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DETERMINATION OF SUITABLEPROTECTED PRODUCTION AREAS: LOWER EUPHRATES BASIN CASE

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Abstract

As a result of the increase in the world population and the decrease in agricultural land, the need for food increases every day. Nowadays, breeding studies are carried out to increase the yield of plants to get more products from the same area. Furthermore, controlled production areas are created by optimizing climatic conditions and the continuity of production is ensured. It is called greenhouse, where production can be carried out throughout the year and the indoor temperature and humidity conditions can be controlled. Nowadays, greenhouses are now functioning as an industrial enterprise. However, greenhouses need to comply with the principles of quality production, efficient income growth and physical environmental protection. Almost all of the plant production in greenhouses in Turkey is done in the Mediterranean region, but in the Southeastern Anatolia Region, it is done in a very limited greenhouse area. The increase of protected agricultural areas in the Mediterranean region and the fact that the production volume cannot reach a certain limit makes it necessary to investigate alternative protected production areas. In this study, climate conditions of Antalya province and climate data of four provinces of the Lower Euphrates basin are compared with each other and statistically compared. As a result of, differences have been found between Antalya province and the provinces in the Lower Euphrates basin in terms of minimum, maximum, and average temperatures. However, there is no difference between the provinces in the basin except for Gaziantep in terms of climatic conditions. Therefore, it has been determined that Gaziantep province is not suitable for greenhouse cultivation. However, it has been concluded that if greenhouse cultivation is performed in this province, it is appropriate to perform cultivation in the areas where alternative energy sources can be used. It has been concluded that in the case that heating costs are reduced using alternative energy sources, Şanlıurfa and Kilis provinces are climatologically suitable for greenhouse cultivation and Adıyaman province is partially suitable for it.

Keywords: Climatization, Greenhouses, Heat load, Lower Euphrates basin

INTRODUCTION

Plant production should be performed throughout the year so that nutritional requirements can be met. Greenhouse, which enables the production to be performed throughout the year, is a plant production structure where indoor temperature and maintenance conditions can be kept under control. The world population growth rate brings the increase in nutrient requirement with it. Accordingly, greenhouse areas in the world and in Turkey have increased over the years.

While greenhouse cultivation was performed in the area of 36304.2 (ha) in Turkey in 1995, it increased to 64911.8 (ha) in 2014. 8097.6 (ha) of this area are glass greenhouses, 29865.1 (ha) are plastic greenhouses, 11277.1 (ha) are high tunnel greenhouses, and 15672 (ha) arelow-tunnel greenhouses. Upon examining the development of greenhouse cultivation in Turkey, the average annual rate of increase is about 15% (Anonymous, 2015).

Nowadays, both the increase in the quantity of the product obtained per unit area and keeping the temperature conditions inside the greenhouse under control have made greenhouses modern production areas. Although greenhouse areas in the Mediterranean and Aegean regions of Turkey are sufficient to meet the domestic consumption potential, they are decreasing with each passing day due to the use of agricultural lands as both settlements and industrial areas or tourism areas.

The economic gain is proportional to directly ability to perform greenhouse cultivation. In a study conducted by Boyacı et al., 2016, the potential of greenhouse farming in Kırşehir province was investigated considering the long-term climatic data, geographical location and agricultural structure. Upon examining the long-term annual climatic data of Kırşehir province between 1960 and 2015 in terms of greenhouse farming, it has been determined that the temperature has increased and the relative humidity rate has tended to decrease. According to this, when the heating costs are considered in Kırşehir province, where the long-term annual average temperatures are low and the number of frost days is high, it is found out that it is not economical to perform greenhouse farming in these months (Boyacı et al., 2016).

In our country, of which insolation area and duration are quite good in terms of its location on the earth, solar energy comes to the forefront as an alternative energy source. The potential of our country to benefit from solar energy is higher when compared to all European countries except for Spain (Dikmen and Gültekin, 2011). While the global radiation values (KWh/m^2-day) and insolation durations (hour) of the provinces in the Lower Euphrates basin (Adıyaman, Gaziantep, Kilis and Şanlıurfa) are not much different from Antalya province, the minimum temperature values are 6^{o}C – 8^{o}C lower especially in winter (December, January) (Anonymous, 2016).

