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Analyzing the Economic Viability and Energy Requirements of Soilless Greenhouse Tomato Cultivation in the Context of Climate Change in the Mediterranean Basin

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Authors' contributions

This work was carried out in collaboration between both authors. Author NB prepared the first draft by making breeding and cost calculations. Author ZZ compiled the climate data, created the final version of the article. Both authors read and approved the final manuscript.

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ABSTRACT

Controlling environmental conditions in agricultural production has a direct influence on the yield. In vegetative production, the most common and effective implementation of environmentally controlled production is in greenhouses. In the event that the daily average temperature drops below 12ºC, greenhouses should be heated. Heating in greenhouses has a significant share in production costs. While overall production costs in high technology greenhouses depend on the size of the greenhouse and the length of the production period, the heating costs vary depending on the greenhouse equipment and external climatic conditions.

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In this study, the costs of inputs used in the production of truss tomatoes in the great majority of high technology greenhouses in the Mediterranean climate zone were determined, their share in the total cost was calculated and a comparison with the costs of truss tomato production in Southeastern European countries was made.
The calculations show that among the production costs under Mediterranean climate conditions, cost of labor is the highest with a ratio of 37% while energy (heat + electricity) cost is the second highest. While the unit cost of truss tomatoes in Southeastern Europe is 0.51 €.kg^{-1}, the production cost under Mediterranean climate conditions is 0.59€.kg^{-1}.

Keywords: Agricultural greenhouse; greenhouse heating; production costs; climate change.

1. INTRODUCTION

The control of plant growth factors in agricultural production has a direct influence on the yield. Therefore, in recent years, environmentally controlled agricultural production techniques have developed with an increasing speed. In environmentally controlled plant production systems, there is a tendency to change all aspects of natural environmental factors in line with the optimum requirements of the plants. In vegetative production, the most common and effective implementaton of environmentally controlled production is carried out in greenhouses [1].

The objective of innovative technologies in greenhouses is to improve "Life Cycle Quality". For this reason, it is important that for sustainability the inputs and outputs required for the yield to be obtained from the unit area in greenhouse cultivation be analyzed accurately [2,3].

The most important climatic parameters in greenhouse cultivation are temperature, humidity, solar radiation and length of the day. In the event that the daily average temperature drops below 12^{o}C, greenhouses should be heated. However, if the average daily temperature is between 7^{o}C and 12^{o}C, the greenhouses need to be heated only at night hours [4-7]. When the climate values of the Mediterranean region, where greenhouse cultivation is common, are examined, it is seen that the air temperature ranges between 7^{o}C and 12^{o}C during the December-February period [8].

Under in the climatic conditions of the Mediterranean region, in order to carry out production in greenhouses throughout the year, in certain periods of the year greenhouses must be heated at night, ventilated and shaded during the daytime, and cooled during hot periods. However, during the periods when the greenhouse requires cooling, the plants produced in the greenhouse grow in external climatic conditions and as cooling requires energy and clean water, cooling is not a preferred method in greenhouses and thus greenhouses are left empty during these periods [9].

The yield obtained from greenhouses varies depending on the length of the production period as well as the climatic factors. In single crop cultivation under unheated conditions in the Mediterranean region, the production period starts in October and ends in June. Under these conditions, there is no regular heating in the greenhouse, and there is only en effort to protect the product against frost through simple methods. The tomatoe yield obtained from the greenhouse in unheated conditions varies between 15-18 kg.m^{-2} while the amount of first quality product is around 65%. In Turkey, high technology greenhouses established as large enterprises in recent years have been practicing regular heating and 30 – 32 kg.m^{-2} tomato yield is obtained. 80% of this yield is first quality product [10,11].

Though heating in the greenhouse affects the yield and quality in a positive way, it increases production costs. In the event that heating in greenhouses is provided using fossil energy sources, depending on the climate of the region, heating costs vary between 20% and 60% of production costs [10]. Production inputs such as labor, seedlings, fertilizer, water, pesticide, growing medium (cocoopeat) and packaging expenses vary depending on the greenhouse size and the length of the production period whereas heating expenses vary depending on the regional climate, greenhouse size and equipment. An accurate calculation of heating costs, which has an important share in overall production costs, is thus highly significant when examining the production cost.

