COMPARING THE ECONOMIC EFFECTS OF OPEN FIELD AND PROTECTED AREA ORGANIC TOMATO CULTIVATION SYSTEMS

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A R T I C L E I N F O

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A B S T R A C T

To compare the economics of different systems of organic tomato production, two models were created, one assuming outdoor production, and the other representing production in a protected area under a greenhouse, based on the data obtained through interviews with organic tomato producers from Vojvodina. The cost and sensitivity analysis revealed that the greenhouse model yields better results overall (a financial result of €273/100 m2 compared to €58/100 m2), despite the higher costs due to amortization, interest and costs related to the higher yield obtained. The production model also showed less dependence on the change in organic tomato yield and price, as well as key cost groups and post-harvest losses, which in both cases were mediated by growing coriander as an intercrop. This research improves the knowledge of the economics of organic tomato cultivation and at the same time proposes a methodology to analyze the economic impact of other organic productions.

Introduction

Tomatoes grown in a protected area are more regular in shape, size and color, which make them more attractive on the market than tomatoes cultivated in open field conditions (Engyndenyz & Tuzel, 2002). Greenhouse production ensures a higher yield per unit area, the possibility to produce outside the peak season and an overall higher added value of the product (Mohammed and Al Dulaimi, 2021, Gül et al., 2021). However, more favorable production conditions also promote the faster spread of diseases and

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pests (Engyndenyz & Tuzel, 2002). This production risk is particularly pronounced in organic farming given the limited options for yield protection. There is a gap in the existing literature regarding the analysis and comparison of the economic impact of organic tomato production in the open field and in the greenhouse (Santos Neto et al., 2017). The literature search conducted revealed a few papers that considered the economics of organic tomato production. Previous research has mainly focused on comparing the economic effects of organic and conventional cultivation (Engyndenyz & Tuzel, 2002, Luz et al., 2007, Santos Neto et al., 2017, Abebe et al., 2022), while only two papers were found analyzing the economics of organic tomato cultivation in a protected area (Engyndenyz & Tuzel, 2002, Nian et al., 2022).

The aim of this work is to compare the economics of the two systems of organic production which is done by analyzing the results obtained in terms of the level and structure of costs, production value, net profit and other indicators from the compiled analytical calculations. By simulating income and costs under different conditions of organic production, it is investigated whether the quantitative and qualitative yield increases of tomatoes in a protected area exceed the cost increases and whether these conditions are economically more advantageous for the producer compared to open field cultivation. Sensitivity analyzes were used to determine the effects of changes in yield, organic tomato price, the proportion of post-harvest losses and the main cost groups of the two production systems. This paper aims to fill the identified research gap, but also proposes a methodology for analyzing the economics of other organic productions.

Materials and methods

Based on literature research, analysis of available data on organic tomato production under different production conditions and interviews with organic tomato producers in Vojvodina, two production models were simulated on an area of 100 m^2.

A total of 32 producers (from the districts of North Bačka, West Bačka, South Bačka, North Banat and Central Banat of Vojvodina) were surveyed, of which 15 farms grew tomatoes only in the open field, six farms organized part of their production in the open field and in protected areas and 11 farms grew tomatoes only in protected areas in the 2022/2023 season.[4] In this sense, the analysis of the economic effects includes the data from 21 farms in the case of outdoor production, i.e. 17 in the case of greenhouse cultivation. Model 1 assumes open field production with a drip irrigation system. Model 2 considers production in a greenhouse covering the entire area and a drip irrigation system. While the main objective of the research is to further develop empirical knowledge on the economics of organic tomato production by comparing these two production systems, the results will also improve the basis for analyzing the impact of investments in the construction of greenhouses according to the recorded

4 All the farms surveyed have a certificate for organic production issued by the Ministry of Agriculture, Forestry and Water Economy of the Republic of Serbia and have undergone the conversion period.

production conditions in the Vojvodina region, where a significant part of organic tomato production in the Republic of Serbia is realized (Sredojević, 2014).

