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The effect of climate on leaf micromorphological characteristics in some broad-leaved species

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Abstract

This study aimed to determine the change in micromorphological characteristics depending on the species and the climate conditions in some landscape plants grown in areas with different climate conditions. For this purpose, leaf samples of five different woody species from the areas dominated by continental, Black Sea and Mediterranean climates were collected, and the scaled images of these samples were obtained via scanning electron. The stoma length, stoma width, pore length, pore width and stoma density were determined using the measurements conducted on these scaled images. The obtained data were evaluated statistically, and changes in these characteristics depending on the climate and the species were determined. The lowest values for all characteristics, except stoma density, were obtained in the terrestrial climate, whereas the highest values were obtained in plants grown in the Mediterranean climate. In terms of stoma density, the lowest value was obtained in plants grown in the Mediterranean climate, whereas the highest values were obtained in terms of other characteristics, and the highest value was obtained in plants grown in the terrestrial climate, whereas the lowest values were obtained in terms of other characteristics. However, when the changes depending on the species were examined, it was determined that different species react differently depending on the climate type.

Keywords Climate · Micromorphological characteristics · SEM · Stoma

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1 Introduction

With the rapid development process in the world, structural changes in economic, social, cultural and political areas have accelerated the process of urbanisation and have resulted in the destruction of green spaces. Rapid urbanisation and industrialisation have caused human beings, who are a part of nature, to move away from nature and carry a piece of nature to their living space. At this point, landscaping has become a part of modern life (Sevik and Cetin 2016; Cetin 2015, 2019; Sen et al. 2018; Cetin et al. 2018a, 2019; Adiguzel et al. 2020; Kaya et al. 2019).

Landscaping, unlike other designs, has placed the use of plants to forefront. Plants fulfil many ecological, economic and social functions in addition to their aesthetic role in landscaping areas. Plants add aesthetic value to the environment they grow in, have positive psychological effects on people and contribute to increased productivity of people (Djukanovic et al. 2002; Chang and Chen 2005; Kravkaz Kuscu et al. 2018a, b; Kaya 2009; Yucedag and Kaya 2016; Nowak et al. 2005; Bozdogan Sert et al. 2019; Sevik et al. 2019a,b,c; Yucedag et al. 2019). They also positively affect human health by decreasing noise levels as well as pollutants such as particulate matters in the air, CO_2 and heavy metals (Tani and Hewitt 2009; Papinchak et al. 2009; Turkyilmaz et al. 2018a,b). Plants promote the production of economically valuable primary and secondary products (Sevik 2012). In addition, they perform multiple secondary functions, such as erosion and flood prevention, and provide shelter and food for wild animals (Cetin et al. 2017).

Plants are an indispensable part of landscaping. Outdoor landscape designs become valuable to the extent that they can go beyond their usual usage, and this has a significant effect on plant selection in landscaping and leads to the use of species that are not found in the natural vegetation of the region. Plants used outside of their natural propagation areas for landscaping purposes often fail to achieve the performance shown in their habitats; they cannot reflect the forms observed in their natural propagation areas and usually withstand the stress factors alone. These stress factors affect not only the visible morphological characteristics but also the invisible micromorphological characteristics of the plants (Yigit 2016; Sevik et al. 2017; Cetin et al. 2018b). Climate is directly effective on all the characters of plants. In landscape studies, the effects of climate on plants can be examined from two angles. Firstly, the more climatic conditions in the region where the plants are used, the better the plant willing to care for, and the lower the maintenance costs. For example, when a high water demand is used in an area with arid climatic conditions, it will need to be watered continuously. Secondly, if the climatic conditions of the region are particularly low and the highest temperatures are outside the plant tolerance values, it will not be possible for the plant to live in that region. Therefore, the harmony between the climate demands of the plants to be used in landscape studies and the climate conditions of the region is extremely important (Cetin 2015; Cetin et al.2018d, 2019; Sevik et al. 2019a, b, c; Topacoglu et al. 2016; Yigit et al. 2019; Bozdogan Sert et al. 2019; Kaya et al. 2019).

In Turkey, three main climates with considerably different characteristics are observed. In landscaping, there are abundant plants grown in areas in which these three climatic conditions prevail. These plants generally do not significantly differentiate morphologically from each other. However, there is no sufficient information on how they differentiate micromorphologically. In fact, changes at the microlevel can provide insight into a broad range of characteristics from stress levels of the plant to adaptation levels of the plant to the cultivation area.