Greenhouse crop production is now a growing reality throughout the world with an estimated 405 000 ha of greenhouses spread throughout Europe, of which some 105 000 ha are located in the South Eastern European (SEE) countries. The degree of sophistication and the technologies applied depend on local climatic conditions and the socio-economic environment [12].

Greenhouse production originated in northern Europe, and experience there stimulated development in other areas, including the Mediterranean, North America, Oceania, Asia and Africa, with various degrees of success. Experience has shown that a mere transposition of north European technologies to other parts of the world and different agro-ecological environments is not a valid process. Technologies must be adapted to match the local requirements and further research is needed in each environment.

The last 20 years have seen a revolution in greenhouse production in terms of structure design and type and quality of covering materials; plant nutrition management; mulching; use of high-yielding hybrids and cultivars; plant training and pruning techniques; integrated pest management; use of pollinator insects; climate control; soil solarization and other technologies. Just a few years ago, a tomato yield of 100 tonnes/ha in a greenhouse was considered a good performance. Today, a harvest of 600 tonnes/ha is not unusual in high-tech greenhouses.

In SEE countries, protected cultivation is still in a period of transition following a decline in importance in the wake of the social changes of the 1990s. The shift from centrally controlled greenhouse industrial units to small-scale family enterprises has been slow as a result of dependency on the technological capacity and investment potential of small-scale growers. Popsimonova et al. [13] calculated the production costs of truss tomatoes in Southeastern European countries [14].

In this study, the average yield obtained from the greenhouse was accepted as 40kg.m^{-2} and the cost of tomatoes was determined to be 0.51 €.kg^{-1}. The highest share among direct production expenses in the production of truss tomatoes in soilless agriculture in Southeastern European countries is that of fuel expenses with 38,5%.

Determining production costs in greenhouses is not only necessary for accurate feasibility studies, but also important in terms of deciding how much savings will be made in which production input in order to reduce production costs. For this stated reason, this study aims to determine the production expenses and their ratios in the total cost of truss tomato production in the high technology greenhouse established in Adana and compare the values with the production costs in the Southeastern European countries.

2. MATERIALS AND METHODS

The study was carried out in a high technology plastic greenhouse with a thermal curtain where under Adana climate conditions truss tomatoes are produced. The greenhouse where the research was conducted has a floor area of 20,800 m2, and its side walls have a height of 5 m while the ridge is 7,5 m high. The side walls of the greenhouse are covered with a double layer of Polycarbonate (PC) at 8 mm intervals, and the roof is covered with 180 µm reinforced PE plastic. In the greenhouse built as a block, the tunnel width is 9,6 m, and at 25 cm intervals in the cocopeat media placed on 6 rows of gutterr in each tunnel, truss tomatoes were planted. 2.5 m-^{2} tomato seedlings were used in the planting of truss tomatoes in the greenhouse.

Irrigation process in the greenhouse was carried out using the spaghetti drip method, based on the solar radiation reaching the greenhouse during the day. For every 100 j.cm^{-2} radiation intensity, 100 j.cm^{-2} of water was given. The adequacy of irrigation was checked based on the drainage water (33%) returned from the system. Fertilizer was applied with irrigation water according to the recipe uploaded to the computer in the irrigation system by taking into account EC and pH.

Heating in the greenhouse was obtained with a central heating system. Steel heating pipes with a diameter of 51 mm are laid on the service roads near the greenhouse floor. For greenhouse heating, imported coal with a lower calorific value of 8.14 kWh. Kg^{-1} was used. The imported coal quantity consumed for heating the greenhouse during the production period was recorded and at the end of the season the coal quantity corresponding to unit area was calculated.

In order to preserve heat in the greenhouse, a thermal curtain consisting of acrylic and aluminum strips was used (LS17). Depending on the solar radiation the thermal curtain was managed manually. The thermal curtain was folded after sunrise and opened just before sunset.

Ventilation and heating in the greenhouse were managed by controlling with the climate computer. The heating temperature in the greenhouse was set to a minimum of 15ºC, and the temperature in the greenhouse was regulated by a three-way valve. Ventilation temperature was set to 20ºC. However, in case of excessive humidity in the greenhouse, the ventilation flaps were activated automatically to try and control humidity. Temperature, humidity, pipe temperatures, positions of thermal and ventilation flaps in the greenhouse were recorded by the computer at one-hour intervals.