The production models assume that the entire yield of tomatoes is sold. Sale to a retailer is assumed as the most common marketing channel in the case of organic tomato production (Abebe et al., 2022), while possible government incentives are neglected given their relatively small share in the value of this production (Radović et al., 2023). The need for human labor is covered by the work of farm members, i.e. there is no need to hire seasonal workers, even during the harvest period, as the total yield of organic tomatoes is relatively low. At the same time, the tomato harvest extends over a period of four to six weeks, which allows for a more even distribution of labor compared to other productions (Santos Neto et al., 2017, Vanitha et al., 2018). Machine requirements are minimal for the defined models.

When preparing the analytical calculations, the total costs were divided into two basic groups: production costs and marketing costs. Production costs are divided into five groups: costs of materials (which include all materials used in production, the cost of technical maintenance of fixed assets and the cost of soil and leaf analyzes performed), labor costs (man and machine), amortization, and interest (on the total initial invested funds and variable production costs) and non-material costs and common costs. The last group includes, in addition to the common costs attributed to organic tomato production, the costs of production certification, inspection, yield insurance, land lease and various administrative costs. Marketing costs include all costs incurred after production, such as packaging materials and human and machine labor for various operations. The calculations refer to a production cycle. Some similar works in the past have overestimated the financial result by not considering parts or whole groups of fixed costs, especially amortization (Zárate et al., 2009, Assi et al., 2010, Nastić et al., 2020). In the existing literature, there are also examples of the same type of research considering total costs, where fixed costs have been presented and analyzed as a single general group (Demirtaş et al., 2016, Oruç and Gozener, 2020) or in a detailed way with multiple groups (Engyndenyz & Tuzel, 2002, Santos Neto et al., 2017, Vanitha et al., 2018, Dorogi and Apáti, 2019, Souza e Souza, et al., 2023), which is the approach adopted in this paper.

When compiling the analytical calculations, most of the results and costs in production were calculated as an average of the values recorded in the individual farms for the two production systems. This approach was applied to material and labor costs, a portion of interest costs (on variable costs), a portion of intangible and other production costs and marketing costs. For the other costs, as they are largely fixed, only the data from five farms (two for outdoor production and three for greenhouse production) were used, which grow tomatoes on an area similar to the 100 m2 assumed in the models created. This is the amortization (and valuation of the initial investment) of the greenhouse and the irrigation system, the interest on investments in the acquisition of fixed assets and the land rent, administrative and common costs. It is also pointed out that almost all of the farms that took part in the survey do not specialize in growing tomatoes, but also grow other vegetables and crops or raise livestock.

The basic additional cost groups generated by production in a protected area are the cost of greenhouse amortization and the cost of materials used and consumed in a given production cycle (e.g. sticky traps). In addition, different conditions lead to differences in the amount of material used. The above explanations provide an overview of the basic general differences between the individual cost groups resulting from the different production conditions assumed by the models (*Table 1.*).

Table 1. Organic tomato production models and the main causes of differences in costs and results between the two models

Element	Model 1	Model 2
Irrigation system	**YES**	**YES**
Greenhouse	**NO**	**YES**
Causes of differences in costs and results	A somewhat larger volume of material input, given the outdoor production (Duhan, 2016)	Increasing the quantity and quality of yields through production in a protected area
	Higher demand for human labor in outdoor production	Additional costs for the amortization of the greenhouse
	Higher demands on the use of machinery in outdoor production	Higher interest costs for the funds invested in the purchase and construction of the greenhouse as well as interest on a larger proportion of the variable costs
	Higher fixed costs, as it is possible to organize only one production per year on the same plot of land	Higher costs for insurance, packaging and human labor due to a higher yield

Source: The authors' own systematization based on Wehinger T., 2011.

