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Original scientific paper

GROWTH CHARACTERISTICS OF *Tilia tomentosa* Moench. FROM DIFFERENT DISTRICTS IN THE REGIONS OF MARMARA AND WESTERN BLACK SEA IN TURKEY

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Climate change will affect all ecosystem services of green areas in the districts. In many cases, the tree species in parks and districts are suffering from the increasingly warmer and drier summers and newly immigrated pests and diseases. *Tilia tomentosa* Moench. is considered as an important tree species under climate change for dry and warm conditions in Central and Southeastern Europe countries. This tree species is often used as valued urban tree. In the present study we investigate the growth patterns of *T. tomentosa* Moench. in relation to their growing conditions in order to evaluate its interactions in urban contexts. All the studied characters varied significantly among the sampled districts. Within each of the regions, number of flowers showed a wide range 72-104 per m^2 in Marmara region and 54-124 per m^2 in Western Black Sea region. All studied characters, beyond number of flowers, positively correlated with each other. This study revealed that especially fruit length had a strong and positive correlation with altitude and

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a high negative correlation with temperature. Further researches are required to quantify more growth flower characters of the species from Turkey.
Keywords: Flower, growth, *Tilia tomentosa,* climate change, Urban forestry, Turkey.

INTRODUCTION

The aesthetic value of plants is very important in landscape practices. The more extraordinary and the higher visual quality a plant is, the more valuable it is. Therefore, the use of plants is a common occurrence in landscape practices (YÜCEDAĞ *et al*., 2018). Hence, the importance of plant existence in urban centers has increased, and this plant existence has been regarded as an indicator of the quality and livability of districts (CETIN, 2016; YÜCEDAĞ *et al*., 2017).

One of the plants often used as valued park trees along avenues and roads as they offer good compromises in urban areas is genus *Tilia* L. (PAWLIKOWSKI, 2010; WERYSZKO-CHMIELEWSKA and SADOWKA 2010; JACQUEMART *et al*., 2018). The genus is also represented by economic and ecological important tree species (IVANOV *et al*., 2014). It is in the family of Tiliaceae with about thirty tree species, native throughout most of the temperate northern Hemisphere, in Asia, Europe and eastern North America with the exception of western North America. Only four of these species occur naturally in Europe, i.e. *Tilia dasystyla* Stev., *T. tomentosa* Moench., *T. cordata* Mill. and *T. platyphyllos* Scop. (DALEMSKA *et al.*, 2016). *T. tomentosa* (Syn: *T. alba*, *T. argentea* D.C.) is native to southeastern Europe and southwestern Asia, from Hungary and the Balkans east to western Turkey (Marmara and around the Black Sea Regions), occurring at moderate altitudes (TOKER, 1995; FILIZ *et al*., 2015; PETROVA *et al.* 2017).

T. tomentosa Moench. is a deciduous tree growing to 20-35 m tall, with a trunk up to 2 m in diameter (PETROVA *et al*., 2017). It appears to tolerate drought better than other *Tilia* species (GILMAN and WATSON, 1994). As a young three it has a pyramidal form but develops into an upright silhouette with an oval canopy. The leaves turn yellow before dropping in autumn. In early summer, the trees are perfumed with extremely fragrant clusters of small, yellow/white blossoms but these are difficult to see due to the dense cover of the large leaves. The flowers attract large numbers of bees and a small, egg-shaped fruit follows the blooms. It could be quite popular for use as a shade, specimen, or residential street tree. Moreover, it could be better considered in urban landscaping to cope with stressing conditions

The species is widely planted outside its native range across Europe and North America. Its high drought and pest tolerance qualifies *T. tomentosa* as an excellent urban tree (KOCH and STEVENSON, 2017). The species considered as a top species for improving air quality (SELMI *et al.,* 2016) has been successfully grown in urban areas where air pollution, poor drainage, compacted soil, and/or drought are common (GILMAN and WATSON, 1994).