Harvesting in the greenhouse started in November and continued until the first week of July. The harvested truss tomatoes were sorted in the greenhouse by the workers, packaged and put up for sale.

The research was carried out in a year, all the production expenses needed in the greenhouse were recorded throughout the production period and all expenses corresponding to the unit greenhouse area were calculated euro.

3. RESULTS AND DISCUSSION

1. Among the direct production costs in the greenhouse, seedlings, production medium (cocopeat), fertilizer, actions against diseases, packaging materials and boxes, fuel, electricity, support ropes, clamps etc. expenses were examined [15]. Direct production costs related to the soilless production of truss tomatoes in the greenhouse under Mediterranean climate conditions are given in Table 1. As can be seen from the diagram, direct costs in the production of truss tomatoes in a regularly heated greenhouse were determined as 11.426€.m^{-2} per unit greenhouse area.

The direct costs Popsimonova et al. [13] determined in their study that they carried out for the Southeastern European countries for the production of truss tomatoes in soilless culture are given in Table 2. The direct costs in the production of truss tomatoes in soilless agriculture for the climate conditions of Southeastern Europe have been calculated as 18.153 €.m^{-2} per unit greenhouse area.

Table 1. Direct production costs calculated per unit greenhouse area in the production of truss tomatoes in soilless cultivation in the greenhouse under Mediterranean climate conditions

No.	Direct expenses	Cost t€.m^{-2}	%
1	Biological and agricultural pest control and special fertilizer	0.228	2.00
2	Fertilizer	1.615	14.13
3	Heating (Coal)	3.390	29.67
4	Boxes and packaging	2.529	22.13
5	Seedlings	1.204	10.54
6	Cocopeat (cultivation medium)	1.233	10.79
7	Good farming + Bumble bees + Cleanliness and Hygiene	0.272	2.38
8	Electricity expenses	0.955	8.36
	TOTAL direct expenses	11.426	100.00

Table 2. Direct production costs calculated per unit greenhouse area in the production of truss tomatoes in soilless cultivation in the greenhouse in Southeast European countries [13]

No.	Direct expenses	Cost €.m^{-2}	%
1	Seedlings	3.00	16.53
2	Rockwool (cultivation medium)	0.75	4.13
3	Fertilizer	2.00	11.02
4	Plant protection products	0.10	0.55
5	Irrigation water supply	1.20	6.61
6	Support ropes + clamps + Bumble bees	0.83	4.56
7	Heating (Natural gas)	7.80	42.97
8	Electricity	0.08	0.41
9	Boxes and packaging	2.40	13.22
	Total direct expenses	18.153	100.00

As can be seen from the results obtained, the direct production costs in the Mediterranean region climate zone, where greenhouse cultivation is common in Turkey, are lower than those in Southeastern European countries. Also, as seen in Table 1 and Table 2, among the direct production expenses, cost of heating is the highest in both Mediterranean climate zone and Southeastern European countries.

3.1 Fuel Consumption

In the soilless production of tomatoes made in high technology greenhouses in the Mediterranean region, the greenhouses are regularly heated in order to keep the temperature at 14-15ºC and imported Siberian coal is used as fuel. Mediterranean climate conditions do not require heating in the greenhouse during daylight hours. During the production period starting the last week of August and continuing until the first week of July, the heating system in the greenhouse is activated at the early morning hours of only a few days. The amount of imported coal consumed during the production period in the greenhouse where the research was conducted is given in Table 3. As can be seen from the table, in the event that the temperature in the 20,800 m^2 greenhouse with a thermal curtain is to be kept at a minimum of 15ºC. The amount of imported coal consumed during the production period is 346,180 kg. This value is equivalent to 16.643 $kg.m^{-2}$ per unit greenhouse area [16-18].

Popsimonova et al. [13] based their heating cost calculations for Southeast European countries on natural gas as the fuel used in heating the greenhouse. The researchers calculated the amount of natural gas to be consumed during the production period as 13 $m^3.m^{-2}$. In the calculations, the price of natural gas was taken as 0.60 €.m^{-2} and fuel expenses had a 43% share in direct production costs.

