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COMPARISON OF HEAT REQUIREMENTS IN GREEN-HOUSES FOR KIRŞEHIR AND KAHRAMANMARAŞ PROVINCES

ABSTRACT

Greenhouses are artificial growing environments that can provide the growth factors required for the production of crop plants out of season. In these structures, the low temperature values that occur during the year cause losses in yield and quality because they are not suitable for plant cultivation. In order to be able to grow out of season in these periods, the amount of heat required by the plants should be provided with additional heating. In the study carried out to determine the amount of heat needed in greenhouses throughout the year for the provinces of Kırşehir and Kahramanmaraş, which are located in two different regions of Turkey, the heat requirements that will arise in the presence or absence of a thermal screen in greenhouses with the same characteristics were calculated. In the calculations, the most common tomato plant grown in both provinces has been considered. Accordingly, if the greenhouse temperature is kept at a constant temperature of 18°C throughout the year, the heat energy requirements that emerge during the year are 469.90 kWh m^{-2} for Kırşehir and 254.71 kWh m^{-2} for Kahramanmaraş. In the case of using a thermal screen, these values were calculated as 401.53 kWh m^{-2} for Kırşehir province and 218.91 kWh m^{-2} for Kahramanmaraş province. As a result of the study, the amount of heat energy needed in greenhouses in provinces decreased with the use of thermal screens. It has been determined that this situation is extremely important in terms of reducing the share of heating in production costs and the amount of carbon dioxide released into the atmosphere by fossil energy sources used for heating purposes.

Keywords: *Greenhouse, heat requirement, thermal screen, energy saving*

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INTRODUCTION

A well-designed greenhouse should provide the necessary climatic conditions for plant growth and production throughout the year and should keep important climatic factors as close as possible to the determined optimum values (von Elsner et al., 2000). The main goal of environmental control in greenhouses is the optimization of crop production. The greenhouse cover and the heating system cause a change in climatic conditions compared to external conditions such as increased temperature, water vapor pressure of the air, radiation, reduced air velocity and large fluctuations in carbon dioxide concentration. These changes have an impact on the growth, production and quality of the product (Bakker, 1995). Climate is an important factor affecting both the structural and functional properties of greenhouses. The design of a greenhouse aims to take advantage of external climatic conditions to improve the indoor microclimate. Therefore, the overall greenhouse design is significantly affected by the climate and the latitude of its location (von Elsner et al., 2000). Even in temperate climates such as the Mediterranean region, greenhouse heating is necessary to maximize crop production in terms of quantity and quality, thereby increasing overall greenhouse efficiency. Heating costs not only have a critical impact on profitability, but can also determine the long-term survival of the greenhouse industry. Besides costs, high energy consumption for heating is associated with environmental pollution from harmful gas emissions (Tadj et al., 2010).