In the subsequent evaluation of the results from the analytical calculations, the costs were divided into variable and fixed costs according to their change depending on the production volume. The variable costs include the costs for all materials and labor (machinery and human labor) as well as the costs for certification, inspection, insurance and marketing, as they are predominantly variable. The rest are fixed costs. Production in a protected area enables the organization of at least two productions per year (Vanitha et al., 2018). Therefore, this analysis assumes the possibility of realizing two productions in a protected area per year, which means that half of the annual fixed costs in the case of model 2 are attributed to the analytical calculation for one production cycle.

By analyzing the cost differences presented, the economic efficiency of different production conditions are finally compared. The initial investment for the purchase and installation of the greenhouse and the irrigation system are calculated and presented separately in order to estimate the annual amortization costs that will be included in the production costs of both models.

Organic production requires a lower sowing density compared to conventional production, primarily to prevent the development and spread of diseases (Lopez-Marin et al., 2019). This results in a lower tomato yield, but at the same time creates additional space for sowing intercrops. In this paper, following the approach of Santos Neto et al., it is assumed that sowing coriander is a suitable intercrop for organic tomatoes that increases income and improves the sustainability of this production (Miles and Peet, 2000, Santos Neto et al., 2017). In the case of open field production, a tomato yield of 3.2 kg per m^2 (total 320 kg) is assumed, i.e. 4.4 kg/m^2 (total 440 kg) for the greenhouse production model. It is estimated that yields in organic tomato production are 60% to 75% lower compared to conventional production (Tüzel, 2001, Engyndenyz & Tuzel, 2002, Abebe et al., 2022). When calculating the production value, the total yield of the main product is divided into two quality classes with different market prices (€2.55/kg and €1.49/kg). For outdoor production, the class structure is 60:40 in favor of the first class. With the construction of the greenhouse, in addition to a higher yield of organic tomatoes, an improvement in the quality structure in favor of the first class of 70:30 was assumed. The yield of coriander is 0.95 kg/m^2 (model 1) and 1.25 kg/m^2 (model 2) at a market price of €0.8/kg.

Organic tomato cultivation is also characterized by significant post-harvest losses (Abebe et al., 2022). This refers primarily to the impact of pests, but also to the portion of production that is returned to growers due to insufficient quality before it reaches the market. Most authors have not considered yield reduction on this basis. Abebe et al. estimate that these losses reach up to 25% of the production value (Abebe et al., 2022). In this paper, a 10% yield reduction in organic tomatoes is assumed, while the impact of different levels of loss on the result is subsequently investigated through a sensitivity analysis.

Based on the data from the calculations made, the following indicators were further calculated:

$$\text{Gross margin} = \text{Production value} - \text{Variable costs} \tag{1}$$

$$\text{Net result} = \text{Gross margin} - \text{Fixed costs} \tag{2}$$

$$\text{Return per euro of expenditure} = \frac{\text{Production value}}{\text{Variable costs} + \text{Fixed costs}} \tag{3}$$

$$\text{Natural productivity of work} = \frac{\text{Yield}}{\text{Human labor}} \tag{4}$$

$$\text{Valued productivity of work} = \frac{\text{Net result}}{\text{Human labor}} \tag{5}$$

The gross margin and net profit are first used to examine the economic justification of production under the given conditions, while the return per unit of expenditure and the productivity indicators are used to compare the models. The return per euro of expenditure reduces different production results and costs to a comparable basis (Vanitha et al., 2018, Pavlović et al., 2010). The inclusion of labor productivity indicators was subsequently influenced by the initial research findings after a significant share of human labor costs was identified.

The differentiation of certain cost groups with a significant share finally made it necessary to carry out a sensitivity analysis of the financial results of both models. In contrast to previous studies (Engyndenyz & Tuzel, 2002, Dorogi and Apáti, 2019, Nastić et al., 2020, Abebe et al., 2022), this part examined not only the effect of the change in the yield and price of organic tomatoes on the financial result, but also how the result changes depending on the increase or decrease of the most represented cost groups, as well as in the case of a decrease in production value due to post-harvest losses. In this way, insight was gained into the stability of financial results in relation to changes in the main economic conditions, that are determined by internal (yield, material consumption, labor or protection against diseases) and external influences (prices of products, materials, labor, etc.).