Agricultural activities in the Lower Euphrates basin, especially greenhouse cultivation, are significant economic activities. Field agriculture and vegetable farming are the main sources of income for a large part of the population. Increasing the potential greenhouse areas in the basin and getting income from vegetable farming will both increase the amount of income per capita in the basin and contribute to the economy and reducing unemployment in the basin by carrying out vegetable production, which is performed only in summer, throughout the year.

The current paper presents a scheme of conducting an analysis of variance (ANOVA), which can be a statistical method used for the analysis of various complex problems in different fields of science. The ANOVA method was used to analyze the difference between mean changes. It was considered relevant to present the reliable mechanism of variance analysis because it is one of the most important methods of statistics, which is more and more widely used in various fields of science.The ANOVA is used in different fields of empirical research, which are the subject of the phenomenon with a complex structure. Issues related to medicine, psychology, chemistry, and agriculture can be listed as an example; moreover, the analysis is used in various industries to solve complex technological problems and optimize the production processes, too (Raykov and Marcoulides, 2008; Güler et al., 2012; Rao et al., 2012; Niedoba andPieta, 2016).

In this study, it was aimed to determine the potential greenhouse areas depending on the climatic values of the Lower Euphrates Basin provinces. For this purpose, based on the climatic conditions of Antalya province, it was attempted to determine whether the provinces in this basin are suitable for greenhouse cultivation.

MATERIAL AND METHOD

The study was carried out in the Southeastern Anatolia Region of Turkey and it covers Adıyaman, Gaziantep, Kilis and Şanlıurfa provinces in the Lower

Euphrates basin and Antalya province in the Mediterranean Region (Figure 1). The daily meteorological values (Minimum, Average, Maximum Temperatures (^{o}C) and Insolation Amount (Kwh/m^2-day) between 2006 and 2015 were used in the study (Anonymous, 2016).

The study was carried out in two parts; in the first part, the long-term daily minimum temperatures in Antalya, Adıyaman, Gaziantep, Kilis, and Şanlıurfa provinces were analyzed by the two-way variance analysis method and it was determined and interpreted whether the average minimum temperatures for each month showed a statistically significant difference by the provinces. Using the data obtained, the Duncan multiplecomparisontest was applied at 5% significance level to the temperature averages by provinces and the results obtained were interpreted for Antalya and the Lower Euphrates basin provinces.

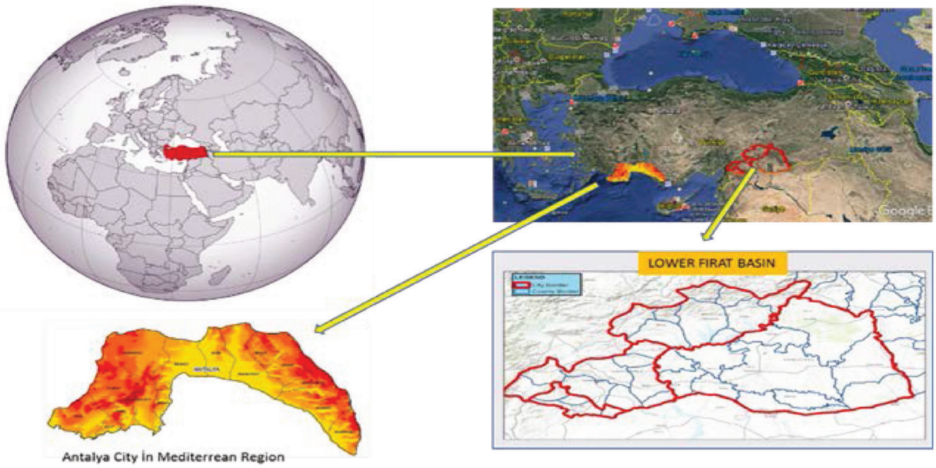

Figure 1. Study Area (Antalya and the Lower Euphrates Basin) in Turkey

In the second part of the study, the heating loads that occurred when a greenhouse in Antalya, which was PE-covered, arc-roofed greenhouse and constructed with steel and in which tomato growing was performed (Table 2), was established in one of the provinces in the area of the Lower Euphrates basin, without changing any structural characteristics of it, were found and accordingly, the climatic suitability of the provinces in the basin was determined. In this context, the minimum temperature values of October, November, December, January, February, and March and the heating loads depending on these values were examined. Tomato growing in the greenhouse was considered and the changes in the minimum temperature values were interpreted.