In order to obtain the highest efficiency expected from plant production in greenhouses, it is necessary to heat the greenhouses in periods when the outdoor temperature is low. Today, high energy prices increase the heating costs in greenhouses and the cost of the products grown increases. In order to provide the most suitable indoor conditions in terms of quality, quantity and development time of the products grown in greenhouses, which are mainly used for off-season production, heating should be done in cold periods in winter. During these periods, some problems arise in the quality, quantity and harvest time of the products grown in greenhouses that are not heated (Boyacı, 2021). A traditional solution to low temperature problems is to use heating systems inside the greenhouse. Since energy and fuel prices are not cheap, their efficient use directly affects production costs and must be balanced with product loss risks (Baptista et al., 2012; Tamimi et al., 2013). According to the climatic characteristics of the region, the type of product grown and the type of production, heating costs constitute 30-80% of the total production costs in heating with classical fossil fuels (Tekinel and Baytorun, 1990; Santamouris, 1993, Yağcıoğlu, 1999; Kendirli and Çakmak, 2010). However, the amount of heat added to the greenhouse depends on the changing weather conditions, where winter becomes the critical period (Ozgener et al., 2005). Greenhouses are important for stable food production, but require large amounts of energy to maintain their microclimate in regions with harsh climates (Kim et al., 2018). Greenhouses are high energy consuming and seasonal production facilities. In some cases, energy consumption in greenhouses accounts for 50% of the greenhouse production cost. High energy consumption has become an important factor hindering the development of greenhouses. To increase the energy efficiency of the greenhouse, it is important to estimate the energy consumption (Shen et al., 2018). The correct calculation of the amount of heat energy, which constitutes a large part of the energy used in greenhouses, is very important for the production to be made. In recent years, greenhouse activities in our country have spread from the Mediterranean and Aegean regions, where cultivation is carried out depending on ecology, and has started to develop towards regions with modern greenhouses and geothermal resources, which are renewable energy sources. However, in Turkey, which has the potential to heat 30000 decares of greenhouses with geothermal resources, the area of greenhouses heated by geothermal energy is 4344 decares (Anonymous, 2021a). The effective use of this potential is very important in terms of a more environmentally friendly and sustainable greenhouse cultivation, as well as reducing the share of heating in production costs. In terms of degree day regions according to provinces in TS825, Kırşehir province III. in the region, Kahramanmaraş province II. is located in the region. According to the data of TUİK (2021a), it is seen that Kırşehir province ranks 41st and Kahramanmaraş province 26th in terms of greenhouse area in our country. However, there are 7 important geothermal fields in the districts of Kırşehir, one of these two provinces. The temperature of the hot waters coming out of these fields is between 30.3-76.5°C (Boyacı et al., 2016). The temperature of the thermal springs in Ilıca town of Onikişubat district of Kahramanmaraş province generally varies between 41-49ºC according to the season (Sandal and Karademir, 2015). Kırşehir and Kahramanmaraş provinces are among the provinces where greenhouse activities can be increased but the full potential cannot be developed with these geothermal resources.

Turkey is divided into 4 different regions in terms of degree day regions according to the provinces. In this study, it was carried out to compare the amount of heat energy, fuel amount, fuel cost and amount of carbon dioxide to be released into the atmosphere in greenhouses with the same structure in the provinces of Kırşehir and Kahramanmaraş located in different regions.

MATERIAL AND METHOD

In the study, greenhouse sizes for Kırşehir and Kahramanmaraş provinces are given in Table 1. In the calculations, the total heat transmission coefficient required for a single layer of PE plastic is taken as ka′ =7.0 W $m^{-2}K^{-1}$ for a wind speed of 4 m s^{-1}.

Table 1. Greenhouse dimensions considered in the calculation

Equipment specifications	Dimensions	Equipment specifications	Dimensions
Number of partitions	4	Front area	317.05 m^2
Partition width	8.00 m	Roof area	2239.11 m^2
Greenhouse length	60.00 m	Greenhouse volume	9408 m^3
Roof slope angle	27.70°	Cover area	2976.15 m^2
Side wall height	3.50 m	Floor area	1920 m^2
Roof height	2.10 m	Roof length	9.33 m
Side wall area	420 m^2	Ridge height	5.60 m

The heat requirement in the greenhouse was calculated with the ISIGER-SERA expert system model (Baytorun et al., 2016). The ISIGER-SERA model calculates the heat requirement in the greenhouse from hourly temperature, solar radiation and wind speed values, taking into account the temperature rise. In the calculations made with this model, the results obtained are closer to the real values, since the temperature rise of the solar radiation stored in the greenhouse during the day is taken into account. In the calculation of the heat requirement for tomato plants grown in greenhouses in Kırşehir and Kahramanmaraş provinces, the greenhouse temperature is planned as 18°C and the ventilation temperature as 25°C. A steel pipe heating system placed on the side walls is planned as a heating system. Correction factor depending on the impermeability of the termal screen is taken as 11.05 W m^{-2} K^{-1} if the screen is moderately insulated and closed.