Results and Discussion

The initial investment for the purchase and installation of the greenhouse and the irrigation system for the assumed area of 100 m^2 are shown in *Table 2*. When calculating the annual amortization costs, different lifetimes were assumed for the individual parts of the greenhouse and the drip irrigation system. In other words, the elements of the greenhouse and the irrigation system as well as the transportation and installation services were considered as separate assets with their own planned useful lives. The initial investment value for the purchase and construction of the greenhouse and irrigation system was calculated at €2,379 and €671 respectively. More than two-thirds of the initial investment value of the greenhouse is the cost of purchasing the basic structure, while in the case of the irrigation system; one-third of the investment is the price of the water pump. The transportation and installation costs accounted for a significant share of 24.5% in the case of the greenhouse and 30.7% in the case of the irrigation system. By dividing the initial investment by the assumed useful life of the individual elements, the total annual amortization costs of the greenhouse and the irrigation system were calculated at €181.0 and €44.5 respectively.

Table 2. Initial investment funds for the construction and installation of the greenhouse and irrigation system with amortization calculation (area of 100 m^2)

Element	Initial investment funds		Amortization	
	Value (€)	%	N (years)	Value (€)
Greenhouse				
Frame and kit	868	36.5	25	34.7
Basic locking rail	737	31.0	25	29.5
Foil - Polyethylene (covering material) and ground cover	152	6.4	2	76.0
Roof sprinkler	38	1.6	20	1.9
Transportation and installation	583	24.5	15	38.9
Total (greenhouse)	**2,378**	**100.0**	**1**	**181.0**
Irrigation system				
Main pipe	36	7.8	15	2.4

Element	Initial investment funds		Amortization	
	Value (€)	%	N (years)	Value (€)
Water pump	158	34.5	10	15.8
Filters	45	9.7	8	5.6
Tank for pressure regulation	38	8.4	15	2.6
Other elements of the system	41	9.0	10	4.1
Transportation and installation	141	30.7	10	14.1
Total (irrigation system)	**459**	**100.0**	**1**	**44.5**

Source: Calculation by the authors. Systematization of costs based of Bodiroga et al., 2018.

In view of the fact that the entire area is irrigated, the amortization of the irrigation system was included in the cost structure of both models 1 and 2. Half of the annual amortization amount was attributed to the calculation of production in the protected area (model 2), based on two productions during the year. The direct fixed assets in this production also include the tomato sticks that are used during several cycles and whose amortization costs were indicated in the analytical calculation (*Table 3.*).

The value of organic tomato cultivation increased by the value of intercrops and reduced by the assumed losses of 10% amounted to €689/100 m^2 and €985/100 m^2 for models 1 and 2 respectively. It should be noted that the losses in both models were offset by the value of the coriander.

Table 3. Production value and cost calculation of organic tomato production in the open field (model 1) and in the greenhouse (model 2)

Model		Model 1		Model 2	
Irrigation system		**YES**		**YES**	
Greenhouse		**NO**		**YES**	
Yield per 100 m² (kg)	**Organic tomato**	**320.0**		**440.0**	
	Coriander	**95.0**		**125.0**	
Value of production					
I) Organic tomato	I class of product (price: €2.55/kg)	490		786	
	II class of product (price: €1.49/kg)	191		197	
	Post-harvest losses (10% of I and II class)	68		98	
II) Coriander (price: €0.8/kg)		76		100	
A. Total value of production (I+II)		**689**		**985**	
Type of costs		**€ per 100 m²**		**Share in total costs (%)**	
		Model 1	**Model 2**	**Model 1**	**Model 2**
Costs of production					
a) Costs of materials		*173*	*237*	*27.4*	*33.3*
1) seedlings		29	26	4.6	3.7
2) crop protection		27	24	4.3	3.4
3) fertilizers		54	62	8.6	8.7
4) electricity		2	2	0.3	0.3
5) bumblebees		37	19	5.9	2.7