3.2 Irrıgatıon

In the greenhouse where the research was carried out, the irrigation water was provided from underground water resources. There was no charge for irrigation water, but electrical energy was used for the deep well pumps used to supply irrigation water. The amount of electrical energy used throughout the production period is given in Table 4. As can be seen from the table, during the periods when there is no heating, the amount of electrical energy used at daytime hours is higher than the amount used at evening and night hours. While the amount of electrical energy used during daylight hours in the unheated greenhouse reached 80% of the total electricity consumption, this value decreased to 21% during the periods when there was heating in the greenhouse. The cost of electrical energy consumed by the motors of the irrigation and ventilation covers during the daytime was calculated as 0.303 €.m^{-2}. This is equivalent to 2.65% of direct production costs.

Among the direct production costs in the production of truss tomatoes in Southeastern European countries, irrigation costs have an important place with 6.61%. While electricity costs have a share of 0.41% among direct production costs in Southeastern European countries, this ratio rises to 8.36% in the Mediterranean climate due to the use of deep well pumps.

3.3 Plant Growth Media

Rockwool or cocopeats, which serve as the production medium in greenhouses where soilless agriculture is carried out, have a significant share in direct costs. For soilless agriculture in greenhouses in the Mediterranean region, the share of production medium among direct production costs is 10.79%. The share of rockwool used as a production medium in Southeastern European countries in direct production costs is 4.13%.

Cocopeat, which is used as a production medium in greenhouses where soilless agriculture is carried out, is normally used for one year. However, in soilless production in Turkey, cocopeats can be sterilized after one year of use and continue to be used for two or three years. While this allows a reduction in overall cost, a poor sterilization increases the risk of root diseases.

3.4 Seedlıngs

Turkey is cheaper than Southeastern European countries in terms of seedling costs, which are included in direct production costs. In the Mediterranean region, 2,5 m^{-2} tomato seedlings were used in the production of soilless truss tomatoes. Considering the losses due to regeneration of seedlings in the calculations made under producer conditions, the seedling cost is 1.204 €.m^{-2}. In Southeastern European countries, this value is 3.00 €.m^{-2}.

Table 3. Coal quantities and costs required during the production period in a 20,800 m^2 PE plastic greenhouse with a thermal curtain when the temperature in the greenhousebis kept at a minimum of 15^{o}C.

Temperature	Consumption (ton)	Unit Price (€.ton^{-1})	Cost (€)	Consumption (kg.m^{-2})	Cost (€.m^{-2})
Minimum 15^{o}C	346.180	203.7	70516.9	16.643	3.390

Table 4. Electrical energy used by pumps and gearmotors during the production period and relevant costs

Consumption	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Daytime (06.00-17.00) (kWh)	5460	2712	4393	5398	9135	4962	4575	3743	4310	6310
Peak (17.00-22.00) (kWh)	469	385	5207	6147	8661	5739	3359	702	636	1032
Night (22.00-06.00) (kWh)	917	1691	14062	11292	16273	13394	12609	4619	1307	1238
Daytime/Total consumption (%)	80	57	19	24	27	21	22	41	69	74
Unit Price (€/kwh)	0.118860									
Monthly cost (€/ay)	813.72	569.10	2812.8	2714.2	4049.4	2863.9	2441.7	1077.3	743.23	1019.8

3.5 Boxes and Packagıng

Tomato harvest is directly classified and boxed in the greenhouse. The truss tomatoes produced and harvested in the Mediterranean region are packaged in cardboard boxes of 30*40*13,5 cm, each containing approximately 6 kg of tomatoes. Packaging is made in two layers, and a corrugated intermediate cardboard is placed between the two layers in order to prevent tissue damage in fruits. The packed tomatoes are covered with a polypropylene nylon bag. In Southeastern European countries, 10 kg of tomatoes are packed in each of the cardboard boxes.

Boxes and packaging costs have a significant proportion in direct production costs. While in Turkey cost of the boxes ranks second with 22% among direct production costs, in Southeastern European countries it ranks third with 13%. The price of boxes has a significant effect on the production cost.

In the negotiations made with the producers, the boxes are marketed within the tomato prices in some regions, while in some others they are marketed by deducting the tare. In the study, since the tare used in packaging was weighed with tomatoes, the price paid for the box was partially returned to the producer. The weight of boxes used in packaging was 0.300 $kg.box^{-1}$. Throughout the production period, 101,280 boxes were used in packaging. In cost calculations, the total weight of 30,384 kg has been is added to tomato yield.