In the ISIGER-SERA model, the heat requirement is calculated by Equation 1, and the required fuel consumption in greenhouses based on annual heat energy is calculated by Equation 2. The CO_2 emissions of the fuels used in greenhouse heating to the atmosphere are calculated with Equation 3 (Baytorun et al., 2016).

$$Q = \sum_{n=1}^{8760}(((\vartheta_{in} - \vartheta_{ioHn} - \Delta\vartheta_{spn}) \times k_a' * A_H \times (1 - EE_{ES})) \times t_{si}) \quad (1)$$

$$\mathrm{By} = \frac{\mathrm{Q}}{\mathrm{Hu} \times \eta\mathrm{ges}} \quad (2)$$

$$\mathrm{SEGMy} = \mathrm{By} \times \mathrm{Hu} \times \mathrm{FSEG} \quad (3)$$

In equality; Q: Heat energy requirement of the greenhouse (Wh), ϑ_i: Desired in-door temperature in the greenhouse (°C), ϑ_{ioHn}: Actual temperature in the unheated gre-enhouse (°C), $\Delta_{\vartheta Spn}$: The temperature rise (°C) due to the characteristics of the greenhou-se, ka': Total heat transmission coefficient of the cover material (W $m^{-2}K^{-1}$), A_H: Cover surface area of the greenhouse (m^2), EE_{ES}: Heat saving provided by the thermal screen (-), n: Hours of the year, t_{Si}: Time period (1 h) , By: The amount of fuel corresponding to the unit area (kg m^{-2} or m^3 m^{-2}), Hu: The lower heating value of the fuel (kWh kg^{-1}), ηges: Average operation efficiency (%), SEGMy: Annual CO_2 emission amount (kg eq. CO_2), FSEG: CO_2 emission conversion coefficient according to fuel type (kg eq. CO_2 kWh^{-1}).

The lower heating values of the imported coal to be used in the heating of the greenhouse are 7 kWh, the average operating efficiency is 65%, the price is 0.556 TL (Turkish Lira) and the CO_2 emission conversion coefficient is 0.448 kg Eq. Taken as CO_2 kWh^{-1} (Anonymous, 2021b).

RESULT AND DISCUSSION

Evaluation of the climate of Kırşehir and Kahramanmaraş provinces in terms of greenhouse cultivation

In Kırşehir, a continental climate with cold and snowy winters and hot and dry summers is observed (Anonymous, 2021c). Kahramanmaraş is located in the area where the Mediterranean, Eastern Anatolia and Southeastern Anatolia regions come closest to each other. Mediterranean climate is seen in the south of the province and continental climate in the north. Summers are hot and winters are cold in the province. However, the fact that the province's territory is located in the transition area of the Mediterranean and Southeastern Anatolia regions has caused the climatic conditions in the province to differ (Anonymous, 2021d).

According to the TS825 standards of Kırşehir province III. while located in the region, Kahramanmaraş province II. is located in the region. The long-term annual average daily temperature values of the provinces of Kırşehir and Kahramanmaraş, which have different climatic characteristics, are given in Table 2.

Table 2. Long annual average daily temperature values of Kırşehir and Kahramanmaraş provinces depending on months (°C)

Province	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
III. Region		**Heating**					Ventilation + Shading				**Heating**	
Kırşehir	**-0.3**	**1.1**	**5.5**	10.7	15.2	19.5	22.9	22.8	18.4	12.6	6.2	**1.8**
II. Region		**Heating**			Ventilation + Shading		**Cooling**		Ventilation + Shading		**Heating**	
Kahramanmaraş	**4.7**	**6.1**	**10.4**	15.2	20	25	**28.3**	**28.4**	25	18.8	**11.6**	**6.5**