Model	Model 1		Model 2	
6) technical maintenance (greenhouse and irrigation system)	13	61	2.1	8.6
7) soil and leaf analysis	6	7	1.0	1.0
8) other material costs (threads, sticky traps and irrigation pipes)	5	36	0.8	5.1
b) Labor costs	*174*	*114*	*27.6*	*16.0*
1) human labor	167	109	26.5	15.3
2) machinery labor	7	5	1.1	0,7
c) Amortization	*58*	*121*	*9.2*	*17.0*
1) greenhouse	0	91	-	12.8
2) irrigation system	45	23	7.1	3.2
3) sticks	13	7	2.1	1.0
Type of costs	**€ per 100 m²**		**Share in total costs (%)**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
d) Interest	*25*	*34*	*4.0*	*4.8*
1) interest on total initial investment funds	14	31	2.2	4.4
2) interest on total variable costs	11	3	1.8	0.4
e) Non-material costs and common costs	*96*	*93*	*15.2*	*13.1*
1) certification	29	27	4.6	3.8
2) inspection	9	8	1.4	1.1
3) insurance	21	34	3.3	4.8
4) land rent	15	12	2.4	1.7
5) administrative costs	9	4	1.4	0.6
6) common costs	13	8	2.1	1.1
B. Total costs of production (a+b+c+d+e)	**526**	**597**	**83.4**	**83.8**
Marketing costs				
Type of costs	**€ per 100 m²**		**Share in total costs (%)**	
	Model 1	**Model 2**	**Model 1**	**Model 2**
a) Packaging and nylon	61	80	9.7	11.2
b) Human labor	23	16	3.6	2.2
c) Machinery labor	21	19	3.3	2.7
C. Total marketing costs (a+b+c)	**105**	**115**	**16.6**	**16.2**
D. Total costs (B.+C.)	**631**	**712**	**100.0**	**100.0**
Average price of organic tomato (€/kg)[5]	2.13	2.23	/	/
Break-even average price of organic tomato (€/kg)[6]	**1.73**	**1.99**	/	/
Break-even yield of organic tomato (kg/100 m²)[7]	**261**	**274**	/	/

Source: Authors' calculation.

5 (Production value + Post-harvest losses - Value of coriander)/Total yield of organic tomato

6 The calculation of the break-even average price and yield for organic tomatoes requires the assumption of the share of total costs for organic tomato production (excluding the production costs for the intercrop). In our calculation, we assume that the value and costs of coriander production are approximately the same, i.e. the share of the costs of organic tomato production can be calculated by subtracting the total production costs and the value of coriander. Therefore, the average break-even price is calculated as follows: (Total costs – Value of coriander)/Yield of organic tomato

7 (Total costs –Value of coriander)/Average price of organic tomato

Material costs include organic tomato seeds, special certified organic pesticides and fertilizers, the consumption of which were approximately the same in both models. The use of organic fertilizers contributes significantly to improving the fertility and other properties of the soil, and unlike mineral fertilizers, they have a long-lasting effect, i.e. they increase the yield and quality of the cultivated plants several years after fertilization (Ferguson et al., 2005, Bogdanović et al., 2014). In model 2, the costs for technical maintenance were higher, as the maintenance of the greenhouse is included in addition to the irrigation system, while bumblebees are less effective in the open field, which lead to higher costs in the case of model 1. The share of costs of materials in the total costs was 27.4% in the open field and 33.3% in the protected cultivation of tomatoes.

