Identification of Some Fiber Characteristics in *Rosa sp.* and *Nerium oleander* L. Wood Grown under Different Ecological Conditions

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Climate-dependent changes in wood anatomical characteristics were studied for *Rosa* sp. and *Nerium oleander* sp. grown in phytosociological areas. For this purpose, wood samples were taken from the individual wood species grown in Antalya, Eskisehir, and Kastamonu provenances, where Terrestrial, Black Sea, and Mediterranean climate types prevail, and 11 anatomical characters were identified or calculated. As a result of the study, it has been determined that the climate has large effects on the characteristics that are the subject of the study and that each characteristic is at a higher level in individuals grown in areas where different climate types prevail. The highest values in *Rosa* species were obtained in the individuals grown under Terrestrial climate type in all characteristics except for LW (lumen widths), EC (elasticity coefficients), and FF (F-Factors.) Whereas in *Nerium oleander*, the highest values were obtained in individuals grown in the Mediterranean climate type in FL (fibre lengths), LW (lumen widths), FR (felting ratios), and EC (elasticity coefficients). For the same species type, in the Terrestrial climate, RIJID (rigidity coefficients), MUHT (Muhlstep ratios), and RUNK (Runkel ratios), and in the Black Sea climate DWT (double wall thicknesses) and WT (wall thicknesses) characteristics had high values.

Keywords: Anatomical character; Climate type; Rosa; Nerium oleander L.

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INTRODUCTION

Plants form the basis of the food pyramid because of their special ability to photosynthesize their own food. For this reason, all living life depends directly or indirectly on plants (Cetin *et al.* 2020). In addition to this, plants fulfil many ecological and social functions such as reducing air and noise pollution, preventing erosion, and reducing the speed of wind in the environment (Sevik *et al.* 2020).

Besides the many functions that they provide, plants are also crucial economic resources. In addition to being used as food, woody plants are a raw material source for many industries such as furniture, paper industry, and fibre chipping industry. Both quality and significance of plants as a source of raw materials in these industries are largely related to their anatomical characters (Yigit *et al.* 2016; Sevik *et al.* 2017). The anatomical characters of plants are mostly shaped under the influence of environmental factors. Climate parameters, particularly precipitation and temperature, affect the development and anatomical characters of plants (Ren *et al.* 2018; Turkyilmaz *et al.* 2018a,b).Turkey is affected by three main climate types, which have quite different characters. These climate types are Black Sea, Terrestrial, and the Mediterranean climate. In Turkey, many woody plant species can be grown in areas where all three climate types are dominant. The morphological characteristics of these plants do not differ significantly from each other (Cetin *et al.* 2018a,b). However, information on how they differ anatomically is not sufficient.

In fact, wood anatomical characters that are of great importance especially for the wood raw material industry, can give an idea on many issues such as genetic variation studies, and determination of the stress level adaptability of plants (Yigit *et al.* 2018). However, the studies on how wood anatomical characters change depending on the climate type are minimal. In order to contribute to filling this gap in the literature, this study aims to determine how some anatomical characteristics in two different woody plant species differ in individuals grown in areas where different climate types prevail.

Nerium oleander used in the study is found in the eastern Mediterranean along the coasts of Montenegro, Croatia and Albania, in Southern and Eastern Greece, in many of the Aegean Islands, in Western, Southern and Southeastern Anatolia, Cyprus, Western Syria, Lebanon, Israel, Jordan, Northeastern Iraq and it is widespread in western Iran. In Turkey, it spreads naturally in the provinces of Manisa, Çanakkale, Balıkesir, Muğla, Denizli, Aydın, Antalya, Mersin, Adana, Hatay, and Adıyaman provinces. It is an evergreen, poisonous, and highly decorative shrub that can grow to 6 m tall, belonging to the Apocynaceae family, and is a very valuable shrub that is frequently used in landscaping (Akkemik 2018). It is also an important species in the pharmaceutical industry (Vikas and Payal 2010). *Rosa* sp. is a shrub-like plant belonging to the Rosaceae family, which sheds its leaves in winter. In the flora of Turkey, 26 *Rosa* species and 13 hybrids are registered. There are also many cultivars available. Rosa species are also extremely important species in terms of cosmetics and pharmaceutical industry as well as landscape studies (Akkemik 2018; Bragă and Dincă 2019).