As can be seen in the figure, in the province of Kırşehir, which has continental climate characteristics, 6 months of heating is required in the December-April period according to the daily average temperature. In the province of Kahramanmaraş, heating need arises for 5 months in the period of December-February. Accordingly, when compared in terms of greenhouse cultivation, it is clear that the heating need in Kırşehir will be higher than in Kahramanmaraş. If the daily average temperature is between 12-22°C, ventilation is sufficient to regulate the indoor air in greenhouses. While the internal temperature values can be made suitable for plant cultivation with ventilation + shading between May and October in Kırşehir, in Kahramanmaraş province, the need for ventilation + shading for 5 months in April-June and September-October, and cooling for 2 months in July and August arises. Accordingly, while the heating need is high in Kırşehir, it is seen that the need for cooling will arise in Kahramanmaraş. It is possible to produce for 12 months in the presence of cheap renewable energy sources in the face of low external temperature values in Kırşehir province. Kahramanmaraş province, on the other hand, has a lower heating need with the advantage of having a Mediterranean climate. However, the energy cost required for cooling in July and August will be high. Since the plants produced in the greenhouse are also produced in open field conditions during these periods, it would be more appropriate to terminate the production and leave the greenhouses empty. In this case, the production period in Kahramanmaraş will be 10 months.

Comparison of greenhouse area and production amounts of Kırşehir and Kahramanmaraş provinces

The greenhouse agricultural areas of Kırşehir and Kahramanmaraş provinces are given in Table 3 (TUIK, 2021a). Looking at the chart, it is seen that Kahramanmaraş has approximately 3.9 times more greenhouse production area than Kırşehir.

Table 3. Greenhouse agricultural areas of Kırşehir and Kahramanmaraş provinces

Type of greenhouse	Covered agricultural area (da)	
	Kırşehir	Kahramanmaraş
Low Tunnel	6	-
Glass Greenhouse	-	0.3
Plastic Greenhouse	268	1183.2
High Tunnel	31	-
Total	**305**	**1183.5**

The greenhouse production amount of Kırşehir and Kahramanmaraş provinces is given in Table 4 (TUIK, 2021b). Looking at the chart, it is seen that Kahramanmaraş province has approximately 2.8 times more greenhouse production than Kırşehir province.

Table 4. Greenhouse production amount of Kırşehir and Kahramanmaraş provinces

Greenhouse Vegetables	Type of greenhouse	Production amount (tons)	
		Kırşehir	Kahramanmaraş
Lettuce	Low Tunnel	2	-
Onion	Low Tunnel	3	-
Beans	Plastic Greenhouse	4	-
Lettuce (Curly)	Plastic Greenhouse	3	-
Lettuce	Plastic Greenhouse	3	-
Spinach	Plastic Greenhouse	2	-
Pepper	Plastic Greenhouse	-	115
Cucumber	Plastic Greenhouse	-	5310
Eggplant	Plastic Greenhouse	5	-
Tomatoes	Plastic Greenhouse	8629	18880
Onion (Fresh)	Plastic Greenhouse	2	-
Lettuce	High Tunnel	4	-
Cucumber	High Tunnel	10	-
Tomato	High Tunnel	18	-
Onion	High Tunnel	11	-
Total		**8696**	**24305**

Considering the area and production amounts, it was determined that the production amount corresponding to 268 decares of greenhouse area in Kırşehir was 8648 tons, while the total production amount was 24305 tons in an area of 1183.5 decares in Kahramanmaraş. Accordingly, while the average production per decare in Kırşehir was 32.27 tons, it was determined that it was 20.54 tons in Kahramanmaraş.

As a result of the length of the production period and the regulation of the climatic conditions desired by the plants with automation systems, especially in the greenhouses established in the geothermal regions where the continental climate is dominant, the yield of tomatoes has increased to 50 kg m^{-2} and above. The yield of tomatoes obtained from modern high-tech greenhouses established in the Mediterranean region varies between 30-32 kg m^{-2} due to the short production period (Baytorun et al., 2019). Greenhouse cultivation in Kırşehir is concentrated in Merkez, Çiçekdağı and Kaman districts. While production is carried out in modern geothermal greenhouses throughout the year in Çiçekdağı and Merkez, production is carried out in Kaman district depending on ecological conditions. In the months when the temperature drops, plants such as tomatoes and cucumbers are grown, as well as plants with low indoor temperature demands such as lettuce and onions. In Kahramanmaraş, greenhouse cultivation is concentrated in the districts of Dulkadiroğlu, Onikişubat and Türkoğlu, which have a Mediterranean climate. Here, too, it has been determined that the amount of production obtained from the unit area is lower due to reasons such as production depending on ecological conditions in general, and the high temperatures that occur in summer periods negatively affect production.