The present study aimed to determine the changes in specific micromorphological characteristics of five woody landscape plants, depending on the climatic conditions, that are cultivated in areas of Turkey where different climatic conditions prevail.

2 Materials and methods

2.1 Materials

The study was conducted using plants collected from areas of Turkey where continental, Black Sea and Mediterranean climates prevail. Within the scope of this study, leaf samples of *Cotoneaster franchetti, Cercis siliquastrum, Cotoneaster horizontalis, Acer negundo* and *Robinia pseudoacacia* grown in areas under these three climatic conditions were collected from the cities of Samsun and Rize where the Black Sea climate prevails, the cities of Ankara and Sivas where the continental climate prevails and the cities of Antalya and Izmir where the Mediterranean climate prevails (the coordinates of Samsun: 41°16′46.931″ and N 36°20′9.841″E; Rize: 41°1′31.8468″N and 40° 31′ 3.5976″E; Ankara: 39°55′31.9188″N and 32°51′58.6332″E; Sivas: 39° 45′ 1.2924″N and 37°0′56.1528″; Antalya: 36°32′57.7032″N and 31°59′49.1784″E; Izmir: 38°25′7.86″N and 27°7′43.392″E). Although these cities characterise the prevailing climatic conditions in Turkey, there are significant differences between the climate data (TSMS 2018). Climate is the average of long-term meteorological data occurring in a region. The climate data determined according to the average of the data (at least 50 years) from the date when the meteorological records of the cities subject to the study started to be kept are given in Table 1. Therefore, these differences must be accounted for while evaluating the data. The average meteorological data of the cities in the study are shown in Table 1.

Table 1 Annual average meteorological data of cities (TSMS, 2018)

	Samsun	Rize	Ankara	Sivas	Antalya	Izmir
MT (°C)	14.5	14.3	11.9	8.9	18.6	17.8
MMaxT (°C)	18.2	18	17.8	15.3	24.1	22.6
MMinT (°C)	11	11.1	6.2	2.8	13.7	13.4
MSSD (h)	61	49.4	80.3	80.5	100.3	94.5
MNRD	135.6	172.5	102.3	112.5	75.1	77.7
MMRF (mm)	717.5	2304.1	387.2	429.2	1066.9	695.9
MaxT (°C)	39	38.2	41	40	45	43
MinT (°C)	−9.8	−7	−24.9	−34.6	−4.6	−82

MT (°C): mean temperature; (°C)
MMaxT (°C): mean maximum temperature; (°C)
MMinT (°C): mean minimum temperature; (°C)
MSSD (h): mean sunshine duration (h)
MNRD: mean number of rainy day
MMRF (mm): mean monthly rainfall (mm)
MaxT (°C): maximum temperature

2.2 Method

Within the scope of the study, mature leaf samples were collected from the relevant species at the end of August 2017, pressed and dried and examined using the electron microscope at the laboratory. The scaled images of these samples were obtained from the lower part and near the middle parts of the leaf blade via scanning electron microscope (SEM). The 'jpeg files' were created from these images. After these procedures were completed, STD (stoma density) (in an area of 1 mm^2), STL (stoma length), STW (stoma width), PL (pore length) and PW (pore width) measurements were performed using the 'ImageJ' measurement programme in order to obtain the micromorphological measurements of the leaves. The data obtained were statistically analysed using SPSS software. Analysis of variance (ANOVA) and the Duncan test were applied on the data. In addition, a correlation analysis was performed on the data in order to determine the correlation level and direction of the study characteristics (Cetin et al. 2018c,d; Bozdogan Sert et al. 2019; Kaya et al. 2019).

3 Results

3.1 Changes in the micromorphological characteristics of Cotoneaster franchetti

The changes in the micromorphological characteristics of *Cotoneaster franchetti* across the cities were determined, and the mean values, significance level and F value obtained by ANOVA and homogeneous groups formed by the Duncan test are presented in Table 2.

In the examination of changes in the micromorphological characteristics of *Cotoneaster franchetti* across the cities, ANOVA revealed that all characteristics across the cities were significantly different within at least 95% confidence interval (CI). This difference is significant in terms of PL and other characteristics within 99% and 99.9% CIs, respectively.