Among the other *Tilia* species, *T. tomentosa* is the last species to flower (WERYSZKO-CHMIELEWSKA and SADOWSKA, 2010; JACQUEMART *et al*., 2018). The flowers of *T. tomentosa* used quite prevalent in traditional treatment methods (DALEMSKA *et al*., 2016), have great potential to in industries such as food, medicine and cosmetics due to the rich content of phenolic compounds. It also possesses spasmolytic, diuretic and sedative effects due to flavonoids, essential oil and mucilage components and have been used to treat disorders such as nervous tension, cough, flu, migraine (KIVRAK *et al*., 2017). The fragrant flowers of this tree are toxic to bees (KOCH and STEVENSON, 2017). Trees are usually attacked by aphids which cover the ground and the leaves with a sticky honeydew (BRICKELL, 1990) which may be a negative issue for urban uses. Rarely produces suckers. Quite tolerant of root disturbance, semi-mature trees up to 5 metres tall have been transplanted successfully. Plants in this genus are notably resistant to honey fungus (HUXLEY, 1992).

Recently, there are some studies completed on the morphology and anatomy of *T. tomentosa* fruits (TOKER *et al*., 1997), main flavonoids of leaves (TOKER *et al*., 2004), its pollen release and flowering phenology (WERYSZKO-CHMIELEWSKA and SADOWSKA, 2010; (DABROWSKA *et al*., 2016), morphological differentiation based leaf and twig descriptors (IVANOV *et al*., 2014), genetic variation by RAPD markers (FILIZ *et al*., 2015), phenolic composition of flowers (KIVRAK *et al.*, 2017).

No genetic differentiation was detected between wild and urban materials (FILIZ *et al*., 2015). By contrast, no detailed research on growth characters of the species in question was done in Turkish populations. The first purpose of the study is to analyze the growth patterns of *T. tomentosa* in relation to their growing site conditions. Second purpose is to determine the relations between the growth characters and environmental variables. A general purpose is using this information as an indicator of the species adaptability in urban stressing contexts.

MATERIAL AND METHODS

The study was done for 47 districts located 14 provinces of the Marmara (M) and Western Black Sea (WBS) regions in Turkey (Table 1; Figure 1). All measured trees were park or street trees. Each site was represented by 3 individuals. A minimum distance of 50 m was kept between trees to avoid the sampling of related trees. Average age for each site was determined by the measurement of 10 individuals measured by diameter increment. Altitude and aspect of sites were detected through handheld GPS. Their gradient was measured via a manual inclinometer.

Figure 1. Distribution of *Tilia tomentosa* Moench. on the world (above) and provinces of sampled areas (below)

In total 141 trees from both regions were chosen to measure total height (H), diameter at breast height (DBH), crown length and width (CL and CW), leaf length and width (LL and LW), fruit length (FL) and number of flowers (NF). Three fresh and fully expanded leaves were collected in the mid-to-upper crown of the trees and from the first flush of the year for the measurements of LL and LW. All leaf samples were taken from north side of the trees. The measurements of NF were conducted during the term coinciding with the peak of the blooming of the studied species depend on the study site.

Table 1. Basic information for the study sites in the regions of Marmara and Western Black Sea

No	Site	Region	Altitude (m)	Age	Aspect	Gradient (°)	Slope	Temperature* (°C)	Precipitation* (mm)
1	Çanakkale-Ezine	M	75	38	SW	15	Lower	15	616.3
2	Çanakkale-Lapseki		47	62	S	18	Medium	15	616.3
3	Tekirdağ-Şarköy		225	48	W	32	Upper	14	581.8
4	Tekirdağ-Süleymanpaşa		232	67	NE	30	Upper	14	581.8
5	Kocaeli-Kefken		312	53	E	15	Medium	14.9	813.0
6	Bursa-Karacabey		637	78	W	21	Medium	14.6	706.9
7	Balıkesir-Sındırgı		713	83	NE	16	Lower	14.6	583.0
8	Yalova-Mudanya		63	57	N	18	Lower	10.5	545.5
9	Bolu-Mudurnu	WBS	572	45	W	18	Lower	14.5	838.3
10	Sakarya-Akyazı		234	76	NW	34	Upper	14.5	838.3
11	Sakarya-Karasu		346	61	N	28	Medium	14.5	838.3
12	Sakarya-Hendek		348	57	E	32	Upper	14.5	838.3
13	Düzce-Akçakoca		80	36	NW	10	Lower	13.3	825.5
14	Düzce-Yığılca		336	72	NE	25	Medium	13.3	825.5
15	Düzce-Çilimli		955	53	SW	21	Upper	13.3	825.5
16	Zonguldak-Alaplı		69	65	N	10	Lower	13.6	1218.1
17	Zonguldak-Kocaman		37	73	E	15	Medium	13.6	1218.1
18	Zonguldak-Kilimli		563	58	N	32	Upper	13.6	1218.1
19	Zonguldak-Devrek		462	75	NE	24	Medium	13.6	1218.1
20	Zonguldak-Gökçebey		572	71	W	16	Medium	13.6	1218.1
21	Zonguldak-Çaycuma		523	43	NW	21	Lower	13.6	1218.1
22	Karabük-Yenice		315	76	SW	35	Upper	13.4	489.8
23	Karabük-Safranbolu		492	36	S	15	Medium	13.4	489.8
24	Karabük-Eflani		637	63	NE	28	Medium	134.	489.8
25	Karabük-Ovacuma		645	81	NW	32	Upper	13.4	489.8