Comparison of heat requirements of Kırşehir and Kahramanmaraş provinces

In the provinces of Kırşehir and Kahramanmaraş, the seasonal and monthly calculated values of the heat energy required in case of not using thermal screens in greenhouses are given in Table 5.

Table 5. The heat energy requirement in case of not using a thermal screen

Seasons	Months	Heat Energy Requirement, kWh month^{-1}			
		Kırşehir	**Ratio (%)**	**Kahramanmaraş**	**Ratio (%)**
Winter	December	174098	19	108898	22
	January	204208	23	131044	27
	February	152336	17	95155	19
	Total	**530642**	**59**	**335097**	**69**
Spring	March	108382	12	60502	12
	April	54540	6	23848	5
	May	27019	3	4097	1
	Total	**189941**	**21**	**88447**	**18**
Summer	June	6817	1	-	-
	July	176	-	-	-
	August	460	-	-	-
	Total	**7453**	**1**	-	-
Autumn	September	13479	1	-	-
	October	48731	5	9046	2
	November	111962	12	56449	12
	Total	**174172**	**19**	**65495**	**13**
Annual	**Total**	**902208**	**100**	**489039**	**100**

When we look at the table, it is seen that the most heat energy requirement in the provinces occurs in the winter months according to the seasons. In addition, 59% of the total heat energy in Kırşehir occurs during the winter months, while this rate is calculated as 69% in Kahramanmaraş. Considering the heat energy requirement by months in Kırşehir and Kahramanmaraş provinces, it is seen that while the heat energy required in Kırşehir province is 204208 kWh month^{-1} in January, this value is 131044 kWh month^{-1} in Kahramanmaraş. While the annual heat requirement in Kırşehir is 902208 kWh year^{-1}, it is calculated as 489039 kWh year^{-1} in Kahramanmaraş. Accordingly, it has been determined that the annual heat energy requirement in Kırşehir province is 1.84 times more heat energy requirement than Kahramanmaraş province.

In the provinces of Kırşehir and Kahramanmaraş, the seasonal and monthly calculated values of the heat energy required in case of using a thermal screen in greenhouses are given in Table 6. The heat requirement throughout the year in Kırşehir province is 770938 kWh. In Kahramanmaraş, it was calculated as 420300 kWh.

Table 6. The heat energy requirement in case of not using a thermal screen

Seasons	Months	Kırşehir Province Heat Energy Requirement Values, kWh month^{-1}			
		Kırşehir	**Ratio (%)**	**Kahramanmaraş**	**Ratio (%)**
Winter	December	151440	20	94447	22
	January	178219	23	114497	27
	February	132513	17	82150	20
	Total	**462172**	**60**	**291094**	**69**
Spring	March	91068	12	50744	12
	April	44048	6	19194	5
	May	21043	3	3305	1
	Total	**156159**	**20**	**73243**	**17**
Summer	June	5189	1	-	-
	July	128	-	-	-
	August	417	-	-	-
	Total	**5734**	**1**	**-**	**-**
Autumn	September	11145	1	-	-
	October	40687	5	7881	2
	November	95041	12	48082	11
	Total	**146873**	**19**	**55963**	**13**
Annual	**Total**	**770938**	**100**	**420300**	**100**

In the study, in the calculations made in Kırşehir and Kahramanmaraş provinces, the annual heat energy required for the unit area is given in Figure 1 in case the greenhouses are without and with thermal screens.