According to the Duncan test results, it was determined that the data were collected in four homogeneous groups for STW and in three homogeneous groups for the other characteristics. The examination of data revealed that the lowest values in all characteristics, except for STD, were obtained in Sivas. The highest values for STL and STW

Table 2 Changes in the micromorphological characteristics of *Cotoneaster franchetti* across the cities

City	STL	STW	PL	PW	STD
Ankara	17.11a	12.46b	11.47b	4.68ab	90.27a
Antalya	24.11c	14.48c	16.08c	5.73bc	260.79c
Samsun	21.02b	13.45bc	15.70c	4.07ab	210.64b
İzmir	26.44c	20.44d	12.83b	4.30ab	275.83c
Rize	15.21a	12.45b	13.09b	6.98c	240.73bc
Sivas	14.66a	10.06a	7.12a	2.59a	250.76bc
F value	36.374***	39.949***	16.723***	5.614**	28.854***

**significant at 0.01 level

***Significant at 0.001 level

The letters a, b, c, etc. mean according to the Duncan test results and show that the group is located. It is statistically different from the values contained in different groups, starting with the letter, a numerical value grows

were obtained in Izmir, for PL in Antalya and for PW in Rize. The lowest values for STD were obtained in Ankara, whereas the highest values for STD were obtained in Izmir.

3.2 Changes in the micromorphological characteristics of Cercis siliquastrum

The changes in the micromorphological characteristics of *Cercis siliquastrum* across the cities were determined, and the mean values, significance level and F value obtained by ANOVA and homogeneous groups formed by Duncan test are presented in Table 3.

In the examination of changes in the micromorphological characteristics of *Cercis siliquastrum* across the cities, ANOVA revealed that all characteristics, except for PL and PW, across the cities were statistically significantly different within at least 95% CI. This difference is significant in terms of STL and STW and STD within 95% and 99.9% CIs, respectively.

According to the Duncan test results, the data were collected in two homogenous groups for STW. Ankara, Antalya, Samsun and Rize were in the first homogeneous group, and Sivas was in the second homogeneous group, whereas Izmir was in both homogeneous groups. Based on the Duncan test results, two homogeneous groups were formed for STW; Ankara, Antalya and Samsun were in the first homogeneous group, and Sivas was in the second homogeneous group, whereas Izmir and Rize were in both homogeneous groups.

Based on the Duncan test results, four homogeneous groups were formed for STD; Ankara was in the first homogeneous group, Izmir was in the second homogeneous group, Antalya was in the third homogeneous group, Rize was in the fourth homogeneous group, and Sivas was both in the first and second homogeneous groups. It is noteworthy that there is more than twofold difference between Ankara (with the lowest value for STD) and Rize (with the highest value for STD).

Table 3 Changes in the micromorphological characteristics of *Cercis siliquastrum* across the cities

City	STL	STW	PL	PW	STD
Ankara	20.56a	10.95a	13.88	2.94	120.36a
Antalya	17.62a	9.64a	11.30	2.08	200.61c
Samsun	16.4a	7.9 a	10.91	3.72	160.48ab
İzmir	23.79ab	12.87ab	14.43	3.49	160.48b
Rize	17.52a	13.16ab	14.15	5.38	260.79d
Sivas	30.67b	21.28b	17.40	8.61	140.42ab
F value	3.132*	3.182*	0.837 ns	2.279 ns	25.821***

*significant at 0.05 level

***Significant at 0.001 level

ns not significant

The letters a, b, c, etc. mean according to the Duncan test results and show that the group is located. It is statistically different from the values contained in different groups, starting with the letter, a numerical value grows

3.3 Changes in the micromorphological characteristics of Cotoneaster horizontalis

The changes in the micromorphological characteristics of *Cotoneaster horizontalis* across the cities were determined, and the mean values, significance level and F value obtained by ANOVA and homogeneous groups formed by Duncan test are presented in Table 4.

In the examination of changes in the micromorphological characteristics of *Cotoneaster horizontalis* across the cities, ANOVA revealed that all characteristics, except for PW, across the cities were statistically significant different within at least 95% CI. Based on the results of ANOVA, the data were different in terms of STL, STW, PL and STD within 95%, 99%, 99% and 99.9% CIs, respectively.

Based on the Duncan test results, two homogeneous groups were formed for STL, STW and PL, and three homogeneous groups for STD. In terms of STL, Antalya was in the first homogeneous group, Sivas and Antalya were in the last homogeneous group, and Samsun, Izmir and Rize were in the last homogeneous group.