EXPERIMENTAL

Materials

The study was carried out on *Nerium oleander* and *Rosa* individuals grown in various phytosociological areas. Within the scope of the study, the wood samples were taken from individuals grown in various climate regions in Turkey with three different ecological conditions, such as Antalya province, where the Mediterranean climate type prevails, Eskisehir province, where the Terrestrial climate type prevails, and Kastamonu province where the Black Sea climate type prevails. While the annual average temperature is 18.8 °C in Antalya, one of the provinces subject to the study, it is 11.3 °C in Eskişehir and 9.8 °C in Kastamonu. While the average number of rainy days is 85.4 days/year in Antalya, 102.4 days/year in Eskişehir, 146.5 days/year in Kastamonu, the annual average precipitation is 1061.7 mm in Antalya and 372.9 mm in Eskişehir, and 482.3 mm in Kastamonu province (MGM, 2021). The samples used in the study were taken from the mature woods of the main stems of the individuals. Since all three climate types prevail at different altitudes, sampling from the same altitude is not possible. However, sampling was conducted from areas where the effects of all the three climate types are clearly seen, and an attempt was made to select similar morphological characteristics of the samples (maturity status, diameter, height, *etc*.). Ten samples of each species were taken.

No similar study has been conducted on these species or on the comparative wood anatomy in different phyto-geographic regions. For this reason, this study is the first research of its kind in Turkey.

Methods

Wood maceration was performed on the plant species used within the scope of the study. Approximately 150 fibre measurements were made for each species, and fibre length, fibre width, and lumen width were measured for each species. With the results obtained, felting ratio, elasticity coefficient, rigidity coefficient, Muhlsteph ratio, Runkel ratio, and F-factor were calculated.

The sample branch pieces taken from plant species were cut into matchstick-size pieces to make them suitable for the maceration process. The cut samples were stored in labelled test tubes. Approximately 0.5 mL of sodium chlorite ($NaClO_2$) solution was added to the samples inside the test tubes. Later, pure water was added in a way to exceed the sample size in the test tubes. Sodium chlorite and acetic acid were used to release the fibres in the maceration process. This method, developed by Spearing and Isenberg (1947), is known as the chlorite method.

Sodium chlorite is a compound used as a disinfectant. A total of 1.5 mL of acetic acid was added onto the sample mixed with the help of a Pasteur pipette, and the glass test tubes were thoroughly mixed. Later, some hot water was poured into an empty beaker and the glass test tubes were placed inside. These processes were repeated three times at 30 min intervals. However, in each of these repetitions, 1 part of $NaClO_2$ and acetic acid were added. After repeating this procedure three times, the lignin was softened.

The samples in the test tubes were cleaned by rinsing with pure water and then dried on the filter paper. The washing process was continued until the rinsing water became clear. After the washing process was completed, some pure water was taken in an empty beaker, and the samples were placed in that water and mixed using a laboratory mixer for 10 min. After the process was completed, the solutions were poured in jars. A total of 10 mL of methanol (CH_3OH) was poured into the jars to prevent bacterial contamination.

In order to make measurements of the decomposed fibre, it was dripped onto the millimetre glass slide with the help of a Pasteur pipette. The fibre measurements were made on the computer with the help of SOIF BK5000-L Binocular Laboratory Microscope-IOS Plan Achromat (Shanghai optical Instrument Import & Export Co., Ltd, Shanghai, China) and a video camera (Samsung Electronics Co., Ltd., Suwon, South Korea). MShot Digital Imaging System (Microshot Technology Pte.Ltd., China & Singapore) program was used for the measurements.

The measurements of fibre lengths, fibre widths, and lumen widths of the species were made with a 4X plan achromat lens. For this purpose about 150 measurements were made from each sample. Within this context, fibre lengths (FL), fibre widths (FW), lumen widths (LW), double wall thicknesses (DWT), and wall thicknesses (WT) were measured. Through these values obtained, felting ratios (FR), elasticity coefficients (EC), rigidity coefficients (RIJID), Muhlstep ratios (MUHT), Runkel ratios (RUNK), and F-Factors (FF) were calculated. The formulas used in determining the anatomical characters are shown below (Eqs. 1 through 6) (Bozkurt 1971; Goksel 1986; Tank *et al.* 1990; Yaman and Gencer 2005; Kirci 2006):

$$\text{Felting Ratio} = \text{Fibre Length } (L) \,/\, \text{Fibre Width } (D) \tag{1}$$

$$\text{Elasticity Coefficient} = \text{Lumen Width } (d) \times 100 \,/\, \text{Fibre Width } (D) \tag{2}$$

$$\text{Rigidity Coefficient} = \text{Fibre Wall Thickness } (W) \times 100 \,/\, \text{Fibre Width } (D) \tag{3}$$

$$\text{Muhlstep Ratio} = \text{Fibre Wall Area } (D2 - d2) \times 100/\text{Fibre Cross-Sectional Area } (D2) \tag{4}$$

$$\text{Runkel Ratio} = 2 \times \text{Fibre Wall Thickness } (W) \,/\, \text{Lumen Width } (d) \tag{5}$$

$$\text{F-Factor} = \text{Fibre Length } (L) \times 100 \,/\, \text{Fibre Wall Thickness } (W) \tag{6}$$

The data obtained from this study were evaluated with the help of the SPSS package program (SPSS 20.0 version. IBM Turk Co., Ltd., İstanbul, Turkey). Later, the variance analysis was applied to the data, and homogeneous groups were formed by applying Duncan’s test, if there was a significant difference at the level of $P < 0.05$, and the results were interpreted (Kalipsiz 1994; Ercan 1995).