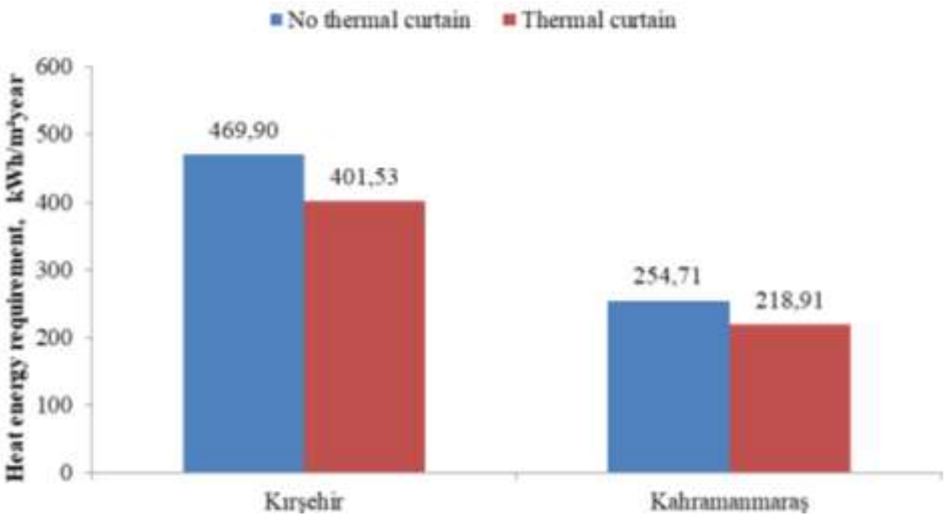

Figure 1. The amount of heat energy required per unit area in greenhouses

Accordingly, while the amount of heat energy required for the unit area is 469.9 kWh m^{-2} year^{-1} for Kırşehir province without thermal screen, this value is calculated as

254.71 kWh m^{-2} $year^{-1}$ for Kahramanmaraş province. In case the thermal screens in greenhouses are moderately insulated and closed, it is calculated as 401.53 kWh m^{-2} year for Kırşehir province and 218.91 kWh m^{-2} year for Kahramanmaraş province. In the provinces of Kırşehir and Kahramanmaraş, the amount of heat energy required per unit area is given in Table 7 if single layer aluminum thermal screens are used and the thermal screens are moderately insulated and closed.

Table 7. Saving rate due to the impermeability of the thermal screen

Equipment	Kırşehir	Kahramanmaraş
Without thermal screen (kWh m^{-2} $year^{-1}$)	469.90	254.71
Thermal screen (kWh m^{-2} $year^{-1}$)	401.53	218.91
Heat saving rate (%)	15	14

Accordingly, in the case of using thermal screens in the provinces, the annual amount of heat energy to be saved has been calculated as approximately 15%. Increasing energy costs in heated greenhouses cause manufacturers to discuss the profitability of heating. For this reason, energy conservation in heated greenhouses is as important as heating in greenhouses in terms of profitability and energy efficiency (Baytorun and Gügercin, 2015). In studies conducted with different thermal screens in greenhouses, they provided a heat saving of 21.7-35% depending on the sealing of the thermal screens (Le Quillec et al., 2005; Park et al., 2015; Kim et al., 2018; Shakir and Farhan, 2019). As can be seen in the calculations made, it is seen that the heat requirement decreases if necessary precautions are taken for energy conservation in greenhouses. Accordingly, it is also very important in terms of reducing the share of heating in energy costs.

Comparison of the amount of fuel in greenhouses for Kırşehir and Kahramanmaraş provinces

In the provinces of Kırşehir and Kahramanmaraş, the seasonal and monthly calculated values of the fuel amounts that occur in the case of using imported coal for heating in greenhouses are given in Table 8.