26	Bartın-Abdipaşa	445	59	E	12	Lower	12.8	1046.2
27	Bartın-Ulus	568	67	SW	26	Upper	12.8	1046.2
28	Bartın-Karaçaydere	265	63	NW	18	Lower	12.8	1046.2
29	Bartın-Gürgenpınarı	257	41	N	23	Medium	12.8	1046.2
30	Bartın-Amasra	134	75	N	36	Upper	12.8	1046.2
31	Bartın-Kurucaşile	126	69	N	32	Upper	12.8	1046.2
32	Kastamonu-Cide	175	83	NW	28	Medium	9.8	480.0
33	Kastamonu-Şenpazarı	425	76	E	34	Upper	9.8	480.0
34	Kastamonu-Pınarbaşı	543	74	NE	37	Upper	9.8	480.0
35	Kastamonu-Azdavay	637	91	E	32	Upper	9.8	480.0
36	Kastamonu-Daday	618	87	NW	24	Medium	9.8	480.0
37	Kastamonu-Araç	548	90	W	36	Upper	9.8	480.0
38	Kastamonu-İhsangazi	553	84	E	42	Upper	9.8	480.0
39	Kastamonu-Devrekani	667	74	SE	35	Upper	9.8	480.0
40	Kastamonu-İnebolu	63	65	NW	21	Medium	9.8	480.0
41	Kastamonu-Bozkurt	175	86	N	15	Lower	9.8	480.0
42	Kastamonu-Abana	54	41	NE	18	Lower	9.8	480.0
43	Sinop-Türkeli	61	54	N	14	Lower	14.1	686.3
44	Sinop-Ayancık	78	69	NW	18	Medium	14.1	686.3
45	Sinop-Bektaşağa	92	37	SW	25	Lower	14.1	686.3
46	Sinop-Erfelek	327	92	SE	45	Upper	14.1	686.3
47	Sinop-Gerze	60	75	N	10	Lower	14.1	686.3

*Climate records were obtained from ANONYMOUS (2018).

The model of two level nested ANOVA (SOKAL and RHOLF, 1995) was performed to test for significant differences in character mean values between regions and among districts within regions as districts within two regions are not the same as each other. In this variance analysis, both regions and districts were considered as fixed variables. Furthermore, the mean values and standard errors of the mean for all studied characters for each of the districts were calculated. Pairwise comparison of correlations between the studied characters, and between the studied characters and environmental variables were evaluated by using Pearson's correlation coefficients. Component loading plots by using eight variables were obtained with Principle component analysis of factor analysis. Furthermore, to visualize the degree of similarity among districts, morphological differences among districts were visualized with both an unweighted pair group method with hierarchical cluster analyses based on Squared Euclidean distances. All statistical analyzes were carried out by using SPSS program (SPSS Inc., 2011).