The open field production system had a higher demand for human labor. The share of these costs in model 1 was more than a quarter of the total costs, while the share in model 2 was slightly more than 15%. The possibility of spreading the fixed costs over two production processes per year in the case of production in a protected area significantly reduced the production costs in model 2. A realization of three cycles a year, as noted by Vanitha et al., would further reduce the burden of fixed costs, but would also incur additional costs for preventive protection under conditions of repeated production on the same area, which justifies a separate analysis (Vanitha et al., 2018). Overall, amortization and interest costs increased by around €70/100 m^2 in case of production in protected area, which is mainly due to the construction and use of the greenhouse. The share of other production costs was around 15% for model 1 and 13% for model 2 and included the costs of organic certification and inspection, which vary widely and depend on numerous factors (Santos Neto et al., 2017, Abebe et al., 2022), insurance costs, that were higher in the protected area given the higher yield of organic tomatoes, land rent, and the administrative and general costs of the farm attributed to this production. The total costs of organic tomato production in the open field was estimated at €526 (€5.26/m^2), while the costs of production in the protected area was €597 (€5.97/m^2), accounting for more than 83% of the total costs, with the remainder being marketing costs. If the total costs are deducted from the production value, the financial result is €58/100 m^2 and €258/100 m^2 for model 1 and model 2 respectively (*Table 4*.). The return per euro of expenditure was also significantly higher in model 2, as €1.38 of production value was achieved for €1 of total costs, compared to €1.09 in the case of open field production.

Table 4. Indicators for organic tomato cultivation in the open field (model 1) and in the greenhouse (model 2)

Indicator	Model 1			Model 2		
	Value (€)	Value per 100 m^2	Share (%)	Value (€)	Value per 100 m^2	Share (%)
I) Production value	**689**	**6.89**	**100.0**	**985**	**9.85**	**100**
1) Variable costs	511	5.11	74.2	535	5.35	54.3
II) Gross margin (I-1)	**178**	**1.78**	**25.8**	**450**	**4.50**	**45.7**
2) Fixed costs	120	1.20	17.4	177	1.77	18.0
III) Net result (II-2)	**58**	**0.58**	**8.4**	**273**	**2.73**	**27.7**

Indicator	Model 1			Model 2		
	Value (€)	Value per 100 m²	Share (%)	Value (€)	Value per 100 m²	Share (%)
a) Return per euro of expenditure	**1.09**			**1.38**		
b) Natural productivity of work	**6.50**			**13.70**		
c) Valued productivity of work	**1.18**			**8.50**		

Source: Authors' calculation.

The differences in terms of labor input between the two models of organic farming could be seen by comparing the values of the productivity indicators. A higher yield and a lower labor input led to a twice as high value of the natural productivity indicator in the case of production in protected areas (13.70 versus 6.50). If the yield of organic tomatoes was replaced by the net profit, the value of the indicator in model 2 was more than seven times higher than in model 1 (values of 8.50 and 1.18 respectively).

It is obvious that the result of the open field production model was sensitive to the change in tomato yield and price (*Table 5.*). Under the given conditions, the model was almost unprofitable. A 10% decrease in yield or price would already result in the production value being lower than the total costs.

Table 5. Sensivity analysis – Model 1 (open field cultivation)

Element		Model 1 – Yield (320 kg/100 m²)				
		-20%	-10%	0%	10%	20%
Average price (€2.13/kg)	-20%	-162	-113	-64	-15	34
	-10%	-113	-58	-3	52	108
	0%	-64	-3	58	120	181
	10%	-15	52	120	187	255
	20%	34	108	181	255	328
Element		**Amortization (€58)**				
		-20%	**-10%**	**0%**	**10%**	**20%**
Costs of materials (€173)	-20%	104	98	93	87	81
	-10%	87	81	75	70	64
	0%	70	64	58	52	46
	10%	52	47	41	35	29
	20%	35	29	23	18	12
Element		**Post-harvest losses (% of organic tomato production value)[8]**				
		0%	**5%**	**10%**	**15%**	**20%**
Costs of human labor (€167)	-20%	159	127	95	62	30
	-10%	143	109	76	43	10
	0%	126	92	58	24	-10
	10%	109	74	40	5	-30
	20%	93	57	21	-15	-50

Source: Authors' calculation.