3.6 Bıologıcal and Agrıcultural Pest Control

Since insect netting is stretched on the ventilation openings in high technology greenhouses established in recent years, the risk of disease transmission by insects and pests is reduced. In greenhouses yellow sticky traps, double traps and tuta pheromone traps are used. The price paid for pesticides used against diseases that occur in high technology greenhouses in Mediterranean conditions is 0.197 $€.m^{-2}$. In the study, the amount spent for biological and agricultural pest control in the greenhouse under producer conditions was determined as 0.228 $€.m^{-2}$. This has a share of 20% in direct production costs.

In Southeastern European countries, the amount paid for the protection of plants in greenhouses where soilless agriculture is carried out, has a 0.55% share in direct production costs [13]. This means a higher usage of pesticides or a higher cost of pesticides under the production conditions in Turkey.

Fertilizer: In the soilless production of truss tomatoes in the greenhouse, plant nutrients are applied through a drip irrigation system in such a way that each plant is served by a dripper. Fertilizer concentrations provided with irrigation are regulated by controlling EC and pH. The amounts of fertilizer applied to the greenhouse with drip irrigation during the production period are given in Table 5. The price paid for fertilizers was 1.615 $€.m^{-2}$. This has a share of 14% in direct production costs. This rate is 11% in Southeastern European countries [13].

3.7 Other Expenses

Other expenses in the greenhouse include the payments made for the bumble bees used for fertilization, cleaning materials, materials used for hygiene purposes (aprons, gloves, etc.) and good agricultural practices (GAP). The amount of other expenses recorded during the production period has been calculated as 0.272 $€.m^{-2}$ per unit greenhouse area.

Labor: In the greenhouse where the research was carried out in Mediterranean climate conditions, 16 people were employed as 8 $man.month^{-1}ha^{-1}$. Workforce in the greenhouse was used for removing the suckers (axillary shoots), rope wrapping, fertilization, spraying pesticide and harvesting processes. In addition, an agricultural engineer was employed to direct the workers in the greenhouse and make necessary interventions by monitoring the climate computer in the greenhouse. Transactions involving the purchase and sale of goods were carried out by the business manager. Workers in production were employed all year with minimum wage.The minimum wage including taxes was accepted as 643 $€.month^{-1}$ with taxes.

The amount to be paid to the agricultural engineer was calculated as 900 $€.month^{-1}$. Based on these payments, the labor and management cost corresponding to the unit greenhouse area for the production of truss tomatoes in the greenhouse was determined as 6.72 $€.m^{-2}$. This value corresponds to 37% of the total production expenses.

Table 5. Fertilizer types, quantities and costs used in the production of truss tomatoes

Fertilizer Applied	Quantity Used (kg)	Fertilizer Cost (€)	Fertilizer Used ($kg.da^{-1}$)	Fertilizer Used ($kg.ton^{-1}$ yield)	% Utilized
Calcium nitrate	8625	6071.990	431.25	14.375	0.24
Demir (Ferrostrene)	296	4290.766	14.8	0.493	0.01
Potassium nitrate	7300	8791.755	365	12.167	0.21
Potassium sulfate	2350	2611.928	117.5	3.917	0.07
MKP albatros	2075	4137.645	103.75	3.458	0.06
Magnesium sulfate	4300	1268.630	215	7.167	0.12
Ammonium nitrate	50	23.574	2.5	0.083	0.00
Copper sulfate	25	85.723	1.25	0.042	0.00
Borax	25	32.146	1.25	0.042	0.00
Nitric acid	10366	4988.243	518.3	17.277	0.29
TOTAL	35412	32302.401	1770.6	59.020	1.00

Table 6. Working hours and costs required for different processes for greenhouse truss tomato production in soilless culture in Southeastern European countries [13]