The tomato plant was taken as a comparison in the determination of the degree of the effect of minimum temperatures in the greenhouse and information about the climatic demandsis presented in Table 1. In Antalya province, spring cultivation starts in the first week of January and the harvesting period lasts until the end of June. The sowing and planting phase of seedlings includes a one-week period. Autumn cultivation starts in the third week of August and continues until the third week of January (Table 1). The production dates in the study area are parallel to the values in Table 1 like Antalya.

Table 1. Suggested temperature and production times for the spring and autumn cultivation of tomato plant

The spring cultivation	**Temperature**	**Date**	**Period**
Greenhouse planting	18-22 °C	3rdweek of January	1 week
Flower formation, pollination, insemination	18-20 °C	3rd and 4th week of February	2 weeks
Fruit ripening	15-25 °C	Beginning of April – End of April	4 weeks
Harvest	18-35 °C	Beginning of May – End of June	8 weeks
The autumn cultivation	**Temperature**	**Date**	**Period**
Greenhouse planting	18-22 °C	3rdweek of August	1 week
Flower formation, pollination, insemination	18-20 °C	1stweek of September – 2nd week of September	2 weeks
Fruit ripening	15-25 °C	3rdweek of October –2ndweek of November	4 weeks
Harvest	18-35 °C	3rdweek of November – 3rdweek of January	8 weeks

Source: (Anonymous, 2002)

Table 2. Dimensions and calculated values of the greenhouse used in modelling

Greenhouse's Width (m)	9,6
Greenhouse's Length(m)	60
Greenhouse's Floor Area (m^2)	576
Greenhouse's Height (m)	3
Greenhouse's Total height (m)	4
Greenhouse's Cover Surface Area (m^2)	980

The dimensions of the arc-roof, single-span PE (polyethylene)-covered greenhouse used as an example are given in Table 2. In the first part, the climatic data (minimum temperatures) of the basin were assessed with the variance analysis method (ANOVA) using SPSS 20.0 Statistical Package Program and the heating loads were determined according to the coldest months.

In order to correctly determine the heat consumption, the outdoor temperature and the actual values of the total radiation were taken into account. The energy required to heat the greenhouse is provided by solar radiation and additional heating system.

For the effective heat consumption (qh), the formula used by Zabeltitz (1988) was utilized. In this formula, it was shown that the u, Ac, Ag, ti, τ and γ values did not change; in other words, the changes in the outdoor environment temperature (°C) and solar radiation (W/m²) throughout the years and the differences that can be shown by the generated heating load in Antalya and the Lower Euphrates basin were examined. According to this;

$$qH = \frac{Ac}{Ag}.u.(\mathrm{ti} - \mathrm{toeff}) - I.\tau.\gamma \quad (1)$$

here:

q_H: Heating Load (W/m²)

u: coefficient of the total heat consumption ($W.m^{-2}$ K) (Single-span PE u was taken as 7)

Ac: surface area of the greenhouse cover (m²) (taken as 980 m²)

Ag: floor area of the greenhouse (m²) (taken as 576 m²)

t_i: Greenhouse environment temperature (°C) (15°C of the indoor environment temperature was taken as constant.)

t_o eff: outdoor environment virtual temperature (°C)

I: solar radiation (W/m²)

τ: Radiation permeability of the greenhouse (This was taken as 0.65 for single-span PE-covered greenhouses.)

γ: The rate of solar radiation entering the greenhouse, which is effective in the increase of indoor environment temperature (taken as 0.6)

The heat consumption qH (W/m²) of the greenhouse and outdoor environment virtual temperature were calculated daily using the excel program between 2006 and 2015 in Antalya and the provinces in the Lower Euphrates Basin, and the differences between these values were examined by performing the analysis of variance.The statistical model created to calculate the effect of minimum temperatures by the provinces is as follows:

$$y_{ij} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ij} \qquad \begin{cases} j = 1,2,\dots,31 \\ i = 1,2,\dots,5 \end{cases}$$

Here, y_{ij} is the 10-year average minimum temperature value observed on the j^{th} day in the i^{th} province, μ is the average minimum virtual temperature, α_i is the effect of the i^th^ province on the average minimum temperature, β_j is the effect of the j^th^ day on the average minimum temperature,and ε_{ij} is the random error.