8 Initially assumed 10%.

The sensitivity analysis carried out also showed a high dependency of the open field model on changes in costs of materials. The change in labor costs also significantly determined the financial result, which is important considering that the production models assume that seasonal workers are not represented, whose wages per labor unit would be proportionally higher compared to the wages of farm members. This represents a restriction on the conditions for carrying out production on a larger area or, more generally, for hiring additional labor. If the loss of value in the production of organic tomatoes were to increase to 20% compared to the originally assumed 10%, model 1 would have been unprofitable. It was also found that the profitability of the production model in a protected area was sensitive to the change in yield and average price of organic tomatoes, although the risk was lower on this basis, considering that production would have been only unprofitable if the price and yield decreased by 10% and 20% (*Table 6*.). Compared to model 1, model 2 was less dependent on the change of costs of materials. The financial result achieved was also not overly influenced by the level of amortization costs, although the value of the greenhouse was also being amortized. Under the given conditions, the production model in protected area was almost free from the risk of changing labor costs, which creates an opportunity for possible additional hiring.

Table 6. Sensivity analysis – Model 2 (cultivation in a protected area)

Element		Model 2				
		Yield (440 kg/100 m^2)				
		-20%	-10%	0%	10%	20%
Average price (€2.23/kg)	-20%	-83	-4	74	153	232
	-10%	-4	84	174	261	350
	0%	74	174	273	369	468
	10%	153	261	369	477	586
	20%	232	350	468	586	704
Element		Amortization (€121)				
		-20%	-10%	0%	10%	20%
Costs of materials (€237)	-20%	345	333	320	308	296
	-10%	321	309	297	285	273
	0%	297	285	273	261	249
	10%	274	261	249	237	225
	20%	250	238	226	214	201
Element		Post-harvest losses (% of organic tomato production value)[9]				
		0%	5%	10%	15%	20%
Costs of human labor (€109)	-20%	393	344	295	245	196
	-10%	382	333	284	234	185
	0%	371	322	273	224	174
	10%	360	311	262	213	164
	20%	349	300	251	202	153

Source: Authors' calculation.

9 Initially assumed 10%.

Finally, model 2 was more resilient to the growth of value loss in organic tomato production. With unchanged conditions and a 20% loss in the value of organic tomatoes, a profit of €153/100 m^2 would still have been achieved.

The considered change of price of organic tomatoes is decisively determined by the marketing channel. This was particularly considered by Abebe et al. who found that by shortening the chain of marketing intermediaries, three to four times the price of organic tomatoes can be obtained when considering direct sales and the most common way of selling organic tomatoes, namely selling to an intermediary who assumes all (or part of) the post-harvest risks and seeks a buyer to sell the tomatoes to the final customer (Abebe et al., 2022).

Obviously, in addition to assuming the aforementioned risks, the direct sale of products also generates new costs, such as market entry costs, advertising measures and others. With this in mind, subsequent studies should first define any additional costs incurred by the chosen marketing channels and then examine the profitability at different prices for organic tomatoes resulting from the chosen realization model.

Conclusions

The production of organic tomatoes is profitable under the conditions of the analyzed farms in Vojvodina in case of both production systems. Organic tomato production in a protected area achieves more favorable economic results overall than open field cultivation. In addition to a higher financial result (€273/100 m^2 compared to €58/100 m^2 in the case of outdoor production), the model was less sensitive to the change in the main cost groups and to the increase in subsequent yield losses. The profitability of the production model in a protected area is directly determined by the possibility of realizing two productions per year. Otherwise, all fixed costs would be attributed to one production cycle, as is the case with open field the open field model. Production in a protected area still does not eliminate the price and yield risks and some of the production risks that can significantly determine the results in this production.

However, it is undeniable that growing in a protected area, apart from the significant investment for the construction and installation of a greenhouse, estimated at €2,378 for a 100 m^2 production area, increases and to a certain extent stabilizes the yield of organic tomatoes, and that intercropping improves the sustainability of this production. It should also be pointed out that the yields observed in both cases were obtained under conditions of irrigation of the entire plot area.

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Conflict of interests

The authors declare no conflict of interest.

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