Table 8. Amount of fuel used for heating greenhouses

Seasons	Month	Fuel quantities (kg)			
		No thermal screen		Thermal screen	
		Kırşehir	Kahramanmaraş	Kırşehir	Kahramanmaraş
Winter	December	39411	24652	34282	21380
	January	46227	29665	40344	25919
	February	34485	21541	29997	18597
	Total	120123	75857	104624	65896
Spring	March	24535	13696	20615	11487
	April	12346	5399	9971	4345
	May	6116	927	4764	748
	Total	42998	20022	35350	16580
Summer	June	1543	0	1175	0
	July	40	0	29	0
	August	104	0	94	0
	Total	1687	0	1298	0
Autumn	September	3051	0	2523	0
	October	11031	2048	9210	1784
	November	25345	12779	21515	10884
	Total	**39428**	**14826**	**33248**	**12669**
Annual	**Total**	**204236**	**110706**	**174520**	**95145**

In the case of using imported coal for heating and no thermal screens in greenhouses, the amount of fuel to be used in Kırşehir province is calculated as 204236 kg year^{-1}, while it is calculated as 110706 kg year^{-1} in Kahramanmaraş. In the case of using a thermal screen, it was calculated as 174520 kg year^{-1} in Kırşehir and 95145 kg year^{-1} in Kahramanmaraş. In the case of using a thermal screen, it has been calculated that there is a decrease of 29716 kg year^{-1} in Kırşehir and 15561 kg year^{-1} in Kahramanmaraş.

Baytorun et al. (2016) found that 2.62 times more fuel was required in Kütahya compared to Aydın when the internal temperature was kept at 16/18ºC during the day/night in a single-layer PE greenhouse. In addition, it was stated that 3.32 times more fuel amount is needed compared to Antalya province. (Boyacı, 2018) In the case of using single-layer PE plastic in Kırşehir and Antalya provinces, the fuel cost of Kırşehir province is 2.69 times more than Antalya province, and in case of using fuel oil for heating 1.20 times compared to imported coal, 2.45 times in case of using natural gas, and in case of using imported coal reported that fuel costs will be 2.04 times more than natural gas. In the study, it was determined that in the case of using imported coal, 1.84 times more fuel is needed in Kırşehir compared to Kahramanmaraş. In addition, it has been determined that there will be significant reductions in the amount of fuel for Kırşehir and Kahramanmaraş provinces in case of using thermal screens.

Comparison of fuel costs for Kırşehir and Kahramanmaraş provinces

In the provinces of Kırşehir and Kahramanmaraş, the seasonal and monthly calculated values of the fuel cost incurred in the case of using imported coal for heating in greenhouses are given in Table 9.

Table 9. Cost of fuel used for heating greenhouses

Seasons	Months	Fuel cost (TL)			
		No thermal screen		Thermal screen	
		Kırşehir	Kahramanmaraş	Kırşehir	Kahramanmaraş
Winter	December	22022	13774	19156	11947
	January	25830	16576	22543	14483
	February	19269	12036	16761	10391
	Total	**67120**	**42386**	**58460**	**36820**
Spring	March	13709	7653	11519	6419
	April	6899	3017	5572	2428
	May	3418	518	2662	418
	Total	24025	11188	19752	9264
Summer	June	862	-	656	-
	July	22	-	16	-
	August	58	-	53	-
	Total	**943**	**-**	**725**	**-**
Autumn	September	1705	-	1410	-
	October	6164	1144	5146	997
	November	14162	7140	12022	6082
	Total	**22031**	**8284**	**18578**	**7079**
Annual Total		**114120**	**61858**	**97515**	**53163**

In the case of not using a thermal screen in greenhouses, it was calculated as 114120 TL year^{-1} in Kırşehir and 61858 TL year^{-1} in Kahramanmaraş. In the case of using a thermal screen, it was calculated as 97515 TL year^{-1} in Kırşehir and 53163 TL year-1 in Kahramanmaraş. In case of using a thermal screen, it has been calculated that there is a decrease of 16605 TL year^{-1} in Kırşehir and 8695 TL year^{-1} in Kahramanmaraş in the fuel costs. According to the climatic characteristics of the region, the type of product grown and the production method, heating costs constitute 30-80% of the total production costs in heating with classical fossil fuels (Tekinel and Baytorun 1990; Santamouris, 1993, Yağcıoğlu, 1999; Kendirli and Çakmak, 2010; Shen et al., 2018). In the study, in the case of using imported coal in Kırşehir, which has a continental climate, fuel costs will be approximately 1.84 times higher than in Kahramanmaraş. Accordingly, it is clear that the share of heating in production costs will be much higher in Kırşehir. In addition, it has been determined that in the case of using thermal screens, significant savings will be made in fuel costs throughout the year.