RESULTS

Significant differences were found for all growth characteristics between the two regions and between districts within regions (Table 2). The average values of all characters in Marmara region beyond number of flowers were lower than those in Western Black Sea region (Table 3). The lowest characters were found at Sakarya-Hendek with height (10.8 m), diameter at breast height (20.4 cm), crown width (1.7 m) and leaf length (4.2 cm). As shown in Table 3; the highest at Sinop-Bektaşağa had the highest height (21.8 m), diameter at breast height (55.6 cm), crown width (8.8 m) and leaf length (11.8 cm). Leaf width ranged from 1.8 cm (Bartın-Karaçaydere) to 8.3 cm (Kastamonu-Pınarbaşı). Fruit length varied between 3.5 mm and 12.4 mm. Within each region, number of flowers (per m^2) shown a wide range between 72 and 104 per m^2 in Marmara region and 54 to 124 per m^2 in Western Black Sea region. As considered the overall means, it was found as 16.3 m for H, 42.5 cm for DBH, 6.3 m for CL, 4.8 m for CW, 7.8 cm for LL, 5 cm for LW, 8.7 mm for FL, and 82 per m^2 for NF (Table 3).

Table 2. Variance analysis results by all studied characters

Characters	Variance Source	Degree of freedom	F ratio	P
H	Between districts within region	45	1167.7	0.000
	Between regions	1	2698.7	0.000
DBH	Between districts within region	45	949.6	0.000
	Between regions	1	796.6	0.000
CL	Between districts within region	45	1280.2	0.000
	Between regions	1	2652.9	0.000
CW	Between districts within region	45	676.0	0.000
	Between regions	1	220.0	0.000
LL	Between districts within region	45	2944.5	0.000
	Between regions	1	5581.0	0.000
LW	Between districts within region	45	22182.7	0.000
	Between regions	1	28757.1	0.000
FL	Between districts within region	45	567.8	0.000
	Between regions	1	595.4	0.000
NF	Between districts within region	45	535.1	0.000
	Between regions	1	1410.8	0.000

Correlation results between pairs of all studied characters are presented in Table 4. There were strong positive correlations between pairs of all studied characters apart from number of flowers ($P < 0.001$). Number of flowers had no correlation with the other characters. The highest and lowest correlation coefficients (r = 0.96 and r = 0.81) was found between diameter at breast height and crown length, and crown width and leaf width, respectively.

Correlation results between each of all studied characters and environmental variables are given in Table 5. Accordingly, altitude positively correlated with crown length, crown width and fruit length ($P < 0.05$). Yet, it had no correlation with the other growth characters. All studied characters had a negative correlation with temperature ($P < 0.05$). On the contrary, precipitation had a negative correlation only with leaf width (r = -0.37).