In the examination of changes in the PL values across the cities, it was observed that the data were collected in two homogeneous groups, and Ankara alone was in the first homogeneous group and all other cities were in the second homogeneous group. It is noteworthy that, in the cities within the second homogeneous group, the mean PL was 12.22–16.05 µm, whereas the PL in Ankara was only 6.64 µm.

Three homogeneous groups were formed for STD: Rize was only in the first homogeneous group, Antalya was in the first and second homogeneous groups, Izmir was only in the second homogeneous group, and Ankara, Samsun and Sivas were in the third homogeneous group.

3.4 Changes in the micromorphological characteristics of Acer negundo

The changes in the micromorphological characteristics of *A. negundo* across the cities were determined, and the mean values, significance level and F value obtained by ANOVA and homogeneous groups formed by Duncan test are presented in Table 5.

Table 4 Changes in the micromorphological characteristics of *Cotoneaster horizontalis* across the cities

City	STL	STW	PL	PW	STD
Ankara	18.56a	12.44a	6.64a	2.30	255.77c
Antalya	24.19b	14.44a	14.13b	4.03	160.48ab
Samsun	21.65ab	12.57a	14.56b	3.62	220.67c
İzmir	23.19ab	12.77a	15.75b	4.45	180.55b
Rize	21.09ab	13.39a	16.05b	3.94	140.42a
Sivas	25.74b	18.09b	12.22b	4.33	240.73c
F value	3.219*	9.405**	7.935**	1.635ns	16.968***

*significant at 0.05 level

**significant at 0.01 level

***significant at 0.001 level

ns not significant

The letters a, b, c, etc. mean according to the Duncan test results and show that the group is located. It is statistically different from the values contained in different groups, starting with the letter, a numerical value grows

Table 5 Changes in the micromorphological characteristics of *Acer negundo* across the cities

City	STL	STW	PL	PW	STD
Ankara	16.88c	10.31ab	8.17b	2.37cd	120.36a
Antalya	13.17b	9.74a	8.25b	1.19a	176.33b
Samsun	9.03a	11.37ab	4.87a	2.57d	253.33c
İzmir	12.84b	10.49ab	7.37ab	1.59ab	160.48b
Rize	10.43ab	12.7b	4.65a	2.07bcd	348.33d
Sivas	19.90d	15.69c	5.76ab	1.66abc	220.67c
F value	19.144***	8.188**	3.270*	5.132*	56.188***

*significant at 0.05 level

**significant at 0.01 level

***significant at 0.001 level

The letters a, b, c, etc. mean according to the Duncan test results and show that the group is located. It is statistically different from the values contained in different groups, starting with the letter, a numerical value grows

All micromorphological characteristics of *A. negundo* across the cities were significantly different within at least 95% CI according to the results of ANOVA. This difference is significant in terms of PL, PW, STW, STL and STD within 95%, 95%, 99%, 99.9% and 99.9% CIs, respectively.

Based on the Duncan test results, two homogeneous groups were formed for PL, three homogeneous groups for STW, and four homogeneous groups for other characteristics. In terms of STL, Samsun was in the first homogeneous group and Sivas was in the last homogeneous group. Apart from this, Antalya and Izmir were in the second homogeneous group, Ankara was in the third homogeneous group, and Rize was in first two homogeneous groups. In terms of STW, Antalya was in the first homogeneous group, Sivas was in the last homogeneous group, Rize was in the second homogeneous group and Ankara, and Samsun and Izmir were in the first two homogeneous groups.

As seen in the table, two homogeneous groups were formed for PL: Rize and Samsun were only in the first homogeneous groups, Ankara and Antalya were only in the second homogeneous groups, and Izmir and Sivas were in both homogeneous groups. In terms of PW, Antalya was in the first homogeneous group, Samsun was in the last homogeneous group, Izmir was in the first two homogeneous groups, and Sivas was in the first three homogeneous groups. Rize was in the last three homogeneous groups, and Ankara was in the last two homogeneous groups.

3.5 Changes in the micromorphological characteristics of Robinia pseudoacacia

The changes in the micromorphological characteristics of *R. pseudoacacia* across the cities were determined, and the mean values, significance level and F value obtained by ANOVA and homogeneous groups formed by Duncan test are presented in Table 6.