Comparison of carbon dioxide amount for Kırşehir and Kahramanmaraş provinces

In the provinces of Kırşehir and Kahramanmaraş, the seasonal and monthly calculated values of the amount of carbon dioxide released into the atmosphere in the case of using imported coal for heating in greenhouses are given in Table 10.

Table 10. The amount of carbon dioxide emissions due to the fuel used in greenhouses

Seasons	Months	Carbon dioxide emissions (CO_2 equivalent kg year^{-1})			
		No thermal screen		Thermal screen	
		Kırşehir	**Kahramanmaraş**	**Kırşehir**	**Kahramanmaraş**
Winter	December	123594	77308	107508	67049
	January	144969	93029	126519	81282
	February	108144	67551	94072	58319
	Total	**376707**	**237888**	**328099**	**206650**
Spring	March	76941	42951	64650	36024
	April	38718	16930	31270	13626
	May	19181	2908	14939	2346
	Total	**134841**	**62789**	**110858**	**51996**
Summer	June	4839	-	364	-
	July	125	-	91	-
	August	327	-	296	-
	Total	**5291**	**-**	**4071**	**-**
Autumn	September	9569	-	7912	-
	October	34595	6422	28884	5595
	November	79483	40074	67470	34134
	Total	**123646**	**46495**	**104266**	**39729**
Annual	**Total**	**640484**	**347173**	**547295**	**298374**

While the amount of carbon dioxide emitted to the atmosphere in the case of not using a thermal screen in greenhouses was 640484 kg year^{-1} in Kırşehir, it was calculated as 347173 kg year^{-1} in Kahramanmaraş. In the case of using a thermal screen, it was calculated as 547295 kg year^{-1} in Kırşehir and 298374 kg year^{-1} in Kahramanmaraş. In case of using a thermal screen, it has been calculated that a decrease of 93189 kg in Kırşehir and 48799 kg in Kahramanmaraş will occur. Reducing the heat energy required in greenhouses not only increases energy efficiency, but also enables an environmentally friendly production due to less use of fossil energy sources (Baytorun and Gügercin, 2015). One of the goals of sustainable greenhouse systems should be a system that is environmentally friendly and does not produce as much waste as possible (Giuliano et al., 2010). In the study, it has been calculated that there is a 15% decrease in the amount of carbon dioxide released into the atmosphere in the case of greenhouses with or without thermal screens. Reducing this amount for a sustainable greenhouse cultivation is very important for an environmentally friendly production.

CONCLUSION

The high energy costs in Turkey is one of the biggest obstacles to the air conditioning of greenhouses. The cost of production in greenhouses varies depending on the air-conditioning measures. In the study, when the heat energy, fuel amount, fuel cost and amount of carbon dioxide released to the atmosphere are compared in the production to be made in a single-layer PE plastic covered greenhouse with the same characteristics, II. In the province of Kahramanmaraş, which is located in the region, greenhouse cultivation in III. It shows that it is more advantageous than Kırşehir province in the region. Even in the case of using a thermal screen for energy conservation in Kırşehir, it requires more heat energy than the greenhouses in Kahramanmaraş that do not use a thermal screen. However, the production amount obtained in the greenhouses of approximately 220 decares, which are heated with geothermal resources and produced throughout the year in modern greenhouses in Kırşehir, causes the yield per unit area to be higher in Kırşehir. However, it seems possible for Kahramanmaraş to become an important greenhouse area with the advantage of the Mediterranean climate and the use of hot water resources in the hot spring region. At the same time, it is extremely important for the cities to compete with the most important greenhouse centers of Turkey such as Antalya, Mersin and Adana, and to contribute to the country's economy, by using the thermal resources found in these provinces more effectively.

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