Table 3. Means and Standard errors of all studied characters

Site		Mean and Standard Error							
No	Region	H (m)	DBH (cm)	CL (m)	CW (m)	LL (cm)	LW (cm)	FL (mm)	NF (per m^2)
1		11.4±0.7	21.3±0.6	3.8±0.4	1.9±0.6	4.5±1.2	1.8±0.8	5.9±1.1	72±1.8
2		14.2±0.3	43.7±0.7	6.1±0.4	3.5±0.3	7.3±0.8	5.5±1.1	8.4±0.8	78±2.1
3		12.7±0.4	37. 2±0.5	4.9±0.5	3.3±0.3	5.4±0.6	3.2±1.4	5.6±1.3	85±1.5
4	M	14.9±1.1	41.6±0.1	6.3±0.2	4.2±0.4	7.8±0.6	5.6±0.7	8.4±0.6	82±1.6
5		13.2±0.4	40. 5±0.5	5.2±0.6	4.0±0.8	6.1±1.3	3.7±1.2	7.5±0.6	96±0.9
6		19.2±0.6	46.3±0.6	7.3±0.6	6.2±1.0	8.4±1.5	5.9±0.6	9.2±1.2	104±0.6
7		20.4±0.6	48.2±0.6	8.1±0.8	6.7±0.6	9.4±0.7	6.5±0.6	10.4±1.8	83±1.4
8		13.1±0.2	35.6±0.6	4.9±0.5	3.2±0.5	5.6±0.6	3.2±1.0	6.3±1.6	75±1.7
	Mean	14.9±0.2	39.3±0.4	5.8±0.3	4.1±0.3	6.8±0.8	4.4±0.7	7.7±0.5	84±1.3
	Range	11.4-20.4	21.3-48.2	3.8-8.1	1.9-6.7	4.5-9.4	1.8-6.5	5.6-10.4	72-104
9		18.4±0.5	45.9±0.4	6.8±0.5	5.3±0.6	8.3±1.4	6.4±1.3	9.2±1.3	124±1.0
10		15.7±0.6	41. 3±0.6	5.9±0.4	4.4±0.7	7.1±0.7	5.2±1.8	8.4±0.5	118±1.5
11		13.9±0.1	40.8±0.6	5.8±0.4	3.6±0.4	6.4±1.3	3.6±1.2	7.9±0.6	106±2.4
12		10.8±0.4	20.4±0.5	3.4±0.8	1.7±0.4	4.2±1.6	2.3±0.5	6.8±0.8	92±1.7
13		17.5±0.6	44.3±0.8	6.1±0.3	5.1±0.8	8.2±1.2	6.7±0.8	10.3±0.4	94±0.8
14		13.8±0.6	40.9±1.1	5.3±1.1	4.8±0.9	6.1±1.4	3.9±0.6	9.5±1.2	87±1.6
15		15.9±0.6	42.6±1.4	6.2±0.4	5.3±1.0	7.4±0.6	4.8±1.2	8.6±1.1	56±1.4
16		17.8±0.5	45.2±0.6	6.3±0.6	4.8±1.1	8.6±0.8	5.3±1.2	9.7±1.8	75±1.2
17		14.2±0.3	41.2±0.8	6.4±0.6	5.6±0.3	6.5±0.6	3.2±1.4	7.2±0.8	64±1.0
18		18.4±0.1	45.7±0.6	6.7±0.7	5.9±0.3	8.7±1.0	5.7±1.7	9.8±0.6	72±1.7
19		18.2±0.4	45.1±0.5	6.5±0.6	5.8±0.8	8.2±1.1	5.5±0.6	10.4±0.6	93±2.0
20		11.9±0.4	33.4±0.5	4.9±0.4	3.7±0.7	5.1±0.5	2.4±1.2	6.9±0.6	97±1.6
21		17.8±0.6	45.9±0.6	6.8±0.2	5.3±0.5	8.9±0.6	6.3±0.8	9.3±0.4	108±2.3
22		11.2±0.7	21.3±0.6	3.9±0.2	2.1±0.6	4.5±0.6	2.4±1.1	5.8±0.7	72±1.8
23		15.4±0.6	41.8±0.6	6.5±0.8	5.2±0.6	7.3±1.2	3.6±1.2	8.7±1.0	75±1.5
24		19.5±0.6	52.3±0.7	7.8±0.6	6.3±0.6	9.8±1.3	7.2±0.8	11.2±1.3	67±0.9