RESULTS AND DISCUSSION

In our study, the change in the climatic values in Antalya and the Lower Euphrates basin was examined by using descriptive statistics. In this context, descriptive statistics are presented for the 10-year (2006-2015) daily minimum, maximum and average temperatures in Antalya, Şanlıurfa, Adıyaman, Kilis and Gaziantep provinces (Table 3).

While the average minimum temperature for Antalya province was 16.9 °C in October, the closest value to it was determined to be 15.9°C in Şanlıurfa province. The minimum temperatures required for the growth and development of seedlings in the greenhouse cultivation in October are compatible for Antalya and the Lower Euphrates basin.

Table 3. Some descriptive statistics of the 10-year (2006-2015) daily minimum, maximum and average temperatures

City			October	November	December	January	February	March
Antalya	N	Valid	309	298	296	277	275	307
		Missing	1	12	14	33	35	3
	Mean		16.9	12.0	8.7	7.1	7.9	9.6
	Std. Deviation		2.8	3.4	3.1	3.0	3.3	2.7
	Minimum		9.3	1.0	1.2	-.6	-.9	1.8
	Maximum		24.1	18.5	18.0	13.4	28.0	15.4
	Percentiles	% 25	15.1	9.8	6.6	4.9	6.0	7.8
		% 50	16.7	12.3	9.2	7.7	8.1	9.7
		% 75	19.1	14.5	10.7	9.7	10.1	11.5
Şanlıurfa	N	Valid	297	299	310	309	281	298
		Missing	13	11	0	1	29	12
	Mean		15.9	9.2	4.8	2.8	4.1	7.5
	Std. Deviation		2.8	3.0	3.0	3.0	2.9	3.0
	Minimum		8.8	-.4	-4.3	-4.7	-4.0	-1.7
	Maximum		28.0	17.7	15.0	10.8	9.8	15.0
	Percentiles	% 25	13.9	7.1	2.8	.8	2.2	5.7
		% 50	16.2	9.5	4.9	3.0	4.3	7.3
		% 75	18.0	11.4	7.0	4.9	6.2	9.3

City			October	November	December	January	February	March
Adıyaman	N	Valid	310	299	309	309	281	302
		Missing	0	11	1	1	29	8
	Mean		14.1	7.8	3.7	1.6	2.9	6.2
	Std. Deviation		2.7	3.1	3.1	3.2	3.2	3.1
	Minimum		7.0	-1.3	-4.7	-6.3	-5.8	-2.1
	Maximum		21.7	14.7	11.7	9.8	10.7	14.9
	Percentiles	% 25	12.1	5.9	1.7	-.6	.6	4.2
		% 50	14.0	8.3	3.8	1.5	3.0	6.2
		% 75	16.0	9.9	5.8	3.7	5.5	8.3
Kilis	N	Valid	308	293	309	309	282	303
		Missing	2	17	1	1	28	7
	Mean		14.9	9.0	4.3	2.7	4.4	7.2
	Std. Deviation		2.9	3.3	3.0	2.8	3.0	3.3
	Minimum		7.8	.4	-4.1	-4.5	-4.9	-2.3
	Maximum		24.6	18.6	13.5	7.8	12.0	17.5
	Percentiles	% 25	12.8	6.8	2.3	.8	2.4	5.0
		% 50	15.0	9.2	4.4	3.0	4.7	7.2
		% 75	16.9	11.3	6.3	4.8	6.4	9.2
Gaziantep	N	Valid	309	299	308	309	282	302
		Missing	1	11	2	1	28	8
	Mean		11.8	5.7	1.9	.2	1.6	4.7
	Std. Deviation		2.8	2.9	3.3	3.4	2.9	2.8
	Minimum		5.0	-3.0	-6.4	-7.0	-7.6	-3.8
	Maximum		20.6	12.5	9.9	10.2	7.9	12.6
	Percentiles	% 25	10.2	3.8	-.6	-2.2	-.6	3.0
		% 50	11.8	6.0	1.8	.0	2.0	4.8
		% 75	13.7	8.0	4.4	2.7	3.9	6.6

Accordingly, the temperatures required for the growth of the seedlings are suitable for Antalya and the Lower Euphrates river basin (Figure 2 (a)).