By applying the analysis of variance to the data obtained within the scope of the study, it was determined whether there was a statistically significant ($p<0.05$) difference between the characters of the study in individuals who grew up in different climate types. Duncan test was applied to the data that was determined to have a statistically significant difference. Duncan test provides grouping of data and determines in which group each climate type is. As a result of the Duncan test, it is revealed that there is no statistically significant difference found among the climate types within the same groups. As a result of the Duncan test applied within the scope of the study, each group was symbolized with a letter (a: first group, b: second group, c: third group). In addition, the obtained values are sorted in order from smallest to largest, the smallest values are in the first group and the highest values are in the last group. Within the scope of the study, the mean values, the F value obtained as a result of the analysis of variance, the statistical significance level and the groups formed as a result of the Duncan test have been simplified and given in a single table in order to interpret the data more easily.

RESULTS

Table 1 below gives the climate-dependent changes of anatomical characters of *Rosa* sp. individuals analysed within the scope of the study.

It is clear from Table 1 that the climate-dependent changes of all anatomic characters except for FW were at a statistically significant level ($P < 0.05$). When the mean values and the groupings formed as a result of Duncan test are examined, it is seen that the individuals grown in the Black Sea climate type were in the first homogeneous group for all characteristics except for FL, LW, EC, and FF. The highest values in all characters except for LW, EC, and FF were obtained in individuals grown in the Terrestrial climate type. The relationship levels of anatomical characters in *Rosa* sp. individuals are given in Table 2.

Table 1. Changes of Anatomical Characters Depending on Climate Type in *Rosa* Individuals

Characteristics	Mediterranean	Terrestrial	Black Sea	F Value
FL	483.9 a	622.5 c	536.7 b	23.575***
FW	17.06	18.01	17.24	1.357 ns
LW	8.39 b	7.16 a	9.04 b	10.52***
DWT	8.67 a	10.85 b	8.19 a	16.339***
WT	4.33 a	5.42 b	4.09 a	16.389***
FR	30.11 a	36.35 b	32.97 a	9.094***
EC	49.13 b	40.61 a	53.34 c	24.451***
RIJID	50.86 b	59.38 c	46.65 a	24.457***
MUHT	72.79 b	81.60 c	68.81 a	21.988***
RUNK	2.68 b	3.55 c	2.20 a	19.849***
FF	7406 a	6671 a	9035 b	5.402**

Note: letters indicate horizontal differentiation between the factors, * significant at 0.05 level. ** significant at 0.01 level. *** Significant at 0.001 level. ns: not significant.

Table 2. Relationship Levels of Anatomical Characteristics in *Rosa* Individuals

	FW	LW	DWT	WT	FR	EC	RIJID	MUHT	RUNK	FF
FL	0.248**	0.067	0.241**	0.240**	0.699**	-0.110*	0.110*	0.108*	0.101*	0.262**
FW		0.563**	0.726**	0.726**	-0.444**	-0.133**	0.133**	0.119*	0.131**	-0.263**
LW			-0.159**	-0.160**	-0.293**	0.708**	-0.708**	-0.699**	-0.631**	0.314**
DWT				1.000**	-0.286**	-0.747**	0.747**	0.724**	0.681**	-0.576**
WT					-0.286**	-0.747**	0.747**	0.724**	0.681**	-0.576**
FR						0.027	-0.027	-0.018	-0.035	0.475**
EC							-1.000**	-0.980**	-0.889**	0.659**
RIJID								0.980**	0.889**	-0.659**
MUHT									0.793**	-0.723**
RUNK										-0.461**

Note: * significant at 0.05 level. ** significant at 0.01 level. *** Significant at 0.001 level. ns: not significant

When the relationship levels between anatomical characters in *Rosa* individuals were examined, it was seen that almost all characteristics were significantly related to each other. It is noteworthy that there were strong negative relationships between some characteristics, in particular. The change of anatomical characteristics depending on the climate type in the individuals of *Nerium oleander*, which is another species evaluated within the scope of the study, is given in Table 3.