25		14.6±0.7	40.7±0.3	6.2±0.6	5.4±0.4	6.8±0.7	3.5±0.5	7.5±1.5	54±1.5
26		16.3±0.7	43.1±0.6	6.5±0.6	5.1±0.2	7.6±0.5	4.1±0.6	9.5±0.5	84±1.7
27		15.7±0.3	44.2±0.7	6.4±0.4	5.3±0.4	6.9±1.1	3.4±0.6	7.6±0.8	76±1.1
28	WBS	12.1±0.3	32.4±0.5	4.9±0.8	3.4±0.6	4.8±1.3	1.8±0.6	6.2±1.5	72±1.5
29		17.6±0.8	45.8±0.4	6.4±0.6	5.2±0.5	8.6±1.5	4.5±1.0	9.3±1.3	68±1.5
30		16.8±1.0	42.3±0.8	6.1±0.6	4.7±0.7	8.2±1.0	4.2±1.2	9.1±1.4	75±0.8
31		20.4±1.1	54.3±0.1	8.1±0.4	7.2±0.3	10.4±1.0	7.3±0.9	11.3±0.6	77±1.2
32		17.8±0.5	44.9±0.3	6.8±0.2	5.6±0.4	9.2±0.8	6.4±1.5	10.9±0.7	84±1.6
33		17.4±0.5	43.8±0.8	6.6±0.3	5.2±0.5	8.9±0.6	5.9±1.4	9.7±0.6	93±1.3
34		21.7±0.5	55.4±0.6	8.7±0.4	6.3±0.5	11.5±0.6	8.3±0.6	12.4±0.6	98±1.0
35		20.6±0.7	54.7±0.6	8.5±0.2	6.1±0.6	10.6±1.2	7.1±0.6	11.5±1.2	64±0.9
36		21.4±0.4	55.2±0.6	8.6±0.5	6.5±0.7	11.3±1.1	8.2±1.2	12.1±1.6	78±1.2
37		20.8±0.4	54.2±0.9	8.1±0.8	6.0±0.7	10.2±1.8	7.3±1.1	11.3±	74±1.4
38		17.7±0.3	44.5±1.0	6.7±0.7	5.1±0.8	9.2±1.6	6.8±0.8	10.7±0.6	82±2.0
39		16.2±0.4	42.9±0.5	5.9±0.6	4.2±0.2	7.9±1.5	5.1±0.8	8.4±0.5	75±2.1
40		21.2±0.4	55.2±0.4	8.3±0.6	6.8±0.4	10.3±1.0	7.6±0.6	11.2±0.6	72±1.6
41		13.4±0.5	33.4±0.7	4.2±0.6	3.4±0.6	5.1±1.2	2.5±0.6	4.7±0.9	68±1.8
42		13.9±0.1	41.2±0.6	5.3±0.3	4.1±0.6	6.3±0.8	3.4±0.6	5.4±1.1	71±1.5
43		15.8±0.7	41.8±0.4	6.1±0.8	4.9±0.5	8.9±0.6	5.5±0.4	10.2±0.7	94±1.2
44		11.2±0.6	23.6±0.6	3.2±0.7	1.8±0.4	4.8±0.6	2.7±0.8	3.5±0.5	67±2.0
45		21.8±0.6	55.6±0.4	8.8±0.4	6.7±0.6	11.8±0.7	7.9±1.0	9.6±1.0	78±1.4
46		18.3±0.6	43.9±0.4	6.9±0.5	5.4±0.8	9.7±0.7	6.4±1.2	8.4±1.3	73±1.3
47		12.8±0.5	39.9±0.7	5.9±0.4	4.4±0.3	6.3±0.8	4.2±0.9	5.6±0.8	84±1.1
	Mean	16.6±0.4	43.1±0.3	6.4±0.2	5.0±0.4	8.0±1.0	5.1±0.9	8.9±1.1	81±1.3
	Range	10.8-21.8	20.4-55.6	3.2-8.8	1.7-7.2	4.2-11.8	1.8-8.3	3.5-12.4	54-124
Overall Mean		16.3±0.2	42.5±0.3	6.3±0.1	4.8±0.2	7.8±0.8	5.0±0.7	8.7±0.9	82±0.8
Overall Range		10.8-21.8	20.4-55.6	3.2-8.8	1.7-7.2	4.2-11.8	1.8-8.3	3.5-12.4	54-124