In the examination of changes in the micromorphological characteristics of *R. pseudoacacia* across the cities, ANOVA revealed that all characteristics across the cities were statistically significantly different within at least 95% CI. Based on the results of ANOVA, the data were different in terms of STW, PL, PW, STL and STD within 95%, 95%, 99%, 99.9% and 99.9% CIs, respectively.

Table 6 Changes in the micromorphological characteristics of *Robinia pseudoacacia* across the cities

City	STL	STW	PL	PW	STD
Ankara	12.05b	8.68ab	7.70b	3.29b	80.24a
Antalya	8.27a	4.04a	6.22ab	2.66b	220.67c
Samsun	8.30a	4.28a	6.29ab	2.71b	200.61c
İzmir	8.49a	4.82a	6.42ab	3.31b	200.33c
Rize	14.17c	13.25b	7.51b	2.67b	160.48b
Sivas	9.53a	5.21a	4.75a	1.72a	70.67a
F value	14.756***	3.407*	4.122*	6.796**	47.661***

*significant at 0.05 level

**significant at 0.01 level

***significant at 0.001 level

The letters a, b, c, etc. mean according to the Duncan test results and show that the group is located. It is statistically different from the values contained in different groups, starting with the letter, a numerical value grows

Based on the Duncan test results, two homogeneous groups were formed for STW, PL and PW, and three homogeneous groups for STL and STD. In terms of STL, Antalya, Samsun, Izmir and Sivas were in the first homogeneous group, Ankara was in the second homogeneous group and Rize was in the last homogeneous group.

Among the characteristics that formed two homogeneous groups, Antalya, Samsun, Izmir and Sivas were in the first homogeneous group in terms of STD; Rize was in the second homogeneous group and Ankara was both in the first and second homogeneous groups. In terms of PL, Sivas was in the first homogeneous group, Ankara and Rize were in the second homogeneous group, and other cities were in both homogeneous groups. In terms of PW, Sivas was in the first homogeneous group, and all other cities were in the second homogeneous groups.

In terms of STD, three homogeneous groups were formed. Ankara and Sivas were in the first homogeneous group, Rize was in the second homogeneous group and Antalya, and Samsun and Izmir were in the third homogeneous group.

3.6 Results of correlation analysis

The correlation analysis was performed on the data to determine the strength and direction of the correlation among the relevant micromorphological characteristics, and the results are presented in Table 7.

Table 7 Results of correlation analysis

	STL	STW	PL	PW
STW	0.818**	–	–	–
PL	0.802**	0.581**	–	–
PW	0.575**	0.553**	0.742**	–
STD	0.005	0.203	−0.077	0.036

**significant at 0.01 level

The values obtained reveal that all characteristics, except STD, were significantly and positively correlated with each other within 99% CI. Furthermore, the strongest correlations were observed between STL and STW ($r=0.818$) and PL ($r=0.802$). It is noteworthy that the correlation between STD and other characteristics is insignificant.

4 Discussion

Based on the study results, only PL in *C. siliquastrum* and PW in *C. siliquastrum* and *C. horizontalis* were not significantly different across the cities and the city factor had a statistically significant effect on all other characteristics within at least 95% CI.

In terms of STD, each value was only in one homogeneous group. Ankara with the lowest value for STD formed the first homogeneous group, whereas Rize with the highest value for STD formed the last homogeneous group. Antalya and Izmir formed the second homogeneous group, and Samsun and Sivas formed the third homogeneous group. However, our findings indicate that there is a significant difference between the values obtained from the cities in the areas with the same climatic conditions. The examples for this include Rize being in the last homogeneous group and Samsun being in the first homogeneous group (both located in the area with Black Sea climate) in terms of STD values obtained for *Cercis siliquastrum*, and similar results were obtained for STL in *R. pseudoacacia* in these cities. Similar results were also obtained in many characteristics of other species. It has been emphasized in many studies that the character of STD varies significantly in different plants depending on the climate conditions (Sevik et al. 2016; Yigit et al. 2019; Cetin et al. 2018c, d).

Our study results suggest that the city factor precedes the climate factor in affecting leaf micromorphological characteristics. There may be two main reasons for this. The first reason is that the factors affecting plant development and occurring at the microlevel precede general climatic characteristics. The second reason is that climatic factors differ from one city to another, even if they are influenced by the same climatic conditions. For example, the annual average rainfall in Rize (where Black Sea climate prevails) is 2,304.1 mm, whereas this rate in Samsun (where the same climate prevails) is 717.5 mm. This may explain the difference between the micromorphological characteristics of samples collected from different cities in areas with the same climatic conditions.