Table 3. Changes of Anatomical Characteristics Depending on Climate Type in *Nerium oleander* Individuals

Characteristics	Mediterranean	Terrestrial	Black Sea	F Value
FL	411.9 b	380.4 a	367.0 a	5.643**
FW	19.60	19.44	20.89	2.67 ns
LW	10.54 b	8.81 a	9.98 b	7.253**
DWT	9.06 a	10.62 b	10.90 b	6.084**
WT	4.53 a	5.31 b	5.45 b	6.084**
FR	22.34 b	21.03 b	18.97 a	6.816**
EC	54.18 b	46.38 a	48.67 a	8.771***
RIJID	45.81 a	53.61 b	51.32 b	8.776***
MUHT	68.73 a	74.91 b	73.58 b	5.188**
RUNK	1.98 a	3.27 c	2.67 b	15.234***
FF	5704	5051	4789	1.461ns

Note: letters indicate horizontal differentiation between the factors, * significant at 0.05 level. ** significant at 0.01 level. *** Significant at 0.001 level. ns: not significant

Table 4. The Relationship Levels of Anatomical Characters in *Nerium oleander* Individuals

	FW	LW	DWT	WT	FR	EC	RIJID	MUHT	RUNK	FF
FL	0.170**	0.181**	0.056	0.056	0.624**	0.06	-0.06	-0.044	-0.083	0.235**
FW		0.566**	0.740**	0.740**	-0.594**	-0.159**	0.159**	0.166**	0.122**	-0.333**
LW			-0.136**	-0.136**	-0.296**	0.690**	-0.690**	-0.657**	-0.645**	0.242**
DWT				1.000**	-0.472**	-0.754**	0.754**	0.736**	0.674**	-0.598**
WT					-0.472**	-0.754**	0.754**	0.736**	0.674**	-0.598**
FR						0.148**	-0.149**	-0.143**	-0.144**	0.464**
EC							-1.000**	-0.979**	-0.883**	0.654**
RIJID								0.979**	0.884**	-0.654**
MUHT									0.780**	-0.737**
RUNK										-0.432**

Note: * significant at 0.05 level. ** significant at 0.01 level. *** Significant at 0.001 level. ns: not significant.

When the values in Table 3 were examined, it was seen that the climate-dependent changes of all anatomic characters except for FW and FF were at a statistically significant level ($P < 0.05$). When the mean values and the groupings formed as a result of Duncan test were examined, it was seen that the data form two homogeneous groups in terms of characteristics except for RUNK character and the individuals grown in the Black Sea climate type were in the second homogeneous group in all characters except for FL, FR and EC. The relationship levels of anatomical characters in *Nerium oleander* individuals are given in Table 4.

Like in *Rosa* sp. individuals, almost all anatomical characteristics in *Nerium oleander* individuals were significantly related to each other. The fact that many characteristics were calculated correlatively could be the reason for this situation.

DISCUSSION

From this study, it was found that the wood anatomical characteristics in both *Rosa* sp. and *Nerium oleander* species varied in individuals grown in areas where different climate types prevailed. However, the climate types, in which each characteristic has a higher value, are different in the two species.

Some of the characteristics considered in the study are highly important anatomical characteristics for industries when using wood as raw materials. For instance, in the felting ratio that is calculated as the ratio of fibre length/fibre width, increased with increasing fibre length, and if the ratio drops below 70%, the resistance property of the paper decreased (Kirci 2003). Felting ratio values are generally between 40 and 60 in the woods of leaved trees, and over 100 in the woods of coniferous trees (Ozdemir *et al.* 2018). Felting ratio (KECE) was far below this value in both species studied. However, the results indicated that the KECE of the *Rosa* individuals grown in the Terrestrial climate type was 20% higher than in those grown in the Mediterranean climate type. This may be applicable to those species that are important to the paper industry.

Similarly, the rigidity coefficient (RIJID) being high affects the physical resistance property of the paper in a negative way (Alkan *et al.* 2003). An increase in RIJID value revealed, tearing, fracture, and explosion properties of the paper to be decreasing (Tunctaner *et al.* 2003). In this study, it was found that the RIJID value was higher than that in individuals grown in the Terrestrial climate type in both species.

Runkel ratio (RUNK) is another important characteristic in papermaking (Ozdemir *et al.* 2015). The results show that the RUNK value was relatively higher in individuals grown in the Terrestrial climate type. For instance, in *Nerium oleander,* the RUNK of individuals grown in the Terrestrial climate was approximately 65% higher than that of individuals grown in the Mediterranean climate type.

F-Factor (FF) is one of the important characters in the papermaking industry. The FF value provides information on the flexibility of the paper, and when the FF value increases, the usage rate of the fibres is stated to be increasing as well (Tunctaner *et al.* 2003; Istek *et al.* 2009). In this study, the FF value varied considerably depending on the climate type. For instance, the FF value of the Rosa individuals grown in the Black Sea climate was approximately 35% higher than that grown in the Terrestrial climate type.

Wood anatomical characteristics are the most important factors affecting the product quality both in the paper industry and in other industries that use wood as raw material, such as fibre-chip industry and timber industry. For this reason, many studies have been conducted on the identifications of the wood anatomical characteristics of various plant species, and on the suitability of their usage as raw materials in these industries (Marbun *et al.* 2019; Prasetyo *et al.* 2019; Sinha *et al.* 2019; Zhao *et al.* 2019).