In terms of the autumn cultivation, heating is not required in either Antalya or the provinces in the Lower Euphrates basin in October (Figure 2 (a)). While the minimum average temperature in Antalya province does not fall below 10°C in November, the minimum temperatures fall below 10°C in Şanlıurfa and Kilis after the third week and in Adıyaman after the first week (Figure 2 (b)).

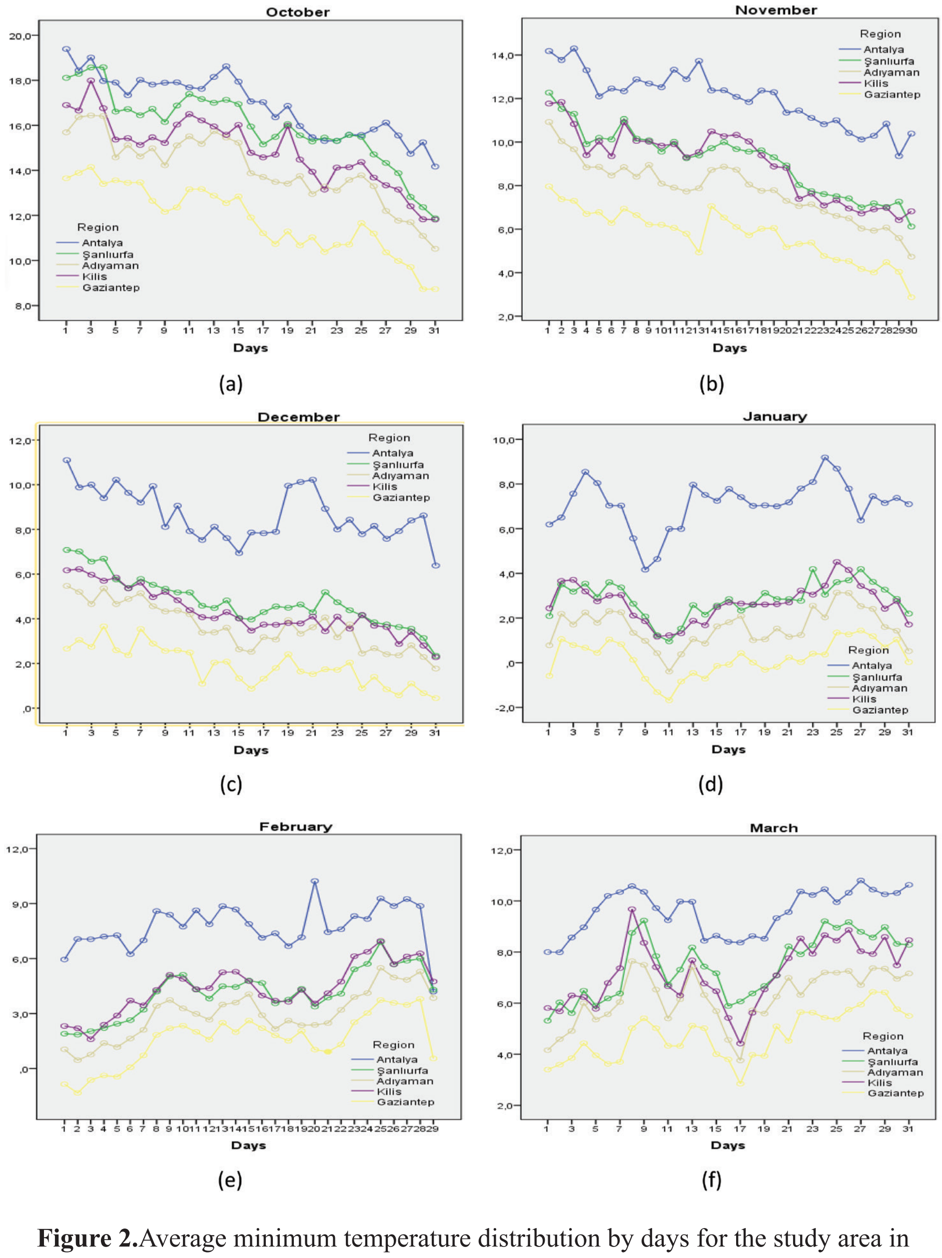

Figure 2. Average minimum temperature distribution by days for the study area in October (a), November (b), December (c), January (d), February (e), March (f)