Another reason for this difference is microenvironmental conditions. The plants analysed in the present study were those that are used in landscaping, and the study samples were collected from parks located in the city centres. Plants used for landscaping can also be used outside of their natural propagation areas, and the conditions required by them can be provided artificially. For example, a plant with high water demand can be grown in an arid region, and its water demand can be met by regular irrigation. Therefore, the microconditions under which the plant grows can be quite different from the main climate type. A similar condition also applies to edaphic factors. Therefore, microenvironmental conditions in plants used in landscaping can be considerably different from the edaphic and climatic conditions of the region, and microenvironmental conditions can predominantly affect the plant's growth performance. Particularly, the edaphic conditions of a region are shaped in many years with the effect of many factors such as 'anthropogenic factors (Cetin et al. 2018d; Sevik et al. 2019a, b, c; Topacoglu et al. 2016; Yigit et al. 2019).

Upon examining the data obtained in our study, it was determined that STD, unlike the other characteristics, is the characteristic that was most affected by the city factor. When evaluated across the cities, the lowest value in terms of STD was obtained in Ankara, whereas the highest value was obtained in Rize, indicating that the climate type has a significant effect on stoma density.

In many studies, the stoma density has been particularly associated to water stress. The study by Dunlap and Stettler (2001) on *Populus trichocarpa* suggests that the stomas are denser in the plants grown in arid regions; similar results were reported in the study by Pearce et al. (2006) on *Populus alba* as well as in other studies (Bosabalidis and Kofidis 2002; Guerfel et al. 2009).

Like other characteristics, stoma density is also influenced by many environmental factors. Stoma density can vary based on many factors such as drought and water stress (Zhang et al. 2006; Liu et al. 2006), light (Sevik et al. 2016), salinity (Zhao et al. 2001; Romero-Aranda et al. 2001), air pollution (Cetin et al. 2017) and conditions of the cultivation environment (Guney et al. 2016; Yigit et al. 2016; Topacogluu 2016).

5 Conclusions

Based on our evaluations in different species, our results show that city factors have a significant effect on leaf micromorphological characteristics. However, the micromorphological characteristics of the plants in different cities in areas with the same climatic conditions were found to be very different. This suggests that the effect of the climate factor on micromorphological characteristics does not dominantly arise alone. In the evaluations, it was found that the city factor precedes the climate factor in affecting leaf micromorphological characteristics, suggesting that factors affecting plant development and occurring at city level or microlevel precede the general climatic characteristics.

The plants analysed in this study were those that are used in landscaping, and the study samples were collected from parks located in the city centres. Plants used for landscaping can also be used outside of their natural propagation areas, and the conditions required by them can be provided artificially. For example, a plant with high water demand can be grown in an arid region, and its water demand can be met with regular irrigation. Therefore, the microconditions under which the plant grows can be considerably different from the main climate type. A similar condition also applies to edaphic factors. Therefore, microenvironmental conditions in plants used in landscaping can be considerably different from the edaphic and climatic conditions of the region, and microenvironmental conditions can predominantly affect the plant's growth performance. Therefore, studies on plants collected from these areas make it difficult to determine the effect of climate on the micromorphological characteristics of the plant. Therefore, subsequent studies on natural plant species may provide more robust data for determining the effect of climate on the micromorphological characteristics of the plant.

Micromorphological characteristics may provide important information in determining the response of the plant to environmental conditions. However, there are a limited number of studies on this topic. In order to provide basic information in this field, trials should be performed in controlled environments, focusing on the determination of the effect of environmental conditions on micromorphological characteristics. For example, the effect of water stress on micromorphological characteristics can be determined by applying different irrigation practices in an environment wherein all conditions are equal. Similar practices on different environmental conditions and stress factors can provide important information on this subject.

Authors contribution Mehmet and Hakan conceived and designed the experiments, and Halil, Abdullah, Mehmet and Hakan performed the experiments. Hakan, Mehmet and Halil analysed the data; Ilknur, Abdullah, Halil, Mehmet and Hakan contributed reagents/materials/analysis tools; and Ilknur, Abdullah Halil, Hakan and Mehmet wrote the paper.

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Compliance with ethical standards

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