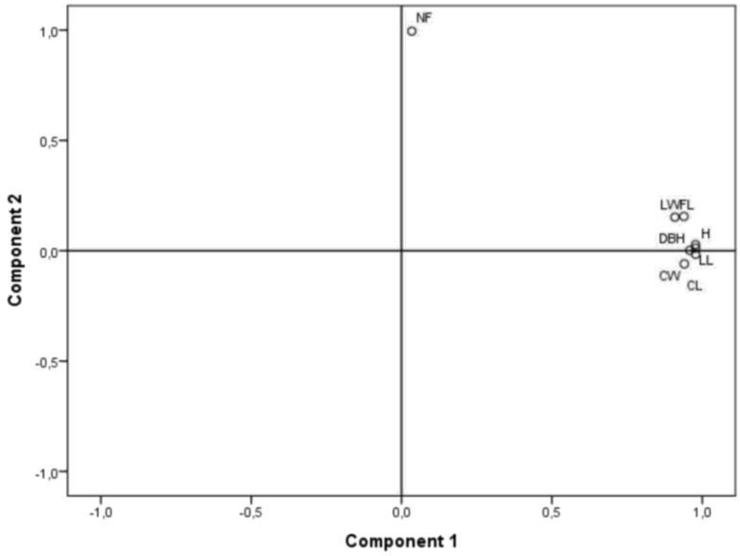

Figure 2. Component loading plots by using eight variables

Table 4. Correlation results between pairs of all studied characters

Character (1)	**Character (2)**	**r**	***P***
Height	Diameter at breast height	0.91	0.000
	Crown length	0.95	0.000
	Crown width	0.91	0.000
	Leaf length	0.97	0.000
	Leaf width	0.93	0.000
	Fruit length	0.88	0.000
	Number of flowers	0.06	0.689
Diameter at breast height	Crown length	0.96	0.000
	Crown width	0.93	0.000
	Leaf length	0.91	0.000
	Leaf width	0.87	0.000
	Fruit length	0.83	0.000
	Number of flowers	0.05	0.745
Crown length	Crown width	0.94	0.000
	Leaf length	0.95	0.000
	Leaf width	0.89	0.000
	Fruit length	0.85	0.000
	Number of flowers	0.03	0.849
Crown width	Leaf length	0.87	0.000
	Leaf width	0.81	0.000
	Fruit length	0.82	0.000
	Number of flowers	-0.01	0.977
Leaf length	Leaf width	0.95	0.000
	Fruit length	0.88	0.000
	Number of flowers	0.04	0.802
Leaf width	Fruit length	0.87	0.000
	Number of flowers	0.17	0.257
Fruit length	Number of flowers	0.16	0.284

Table 5. Correlation results between each of all studied characters and environmental variables

Characters	Altitude		Temperature		Precipitation	
	r	P	r	P	r	P
Height	0.29	0.046	-0.41	0.004	-0.23	0.121
Diameter at breast height	0.28	0.049	-0.37	0.011	-0.16	0.272
Crown length	0.36	0.014	-0.35	0.015	-0.21	0.150
Crown width	0.39	0.007	-0.32	0.030	-0.05	0.755
Leaf length	0.23	0.114	-0.41	0.004	-0.28	0.053
Leaf width	0.24	0.109	-0.38	0.009	-0.37	0.010
Fruit length	0.43	0.003	-0.42	0.003	-0.17	0.257
Number of flowers	0.14	0.361	0.23	0.113	-0.05	0.759

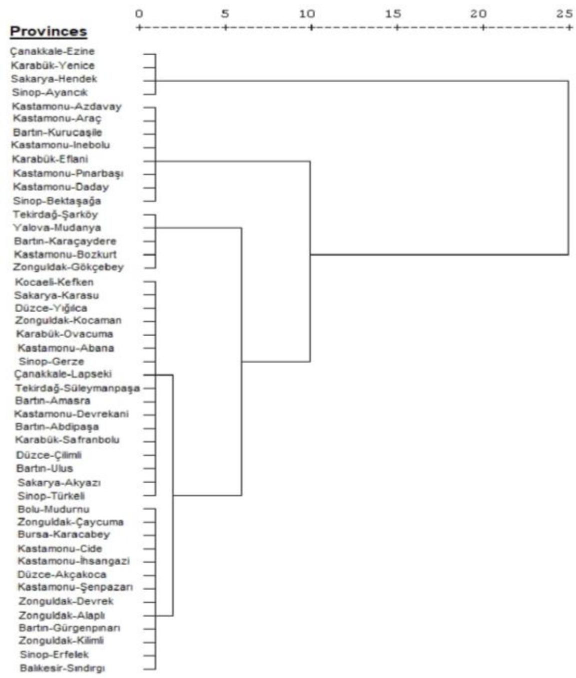

Figure 3. Dendrogram of hierarchical cluster analysis based on Squared Euclidean distances among districts

Two components were obtained from factor analysis. The two components of PCA explained 80 and 13% of the total variation, respectively. While number of flower formed a discrete group, the other variables were similar to each other (Figure 2).

According to the hierarchical cluster analysis (Figure 3) based on eight measured characters, two main groups could be distinguished at the 25.0 distance unit. Only four districts (Çanakkale-Ezine, Karabük-Yenice, Sakarya-Hendek and Sinop Ayancık) were replaced in a group. On the other hand, most districts were grouped within two groups.