On the basis of the autumn cultivation, the temperature for tomatoes must be minimum 15°C and maximum 25°C in November and December, when fruit set occurs (Anonymous, 2002). In the third week of October and the first two weeks of November, within a period of a total of four weeks, it was observed that the temperature values in Antalya province decreased from 16°C to 14°C and the temperatures continued to decrease in the following period. Accordingly, it is necessary to operate heating systems in greenhouses from the 3rd week of October for Antalya. Likewise, in the provinces in the Lower Euphrates basin, this temperature change was found to be 2-4°C lower compared to Antalya (Figure 2 (a, b)). In this case, more heating is necessary in the provinces in the basin than Antalya province. Moreover, the total daily radiation of Gaziantep and Kilis provinces was below the recommended value of 2.3 kWh/m^2 day in December and January and below the limit value of 1 kWh/m^2 day(Krug et al., 2002). Since it is very important to keep the temperature values in the greenhouse constant, the costs of the heating load will increase the cost of production. However, in the case that the production is performed in the basin, the production cost may be reduced because the transportation cost of the products transported from Antalya will be less.

It is stated that using heating in Antalya in the last week of October and throughout November is useful both for the fruit set and the harvest (Anonymous, 2002). In the provinces in the Lower Euphrates Basin, 20%-35% more heating is required for the same periods compared to Antalya. In this period, the minimum temperature differences for Antalya decreased between 6-8°C. In the basin, this ratio started from 14°C and decreased to 4°C (Figure 2 (a, b)). Therefore, it is determined that more heating will be performed for Gaziantep at 51.72%, for Kilis at 44.8%, for Adıyaman at 36.28%, and for Şanlıurfa at 23.8%, especially in the first two weeks of November, compared to Antalya. Active or passive heating systems must be used at full performance throughout the flowering and fruit setting period, because neglecting heating with economic concerns in this period may cause the plant to be damaged and harvesting little or no crops.

Upon examining the climatic values between 2006 and 2015, the total insolation durations of the provinces in the Lower Euphrates basin in November, December and January were found to be below the threshold value of 500-550 hours (Krug et.al., 2002).

In the autumn cultivating, the harvest period for tomatoes lasts for 8 weeks and is performed between the third week of November and the first three weeks of January (Table 1). Within this period, the temperature differences between Antalya and the provinces in the basin show a temperature difference of 4°C in terms of minimum temperatures. It was calculated that heating in December was 76.32 W.m^{-2} for Antalya. In the province closest to this value among the provinces in the basin, Şanlıurfa province, this value was calculated to be 122.72 W/m^2, to be 128.73 W/m^2in Kilis, to be 135.87 W.m^{-2} in Adıyaman, and to be 157.31 W.m^{-2}

in Gaziantep province. These values indicate that there is more heating requirement at 60.8% for Şanlıurfa, at 78% for Adıyaman, at 68.4% for Kilis, and at 106.1% for Gaziantep province. Upon examining the values of January, it was determined that while the heating load in Antalya was 95.38 W/m^2, more heating was required at 53.7% in Şanlıurfa, at 68.6% in Adıyaman, at 54.8% in Kilis, and at 86.47% in Gaziantep province. Meeting the increase in the temperature values inside the greenhouse during the ripening and presentation to the market period of the tomato plant causes the cost to increase. Therefore, measures such as the use of thermal curtains and the shortening of ventilation times in greenhouses can be effective in reducing these costs.