In a study, the most abundant elements found in *Rosa canina* were as K (2963.0 mg/kg), Ca (1820.0 mg/kg), Mg (709.0 mg/kg), P (495.0 mg/kg), and S (289.8 mg/kg). (Paunovic et al., 2019). However, studies on the species mostly focus on its fruits and pharmacological properties (Kerasioti *et al*. 2019; Wanes *et al.* 2020; Jemaa *et al.* 2017). In a study on *Nerium oleander,* the presence of hemicelluloses and lignin in their structure was supported by the low calculated crystallinity index (CrI, 43.4%) and the small crystallite size (2.23) (Jabli *et al.* 2018). However, in *Nerium oleander*, studies on chemical characteristics mainly have concentrated on flowers (Ali *et al.* 2010), and leaves (Margitai *et al.* 2017).

However, in the studies conducted, mostly the wood anatomical characters of the species were evaluated. The present work indicates that there may be significant differences in the wood anatomical characters of individuals grown in areas with various climate types. This is because the wood anatomical characters mainly depend on growth rate and stress factors. These factors are edaphic and climate factors, such as precipitation, temperature, light, air pollution, soil structure, and soil nutrient status (Ren *et al.* 2018; Turkyilmaz *et al.* 2018a,b; Sevik *et al.* 2019a,b; Cetin *et al.* 2020). For this reason, differentiation of these factors may cause the wood anatomical characters to differ significantly. These results reveal the fact that plants' micro-morphological characteristics differ significantly in individuals grown in areas where different climate types prevail (Cetin *et al.* 2018a,b).

Genetic structure is another factor affecting the anatomical characters of plants. Plant anatomical characters are shaped by the mutual interaction of genetic structure and environmental conditions (Hrivnák *et al.* 2017; Yigit *et al.* 2018; Yucedag *et al.* 2019). The plants' reaction to environmental factors are closely related to the genetic structure of plants (Aricak *et al.* 2020; Turkyilmaz *et al.* 2020; Sevik *et al.*, 2020b). It is found that plants belonging to the same species may react differently to the same growing conditions due to the fact that they have different genetic structures (Topacoglu *et al.* 2016; Varol *et al.* 2017; Yucedag *et al.* 2019).

Plants' course of growth, and thus their morphological and anatomical characteristics, are shaped by the environmental and genetic conditions, as well as other factors affecting these characters. For instance, many applications, such as pruning, fertilization, and shading can change the environmental conditions, and thus the growth of the plants, which then change their anatomical characters (Guney *et al.* 2016; Yigit *et al.* 2018).

CONCLUSIONS

1. The results from this study showed that the wood anatomical characteristics of both species differed significantly depending on the climate type. This is of great importance for industries where wood anatomical characters are highly important and determine product quality, especially when wood is used as raw material. This is because the quality of the products to be produced with the wood raw material obtained from the areas, where different climate types prevail, will be different, despite being the same species. Consequently, the level of impact of climate types on wood anatomical characters should be determined through the studies to be conducted on the species that are intensively used or have the potential to be used in these industries.
2. This study revealed that each climate type has various level of impact on different anatomical characteristics. For example, in *Nerium oleander,* the highest values were obtained in individuals grown in the Mediterranean climate type in FL, LW, FR, and

EC characteristics, in the Terrestrial climate type in RIJID, MUHT, and RUNK characteristics, and in the Black Sea climate type in DWT and WT characters. Each of these characteristics is important for various industries. Therefore, identification of the climate type, in which the characteristics needed for each industry develops at the highest level, and supply of wood raw material from this region may contribute to the increase of product quality.

3. In previous studies, the anatomical characters were only evaluated in terms of usability of wood as raw material. However, these characteristics are shaped by the mutual interaction of environmental conditions and genetic structure. Thus, determining how these characteristics are shaped depending on various environmental conditions and genetic structure, and putting them into practice during plant growing can be highly effective on product quality.

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REFERENCES CITED

Ali, H. F. M., El-Ella, F. M. A., and Nasr, N. F. (2010). "Screening of chemical analysis, antioxidant antimicrobial and antitumor activities of essential oil of oleander (*Nerium oleander*) flower," *International Journal of Biological Chemistry* 4(4), 190-202.

Alkan, Ç., Eroğlu, H., and Yaman, B. (2003). *Türkiye'deki Bazı Odunsu Angiospermae Taksonlarının Lif Morfolojileri* [Fiber Morphology of Some Woody Angiospermae Taxa in Turkey], ZKÜ Bartın Orman Fakültesi Dergisi, 5(6), 102-108.