DISCUSSION

All studied characters varied significantly between districts within regions and between regions. For most of characters, Sakarya-Hendek had the lowest mean values and Sinop-Bektaşağa had the highest ones. Likewise, RADAGLOU *et al*. (2008) found that the optimum altitude of *T. tomentosa* in Romania was 150-450 m. Individuals from Western Black Sea region had higher values of all studied characters than those from Marmara region in terms exception number of flowers. The mean number of flower (82 per m^2) in the study was in line with that (80-100 per m^2) indicated by PAWLIKOWSKI (2010) for *T. tomentosa* in the city area of Torun-Poland.

The averages of leaf length and leaf width (7.8 cm and 5.0 cm) in the current study were lower than those (9.2 cm and 9.1 cm) reported by IVANOV *et al*. (2014). This case may be explained by the fact that the trees located inside the districts have smaller leaves than those in natural populations. Similarly, VELICKOVIC (2010) emphasized that *T. cordata* leaves in the reference (unpolluted) area were significantly larger compared with those from the polluted site. Furthermore, overall range for leaf length (4.2-11.8 cm) found in the present study was similar to that (4-13 cm) reported by PETROVA *et al*. (2017). On the other side, the mean of fruit length (8.7 mm) in the present study was higher than that (6.9 mm) of *T. tomentosa* from the garden of Faculty of Science of Ankara University, Turkey indicated by TOKER *et al.* (1997). That may be why the individual from Ankara University is out of its natural distribution area.

All studied characters, exception for number of flowers, positively correlated with each other. Namely, the growing plant size (height and diameter at breast height) resulted in higher crown length and width, leaf length and width, and fruit length. Similar results have been found previously for other tree species such as a positive correlation between diameter at breast height and height in *T. cordota* (MOSER *et al*., 2015) and between leaf length and height in *Rhizophora mangle* (PEEL *et al*., 2017).

This study revealed that especially fruit length had a strong and positive correlation with altitude and a high negative correlation with temperature. Specifically, trees in the districts from high altitudes with low annual mean temperatures had higher fruit length than those in the districts from low altitudes with higher temperatures. On the other hand, it was found that individuals in the city with lower temperature had higher plant and leaf sizes. Although it was widely acknowledged that low temperature at high altitudes inhibits tree growth above the tree line (KORNER and PAULSEN, 2004). Therefore, relating groups in districts should make planting activities by considering these results.

The present study showed a substantial variation occurring among 47 districts from the regions of Marmara and Western Black Sea, Turkey and negative association between most studied characters and temperature. These strong associations indicate an important role of these characters in local adaptation. With ongoing climate change, warm adapted ecotypes of the species must be determined to mitigate effects of climate warming. Districts from Marmara region outperformed in terms of number of flowers. Further researches are required to quantify more growth flower characters of *T. tomentosa* from Turkey.

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KARAKTERISTIKE RASTA *Tilia tomentosa* Moench. IZ RAZLIČITIH DISTRIKATA U REGIJAMA MARMARA I ZAPADNOG CRNOG MORA U TURSKOJ

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Izvod

Klimatske promene će uticati na sve osobine ekosistema zelenih površina. U mnogim slučajevima, vrste drveća u parkovima pate od sve toplijih i suvih leta i novih štetočina i bolesti. *Tilia tomentosa Moench*. smatra se važnom vrstom drveća za uslove klimatskih promena za suve i tople uslove u zemljama Centralne i Jugoistočne Evrope. Ova vrsta drveća se često koristi u urbanim sredinama. U ovoj studiji istražujemo primere rasta *T. tomentosa Moench*. u odnosu na njihove uslove rasta kako bi se procenile njegove interakcije u urbanim sredinama. Sve ispitivane osobine se značajno razlikuju među okruzima u ispitivanom uzorku. U okviru svakog regiona, broj cvetova pokazao je širok raspon od 72-104 po m2 u Marmarskoj regiji i 54-124 po m2 u zapadnom delu Crnog mora. Sve proučavane osobine, osim broja cvetova, pozitivno su korelirane jedna sa drugom. Ova studija je pokazala da dužina ploda ima jaku i pozitivnu korelaciju sa visinom i visoku negativnu korelaciju sa temperaturom. Potrebna su dalja istraživanja kako bi se kvantifikovalo više osobina vezanih za porast cveta ove turske vrste.

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