In terms of the spring cultivation, it is necessary that the temperatures are 18-22°C during the pollination and flowering periods in January and February (Table 1). In this respect, it is observed that the temperature values of Antalya province are between – 0.6 and 13.4°C and at 7.1°C on average (Table 2). The values of Şanlıurfa province, the province closest to these temperature values, were determined. The difference between the average minimum temperatures between Antalya and the Lower Euphrates basin is statistically significant ($p<0.01$).Upon examining the average temperatures in January, it is observed that there is a difference of 4.3°C between Antalya and Şanlıurfa, 4.4°C between Antalya and Kilis, 5.5°C between Antalya and Adıyaman, and 6.9°C between Antalya and Gaziantep (Table 4). Taking these values into consideration, it is also a fact that these changes in the temperature difference will increase the heating loads in the greenhouse.

While January refers to the harvest for the autumn cultivation, it refers to the period of planting and flowering for the spring cultivation. Therefore, the heating need calculated in the autumn cultivation is also valid for this period. However, it is known that plants are tolerant to lower temperatures during the harvesting period compared to the seedling period (Anonymous, 2002). Upon assessing the temperature values of February, there is a temperature difference between 3.8°C and 6.3°C between Antalya and the provinces in the basin (Table 4). The temperature differences in February are lower than in January. As a result of the calculations made, no significant difference was found between the minimum temperatures in January in Şanlıurfa and Kilis provinces.

In the second step of the study, the 10-year (2006-2015) daily minimum temperatures in Antalya, Şanlıurfa, Adıyaman, Kilis and Gaziantep provinces were analyzed by the two-way analysis of variance method. According to the results obtained, the average minimum temperature for each month showed a statistically significant difference according to the provinces and days of months ($p<0.01$). The Duncan multiple comparison test was applied to the temperature averages at $\alpha=0.05$ significance level according to the provinces. The result of the Duncan test is presented in Table 4.

Table 4. Duncan Multiple Comparison test results

City	October** ($\bar{x} \pm sd$)	November** ($\bar{x} \pm sd$)	December** ($\bar{x} \pm sd$)	January** ($\bar{x} \pm sd$)	February** ($\bar{x} \pm sd$)	March** ($\bar{x} \pm sd$)
Antalya	16.9 2.8 a	12.0 3.4 a	8.7 3.1 a	7.1 3.0 a	7.9 3.3 a	9.6 2.7 a
Şanlıurfa	15.9 2.8 b	9.2 3.0 b	4.8 3.0 b	2.8 3.0 b	4.1 2.9 b	7.5 3.0 b
Kilis	14.9 2.9 c	9.0 3.3 b	4.3 3.0 b	2.7 2.8 b	4.4 2.9 b	7.2 3.3 b
Adıyaman	14.1 2.7 d	7.8 3.1 c	3.7 3.1 c	1.6 3.2 c	2.9 3.2 c	6.2 3.1 c
Gaziantep	11.8 2.8 e	5.7 2.9 d	1.9 3.3 d	0.2 3.4 d	1.6 2.9 d	4.8 2.8 d

**: $p<0.01$

CONCLUSIONS

In the study, differences have been found between Antalya province and the provinces in the Lower Euphrates basin in terms of minimum, maximum, and average temperatures. However, there is no difference between the provinces in the basin except for Gaziantep in terms of climatic conditions. Therefore, it has been determined that Gaziantep province is not suitable for greenhouse cultivation. However, it has been concluded that if greenhouse cultivation is performed in this province, it is appropriate to perform cultivation in the areas where alternative energy (geothermal) sources can be used. It has been concluded that in the case that heating costs are reduced using alternative energy sources (Photovoltaic systems, Geothermal sources, Heat Exchangers, etc.), Şanlıurfa and Kilis provinces are climatologically suitable for greenhouse cultivation and Adıyaman province is partially suitable for it. It has been concluded that in order to reduce the amount of heating load of greenhouse cultivation in the provinces in the Lower Euphrates basin, greenhouses should be established close to the geothermal areas or they should have (Photovoltaic) systems that can store the solar energy and convert it into electricity.

Furthermore, it is thought that taking the production date for the autumn cultivation 2 weeks earlier and taking the spring cultivation 2 weeks later in the Lower Euphrates basin, unlike Antalya, in terms of the cultivation schedule can have a positive effect on reducing the heating costs inside the greenhouse.

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