II Tractor services including labor				
Transportation	Implementation	3 (pcs)	1,000 ($€.pcs^{-1}$)	3,000.00 (€)
III Labor costs				
Planting	Working hours	600 (h)	0.98 ($€.h^{-1}$)	588.00 (€)
Pruning	Working hours	2,000 (h)	0.98 ($€.h^{-1}$)	1,960.00 (€)
Loading	Working hours	2,000 (h)	0.98 ($€.h^{-1}$)	1,960.00 (€)
Removing leaves	Working hours	2,500 (h)	0.98 ($€.h^{-1}$)	2,450.00 (€)
Plant protection applications	Working hours	30 (h)	0.98 ($€.h^{-1}$)	29.40 (€)
Havesting (70 kg h^{-1})	Working hours	5,000 (h)	0.98 ($€.h^{-1}$)	4,900.00 (€)
Sorting and packaging	Working hours	4,000 (h)	0.98 ($€.h^{-1}$)	3,920.00 (€)
IV Other expenses				
Fertilizer analysis	Service purchase	15 (pcs)	75.00 ($€.pcs^{-1}$)	1,125.00 (€)
External consultancy	Service purchase	6 (pcs)	200.00($€.pcs^{-1}$)	1,200.00 (€)
Total other variable costs (II + III + IV)				21,132.40 (€)

Table 7. Production costs and percentages calculated per unit greenhouse area in the production of truss tomatoes in soilless culture

No.	Expenditure Item	Mediterranean		Southeast Europe	
		$€.m^{-2}$	%	$€.m^{-2}$	%
1	Biological and agricultural pest control and special fertilizer	0.228	1.26	0.10	0.49
2	Fertilizer	1.615	8.90	2.00	9.87
3	Fuel (coal in Maditerranean, natural gas in Southeast Europe)	3.390	18.68	7.80	38.48
4	Boxes and packaging	2.529	13.94	2.40	11.84
5	Seedlings	1.204	6.64	3.00	14.80
6	Cultivation medium (Cocopeat in Mediterranean, rockwool in SE)	1.233	6.79	0.75	3.70
7	Good farming + Bumble bees + Cleanliness and Hygiene	0.272	1.50	0.83	4.09
8	Labor 0.8 man/da	6.720	37.03	2.11	10.41
9	Electricity expenses	0.955	5.26	0.08	0.39
10	Irrigation water	-	-	1.20	5.92
	TOTAL	18.146	100.00	20.27	100.00

Labor cost calculations based on working hours for truss tomato production in Southeastern European countries are given in Table 6. As can be seen from the table, the total working hours required in a 1 ha greenhouse for planting, pruning, cleaning, harvesting and packaging is 16,130 h. Considering the length of a production period of 10 months in the greenhouse under the climatic conditions of Southeastern Europe, this period is equivalent to 7 man/month ha. For the soilless production of truss tomatoes in Southeastern European countries, the labor and service purchase costs incurred during the production period add up to 2.11 €.m^{-2}. This value is equivalent to 9.3% of the total production costs.

3.8 Total Productıon Costs

The total production costs incurred for the production of truss tomatoes in soilless culture in a regularly heated greenhouse under Mediterranean climate conditions are calculated per unit greenhouse area and given in Table 7. As can be seen from the table, the production costs calculated per unit greenhouse area for the production of truss tomatoes in soilless culture are 18.146 €.m^{-2} while the production costs of truss tomatoes calculated for Southeastern Europe were 20.27 €.m^{-2}.

The highest production cost in the production of truss tomatoes in regularly heated high technology greenhouses under Mediterranean climate conditions was labor cost with a ratio of 37.03%. Heating expenses, which take the second place, constitute 18.68% of total production costs [11]. However, when the electrical energy used by the circulation pumps used in heating is taken into account, it is seen that this rate exceeds 20%. Box and packaging expenses, which are also included in production expenses, constitute the third highest production expense with a ratio of 13.94%. However, in the marketing of tomatoes, since the boxes used for packaging are included in the weighing, they are marketed in within the price of the product. For the stated reason, the expenses made for boxes and packaging do not actually affect the production cost significantly.

In the greenhouse where the research was carried out, planting was made in the last week of August and the first harvest started in the second week of November. The highest yield was achieved in May with 6.64 kg.m^{-2} (Fig. 1). In June and July, when the air temperature rises, the amount of second quality products increased. The cumulative yields of truss tomatoes in Mediterranean climatic conditions (Adana) when the temperature is kept at a minimum of 15°C are given on a weekly basis in Fig. 1. As can be seen from the figure, 29 kg.m^{-2} truss tomato yield was obtained from the production that started in the last week of August and ended in mid-July.

