). Similar values of GR were found for the Fascínio cultivar, with values between R$ 167,873.00 (uncovered soil) and R$ 210,860.00 (plastic mulching) and the leveling point (price) varying between R$ 1,045.00 and R$ 1,224.00 depending on the soil cover.

Thaíse showed a higher operating profit (OP) and profitability index (PI) for tomatoes grown on plastic mulching in relation to other soil covers, indicating greater revenue after deducting cultivation expenses. The treatment with uncovered soil showed 13.18% less OP than the treatment with plastic mulching. Similarly, of the OP was 16.78, 25.20, and 17.48% lower for the treatments with soil cover with sorghum, Sudan grass, and pearl millet, respectively, in relation to the treatment with plastic mulching for the Thaíse cultivar.

For the Fascínio cultivar, the greatest operating profits and profitability indexes were found with the cultivation of this cultivar with plastic mulching. The OP was 28.11, 6.18, 26.27, and 12.71% lower for treatments with uncovered soil and soil cover with sorghum, Sudan grass, and pearl millet, respectively, in relation to the treatment with plastic mulching. All soil covers showed high profitability index values for the two cultivars studied, indicating strong profit levels after deductions for expenses.

Table 3. Estimates of production, prices and financial indicators per hectare for two creeping fresh market tomato cultivars (Thaíse and Fascínio), in different soil covers. Tangará da Serra, MT, 2019.

Production factor at commercialization	Soil cover				
	Uncovered soil	Plastic mulching	Sorghum	Sudan grass	Pearl millet
	Thaíse cultivar (salad type)				
Average price (R$ t^{-1})	2,890	2,890	2,890	2,890	2,890
Yield (t ha^{-1})	67.62	75.93	66.12	61.91	65.72
Gross Revenue (GR) (R$ ha^{-1})	195,431	219,450	191,072	178,919	189,916
TOC (R$ ha^{-1})	71,104	76,256	71,912	71,810	71,759
Operating Profit (OP) (R$ ha^{-1})	124,328	143,194	119,160	107,109	118,158
Profitability Index (PI) (%)	63.62	65.25	62.36	59.86	62.22
Gross Margin (GM) (%)	174.85	187.78	165.70	149.16	164.66
Leveling point (Production) (t ha^{-1})	24.60	26.39	24.88	24.85	24.83
Leveling point (Price) (R$ t^{-1})	1,052	1,004	1,088	1,160	1,092
Production factor at commercialization	Fascínio cultivar (Italian type)				
Average price (R$ t^{-1})	2,890	2,890	2,890	2,890	2,890
Yield (t ha^{-1})	58.09	72.96	68.58	59.19	65.49
Gross Revenue (GR) (R$ ha^{-1})	167,873	210,860	198,196	171,058	189,258
TOC (R$ ha^{-1})	71,104	76,256	71,912	71,810	71,759
Operating Profit (OP) (R$ ha^{-1})	96,769	134,605	126,284	99,248	117,499
Profitability Index (PI) (%)	57.64	63.84	63.72	58.02	62.08
Gross Margin (GM) (%)	136.10	176.52	175.61	138.21	163.74
Leveling point (Production) (t ha^{-1})	24.60	26.39	24.88	24.85	24.83
Leveling point (Price) (R$ t^{-1})	1,224	1,045	1,049	1,213	1,096

TOC = Total Operating Cost. Source: Research data.

Plastic mulching presented the highest GMs among the different types of soil covers for the Thaíse and Fascínio cultivars. High GM values were observed for all soil coverings in the two cultivars evaluated, thus making it possible to include the risk and entrepreneurial capacity costs of this production.

Regarding the leveling point (production) for the two tomato cultivars, a total of 24.60 t ha^{-1} of tomato would be required (uncovered soil), 26.39 t ha^{-1} (plastic mulching), 24.88 t ha^{-1} (sorghum), 24.85 t ha^{-1} (Sudan grass), and 24.83 t ha^{-1} (pearl millet) to cover the production cost, since the two cultivars sold for the same price in the studied region (R$ 2,890.00 per ton). The two creeping fresh market tomato cultivars evaluated in this experiment exceeded the minimum production necessary to cover the costs of their production.

The leveling point (price) of the soil cover system with plastic mulching was R$ 1,004.00 and R$ 1,045.00 per ton of tomato produced for the Thaíse and Fascínio cultivars, respectively. This result indicates economic viability with lower investment by the producer with this soil cover system, which is the most suitable for the study region because of its higher yield and revenue at a similar production cost to the other systems evaluated.

The economic results show that despite the high revenues obtained in this study, production costs affect the profitability of the business. Several factors can affect profitability of tomato cultivation, with yield and marketing price as the most important factors (Krohling et al., 2018), along with other relevant elements such as labor and fertilizers, as determined by this study. Thus, the correct cost control in tomato crop management can reduce labor and cultural practices, thereby impacting production costs and enabling a greater profit of the activity.

Tomato culture aimed at the *in natura* market mainly uses family labor, and reducing this cost results in higher profits, as a lower selling price allows for the product to become more competitive in the market, which results in further work and income for the producer (Dossa & Fuchs, 2017; Socoloski et al., 2017; Machado Neto et al., 2018).

Conclusions

The cultivation of creeping fresh-market tomatoes has high economic profitability, especially when combined with the use of a plastic mulching soil cover.

The costs of manual operations, tomato seeds, fertilization, plastic canvas (double-sided black and white canvas), and irrigation were the highest expenses observed in the production of creeping fresh market tomatoes in relation to the total operating cost (TOC).

For the cultivars studied (Thaíse and Fascínio), the highest operating profit per hectare was found with tomato cultivation on plastic mulching compared to that of the other soil covers tested.

Tomato cultivars (Thaíse and Fascínio) indicated higher gross margin values when grown on plastic mulching.

Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brazil (CAPES), Finance Code 001.

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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.