Aricak, B., Cetin, M., Erdem, R., Sevik, H., and Cometen, H. (2020). "The usability of Scotch pine (*Pinus sylvestris*) as a biomonitor for traffic-originated heavy metal concentrations in Turkey," *Polish Journal of Environmental Studies* 29(2), 1051-1057. DOI: 10.15244/pjoes/109244

Bozkurt, A. Y. (1971). "Doğu ladini (*Picea Orientalis* Link Et Carr.) ile Toros karaçamı (*Pinus nigra* var. *caramanica* (Loud) Rehd.)'dan birer ağaçta lif morfolojisi üzerine denemeler [Essays on fiber morphology in one tree from Eastern spruce (*Picea orientalis* Link Et Carr.) and Taurus black pine (*Pinus nigra* var. *caramanica* (Loud) Rehd.]," *Journal of the Faculty of Forestry Istanbul University Serial A.*1(1), 70-93.

Bragă, C., and Dincă, L. (2019). "Forest is not only wood: Evaluating non-timber products from Dâmbovița county," *Current Trends in Natural Sciences* 8(15), 73-78.

Cetin, M., Sevik, H., and Cobanoglu, O. (2020). "Ca, Cu, and Li in washed and unwashed specimens of needles, bark, and branches of the blue spruce (*Picea pungens*) in the city of Ankara," *Environmental Science and Pollution Research* 27(17) 21816-21825. DOI: 10.1007/s11356-020-08687-3

Cetin, M., Sevik, H., and Yigit, N. (2018a). "Climate type-related changes in the leaf micromorphological characters of certain landscape plants," *Environmental Monitoring and Assessment* 190(7), 1-9. DOI: 10.1007/s10661-018-6783-3

Cetin, M., Sevik, H., Yigit, N., Ozel, H. B., Aricak, B., and Varol, T. (2018b). "The variable of leaf micromorphogical characters on grown in distinct climate conditions in some landscape plants," *Fresenius Environmental Bulletin* 27(5), 3206-3211.

Ercan, M. (1995). *Bilimsel Araştırmalarda Istatistik (Statistics in Scientific Research), Orman Bakanlığı, Kavak ve Hızlı Gelişen Tür Orman Ağaçları Araştırma Müdürlüğü*, Kocaeli, Turkey.

Göksel, E. (1986). "Pamuk saplarının selüloz ve kağıt endüstrisinde kullanım olanakları üzerine araştırmalar [Research on the possibilities of using cotton stems in the pulp and paper industry)]," *Journal of the Faculty of Forestry Istanbul University Serial A* 36(1), 38-54. DOI: 10.17099/jffiu.19035

Guney, K., Cetin, M., Sevik, H., and Guney, K. B. (2016). "Influence of germination percentage and morphological properties of some hormones practice on *Lilium martagon* L. seeds," *Oxidation Communications* 39(I-II), 466-474.

Hrivnák, M., Paule, L., Krajmerová, D., Kulac, S., Sevik, H., Turna, I., Tvauri, I., and Gömöry, D. (2017). "Genetic variation in tertiary relics: The case of eastern-Mediterranean *Abies* (Pinaceae)," *Ecology and Evolution* 7(23), 10018-10030. DOI: 10.1002/ece3.3519

İstek, A., Tutuş, A., and Gülsoy, S. K. (2009). "Sahil çamı odununun lif morfolojisi ve kağıt özellikleri üzerine ağaç yaşının etkisi [Effect of tree age on the fiber morphology and paper properties of maritime pine wood]," *KSU Journal of Engineering Sciences* 12(1), 1-5.

Jabli, M., Tka, N., Ramzi, K., and Saleh, T. A. (2018). "Physicochemical characteristics and dyeing properties of lignin-cellulosic fibers derived from *Nerium oleander*," *Journal of Molecular Liquids* 249, 1138-1144.

Jemaa, H. B., Jemia, A. B., Khlifi, S., Ahmed, H. B., Slama, F. B., Benzarti, A., Elati, J., & Aouidet, A. (2017). "Antioxidant activity and α-amylase inhibitory potential of *Rosa canina* L." *African Journal of Traditional, Complementary and Alternative Medicines* 14(2), 1-8.

Kalıpsız, A. (1994). *İstatistik Yöntemler* [*Statistical Methods*], Faculty of Forestry, Istanbul University, İstanbul, Turkey.

Kerasioti, E., Apostolou, A., Kafantaris, I., Chronis, K., Kokka, E., Dimitriadou, C., Tzanetou, E.N., Priftis, A., Koulocheri, S.D., Haroutounian, S.A., Kouretas, D., and Stagos, D. (2019). "Polyphenolic composition of *Rosa canina, Rosa sempervivens* and *Pyrocantha coccinea* extracts and assessment of their antioxidant activity in human endothelial cells," *Antioxidants* 8(4), 92.

Kirci, H. (2003). Kagit Hamuru Endüstrisi Ders Notlari [Pulping Industry Class Notes], Faculty of Forestry, Karadeniz Technical University, Trabzon, Turkey.

Kırcı, H. (2006). Kağıt hamuru endüstrisi ders notları [Pulping industry class notes], Faculty of Forestry, Karadeniz Technical University, Trabzon, Turkey.