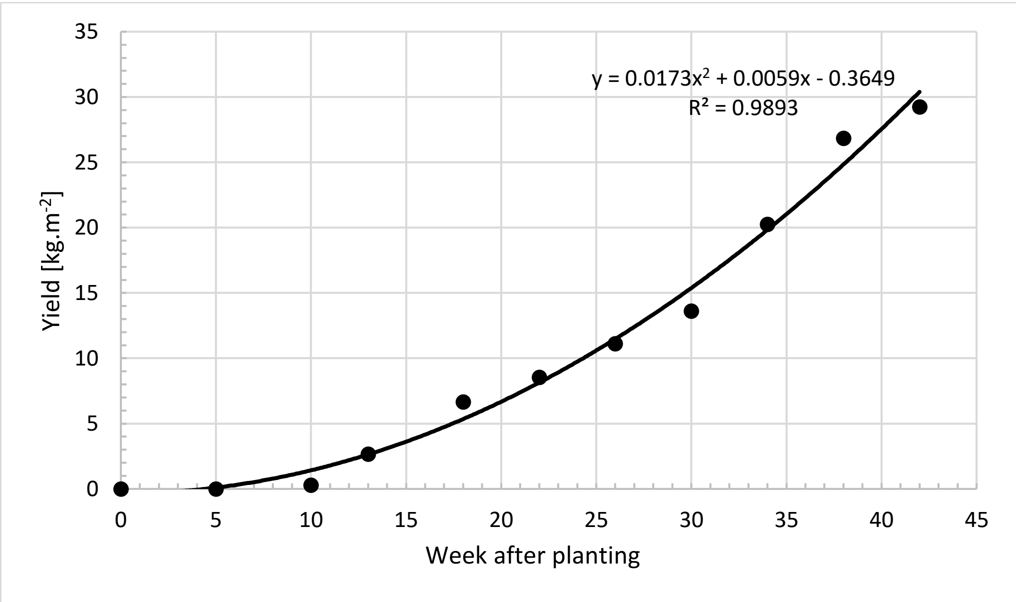

Fig. 1. Cumulative yield values after planting in a regularly heated PE plastic greenhouse with a thermal curtain in Mediterranean conditions (Adana)

Depending on the product supply, the prices of truss tomatoes vary according to the months of the year. As can be seen from the Fig. 1 the highest sales prices are in April (1.54€.kg^{-1}). Due to the decrease in product quality and tomato production in open-field, prices of truss tomato reached the lowest level at 0.60 €.kg^{-1} in July

In the study, when determining the unit cost of the truss tomatoes produced in the greenhouse, the total box weight used in the marketing of the tomato was added to the yield obtained during the production period. The yield of truss tomatoes harvested during the production period from the 20,800 m^2 greenhouse in Mediterranean climate conditions was 584,854 kg. When the weight of the packaging boxes marketed with tomatoes is added to the tomato yield, the yield taken into account in the calculations was determined as 615,238 kg (30.76 kg.m^{-2}).

The yield of truss tomatoes obtained from soilless production in high technology greenhouses in Southeastern Europe is given as 40 kg.m^{-2}. The reason for 25% more efficiency compared to Mediterranean climate conditions is due to the length of the production period [13].

Table 7. illustrates the monthly production costs and market prices of truss tomatoes cultivated in soilless culture in a regularly heated greenhouse in Adana climate conditions. As can be seen from the table, when the yield obtained at the end of the the production season and the production expenditures made are taken into account, the unit cost of tomato is 0.59 €.kg^{-1}.

4. CONCLUSION

The pricing dynamics of truss tomatoes fluctuate throughout the year in response to product supply. According to the presented Fig. 1, the highest sales prices, peaking at 1.54€.kg-1, are evident in April. However, a noticeable decrease in product quality, coupled with open-field tomato production, contributes to a significant drop in truss tomato prices to their lowest point in July.

In the conducted study, the determination of the unit cost for greenhouse-produced truss tomatoes involved the inclusion of the total box weight utilized in marketing with the yield obtained during the production period.

Comparatively, the yield of truss tomatoes from soilless production in high-tech greenhouses in Southeastern Europe is reported to be 40 kg.m-2, indicating a 25% increase in efficiency, as documented by Popsimonova et al. [13]. This efficiency boost is attributed to the extended production period in the soilless cultivation system.

In this study offers insights into the monthly production costs and market prices of truss tomatoes cultivated in soilless culture within a consistently heated greenhouse under Adana climate conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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