Marbun, S. D., Wahyudi, I., Suryana, J., and Nawawi, D. S. (2019). "Anatomical structures and fiber quality of four lesser-used wood species grown in Indonesia," *Journal of the Korean Wood Science and Technology* 47(5), 617-632. DOI: 10.5658/WOOD.2019.47.5.617

Margitai, Z., Simon, E., Fábián, I., and Braun, M. (2017). "Inorganic chemical composition of dust deposited on oleander (*Nerium oleander* L.) leaves," *Air Quality, Atmosphere & Health* 10(3), 339-347.

MGM (2021). Meteoroloji Genel Müdürlüğü (mgm.gov.tr). Accessed on 10.06.2021

Özdemir, A., Tutuş, A., and Çiçekler, M. (2018). "Kaparinin (*Capparis spinosa*) orman ürünleri endüstrisinde kullanılabilirliğinin araştırılması [Investigation of usability of capers (*Capparis spinosa*) in forest products industry]," in: *International Artvin Symposium*, Artvin, Turkey, pp. 962-972.

Özdemir, F., Tutuş, A., Bektaş, İ., and Çiçekler, M. (2015). "Fıstıkçamı ve yalancı akasya türlerinde öz odun-diri odun kısımlarında hücreler arasındaki morfolojik farklılıkların belirlenmesi [Determination of morphological differences between cells in heartwood-sapwood parts in pistachio and pseudo acacia species]," *Turkish Journal of Forestry* 16(1), 60-64. DOI:10.18182/tjf.60594

Ozel, H. B., Donduran, B., Cakmakli, E., and Sevik, H. (2020). "Factors affecting success in natural regeneration works of cedar (*Cedrus libani* A. RICH.) in Kas region of Antalya," *World Journal of Advanced Research and Reviews* 6(2), 54-59. DOI: 10.30574/wjarr.2020.6.2.0127

Paunovic, D., Kaluševic, A., Petrovic, T., Uroševic, T., Djinovic, D., Nedovic, V., and Popovic-Djordjevic, J. (2019). "Assessment of chemical and antioxidant properties of fresh and dried rosehip (*Rosa canina* L.)," *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 47(1), 108-113.

Prasetyo, A., Aiso-Sanada, H., Ishiguri, F., Wahyudi, I., Wijaya, I. P. G., Ohshima, J., and Yokota, S. (2019). "Variations in anatomical characteristics and predicted paper quality of three Eucalyptus species planted in Indonesia," *Wood Science and Technology* 53(6), 1409-1423. DOI: 10.1002/ece3.3519

Ren, P., Rossi, S., Camarero, J. J., Ellison, A. M., Liang, E., and Peñuelas, J. (2018). "Critical temperature and precipitation thresholds for the onset of xylogenesis of *Juniperus przewalskii* in a semi-arid area of the northeastern Tibetan Plateau," *Annals of Botany* 121, 617-624. DOI: 10.1093/aob/mcx188

Sevik, H., Cetin, M., Kapucu, O., Aricak, B., and Canturk, U. (2017). "Effects of light on morphologic and stomatal characteristics of Turkish Fir needles (*Abies nordmanniana* subsp. bornmulleriana Mattf.). *Fresenius Environmental Bulletin* 26 (11), 6579-6587.

Sevik, H., Cetin, M., Ozel, H. B., and Pinar, B. (2019a). "Determining toxic metal concentration changes in landscaping plants based on some factors," *Air Quality, Atmosphere and Health* 12(8), 983-991. DOI: 10.1007/s11869-019-00717-5

Sevik, H., Cetin, M., Ozel, H. B., Ozel, S., and Cetin, I. Z. (2020). "Changes in heavy metal accumulation in some edible landscape plants depending on traffic density," *Environmental Monitoring and Assessment* 192(2), 1-9. DOI: 10.1007/s10661-019-8041-8

Sevik, H., Cetin, M., Ozel, H. U., Ozel, H. B., Mossi, M. M. M., and Cetin, I. Z. (2020b). "Determination of Pb and Mg accumulation in some of the landscape plants in shrub forms," *Environmental Science and Pollution Research* 27(2), 2423-2431. DOI: 10.1007/s11356-019-06895-0

Sevik, H., Cetin, M., Ozturk, A., Yigit, N., and Karakus, O. (2019b). "Changes in micromorphological characters of *Platanus orientalis* L. leaves in Turkey," *Applied Ecology and Environmental Research* 17 (3), 5909-5921.

Sinha, S. K., Chaudhari, P. A., Thakur, N. S., Jha, S. K., Patel, D. P., and Dhaka, R. K. (2019). "*Melia dubia* Cav. wood properties vary with age and influence the pulp and paper quality," *International Wood Products Journal* 10(4), 139-148. DOI: 10.1080/20426445.2019.1688947

Spearing, W. E., and Isenberg, J. H. (1947). “The maceration of woody tissue with acetic acid and sodium clorite,” *Science* 105(2721), 214-214. DOI: 10.1126/science.105.2721.214

Tank, T., Göksel, E., Cengiz, M., and Gürboy, B. (1990). “Hızlı gelişen bazı iğne yapraklı ağaç türlerinin lif ve kağıt teknolojisi yönünden incelenmesi [Investigation of some fast-growing coniferous tree species in terms of fiber and paper technology],” *Journal of the Faculty of Forestry Istanbul University Serial A* 40(1), 40-50.

Topacoglu, O., Sevik, H., and Akkuzu, E. (2016). “Effects of water stress on germination of *Pinus nigra* Arnold seeds,” *Pakistan Journal of Botany* 48(2), 447-453.

Tunçtaner, K., As, N., and Özden, Ö. (2003). “Bazı kavak klonlarının büyüme performansları, odunlarının bazı teknolojik özellikleri ve kağıt üretimine uygunlukları üzerine araştırmalar [Research on growth performance of some poplar clones and some technological properties of wood and their suitability for paper production],” *Kavak ve Hızlı Gelişen Orman Ağaçları Araştırma Enstitüsü*, Kocaeli, Turkey.

Turkyilmaz, A., Cetin, M., Sevik, H., Isinkaralar, K., and Saleh, E. A. A. (2020). “Variation of heavy metal accumulation in certain landscaping plants due to traffic density,” *Environment, Development and Sustainability* 22(3), 2385-2398. DOI: 10.1007/s10668-018-0296-7

Turkyilmaz, A., Sevik, H., Cetin, M., and Ahmaida Saleh, E. A. (2018b). “Changes in heavy metal accumulation depending on traffic density in some landscape plants,” *Polish Journal of Environmental Studies* 27(5), 2277-2284. DOI: 10.15244/pjoes/78620

Turkyilmaz, A., Sevik, H., Isinkaralar, K., and Cetin, M. (2018a). “Using *Acer platanoides* annual rings to monitor the amount of heavy metals accumulated in air,” *Environmental Monitoring Assessment* 190(10), 1-11. DOI: 10.1007/s10661-018-6956-0

Varol, T., Özel, H. B., and Bilir, N. (2017). “Drought effects on reproductive and growth characteristics in seed orchards,” *Pakistan Journal of Botany* 49(4), 1225-1229.

Vikas, G., and Payal, M. (2010). “Phytochemical and pharmacological potential of Nerium oleander: a review”. *International Journal of Pharmaceutical Sciences and Research (IJPSR),* 1(3), 21-27.

Wanes, D., Jabri, M. A., Tounsi, H., Rtibi, K., Zouari, N., Hajji, N., Jridi, M., Abdellaoui, A., and Sebai, H. (2020). “Chemical characterization of bioactive components of *Rosa canina* extract and its protective effect on dextran sulfate sodium-induced intestinal bowel disease in a mouse model,” *Journal of Medicinal Food* 23(10), 1109-1119.

Yaman, B., and Gencer, A. (2005). “Trabzon koşullarinda yetiştirilen kiwi bitkisi (Actinidia deliciosa (A. Chev.) C. F. Liang & A. R. Ferguson)'nin lif morfolojisi [Fiber morphology of kiwi (*Actinidia deliciosa* (A. Chev.) C. F. Liang & A. R. Ferguson) Grown In Trabzon],” *Turkish Journal of Forestry* 6(2), 149-155. DOI: 10.18182/tjf.80788

Yigit, N., Cetin, M., and Sevik, H. (2018). “The change in some leaf micromorphological characters of *Prunus laurocerasus* L. species by their habitat,” *Turkish Journal of Agriculture-Food Science and Technology* 6(11), 1517-1521. DOI: 10.1080/10549811.2016.1225512

Yigit, N., Sevik, H., Cetin, M., and Gul, L. (2016). “Clonal variation in chemical wood characteristics in Hanönü (Kastamonu) Günlüburun black pine (*Pinus nigra* Arnold. subsp. *Pallasiana* (Lamb.) Holmboe) seed orchard,” *Journal of Sustainable Forestry*

35(7), 515-526.

Yucedag, C., Ozel, H. B., Cetin, M., and Sevik, H. (2019). "Variability in morphological traits of seedlings from five *Euonymus japonicus* cultivars," *Environmental Monitoring and Assessment* 191(5), 285. DOI: 10.1007/s10661-019-7464-6

Zhao, X., Guo, P., Peng, H., Zhao, P., Yang, Y., and Zhang, Z. (2019). "Potential of pulp production from whole-tree wood of *Betula platyphylla* Roth. based on wood characteristics," *BioResources* 14(3), 7015-7024. DOI: 10.15376/biores.14.3.7015-7024

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