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Assessment of Afforestation Activities in Thrace Region using Some Oak (*Quercus* sp.) Varieties

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Abstract: In this study, which is a preliminary assessment, afforestation studies established at different times with different oak species (*Quercus* sp.) in the Thrace Region were examined. Accordingly, as a result of the variance analysis applied to the data of the percentage of survival variable, which is important in terms of adaptation ability, it was determined that there was a statistically significant difference at the *P<0.05* confidence level in terms of afforestation areas. In this respect, as a result of Duncan test performed at *P<0.05* confidence level to create homogeneous groups, Ulukonak oak plantation area established with *Q. infectoria* with a survival rate of 89% is in the first group, and this group is classified with a survival percentage of 78%. Celaliye plantation area established with *Q. cerris* species followed. In the study, mean values were determined in terms of afforestation areas regarding the quantitative and morphological characters determined in the trial areas taken from the oak afforestation areas. When these data are examined, the mean diameter value varies between 2.3-5.1 cm in *Q. petraea* afforestation areas of different ages, 2.0-3.6 cm in *Q. infectoria* afforestation areas, 3.5 cm in *Q. frainetto* and *Q. cerris*. It was determined to be 4.9 cm in. Mean height value varies between 2.36-5.58 m in *Q. petraea* afforestation areas, 2.30-2.98 m in *Q. infectoria* afforestation areas, 3.62 m in *Q. frainetto* and 3.93m in *Q. cerris*. has been found to be. The crown symmetry is generally asymmetrical in all afforestation areas, regardless of the oak species. Stem straightness, on the other hand, was in the curve category for all afforestation areas. As a result of the variance analysis applied to the average volume values determined in the sampling areas, a statistically significant difference was determined between the forestation areas at the *P<0.05* confidence level. In this context, afforestation area established with *Q. petraea* oak species formed the first group with an average volume value of 0.00930 m^3, as a result of Duncan Range Test performed at *P<0.05* confidence level to create homogeneous groups in terms of afforestation areas.

Keywords: Oak, Afforestation, Survival Percentage, Adaptation, Growth

Öz: Ön değerlendirme niteliğindeki bu çalışmada Trakya Yöresinde farklı meşe türleri (*Quercus* sp.) ile değişik zamanlarda tesis edilmiş ağaçlandırma çalışmaları incelenmiştir. Buna göre, adaptasyon yeteneği açısından önemli olan yaşama yüzdesi değişkenine ait verilere uygulanan varyans analizi sonucunda ağaçlandırma alanları itibarıyla *P<0,05* güven düzeyinde istatistiki açıdan anlamlı farklılığın olduğu belirlenmiştir. Bu itibarla homojen grupları oluşturmak için *P<0,05* güven düzeyinde gerçekleştirilen Duncan testi sonucunda, %89'luk yaşama yüzdesi ile *Q. infectoria* ile tesis edilen Ulukonak meşe ağaçlandırma alanı ilk grupta yer alırken bu grubu, %78'lik yaşama yüzdesi değeri ile *Q. cerris* türü ile tesis edilen Celaliye ağaçlandırma alanı izlemiştir. Araştırmada meşe ağaçlandırma alanlarından alınan örnek alanlarda tespit edilen kantitatif ve morfolojik karakterlere ilişkin ağaçlandırma alanları itibarıyla ortalama değerler saptanmıştır. Bu veriler incelendiğinde ortalama çap değerinin farklı yaşlardaki *Q. petraea* ağaçlandırma alanlarında 2,3-5,1cm arasında değiştiği, *Q. infectoria* ağaçlandırma alanlarında 2,0-3,6cm arasında değiştiği, *Q. frainetto*'da 3,5cm ve *Q. cerris*'te 4,9cm olduğu belirlenmiştir. Ortalama boy değerinin *Q. petraea* ağaçlandırma alanlarında 2,36-5,58m arasında değiştiği, *Q. infectoria* ağaçlandırma alanlarında 2,30-2,98 m arasında değiştiği, *Q. frainetto*'da 3,62m ve *Q. cerris*'te 3,93m olduğu tespit edilmiştir. Tepe simetrisi ise tüm ağaçlandırma alanlarında meşe türleri fark etmeksizin genel olarak asimetrik niteliktedir. Gövde düzgünlüğü ise yine tüm ağaçlandırma alanları için genel olarak eğri kategorisinde yer almıştır. Örnekleme alanlarında belirlenen ortalama hacim değerlerine uygulanan varyans analizi sonucunda ağaçlandırma alanları arasında *P<0,05* güven düzeyinde istatistiki açıdan anlamlı farklılık belirlenmiştir. Bu kapsamda ağaçlandırma alanları itibarıyla homojen grupları oluşturmak için *P<0,05* güven düzeyinde gerçekleştirilen Duncan testi sonucunda 0,00930 m^3'lük ortalama hacim değeri ile *Q. petraea* meşe türü ile tesis edilen ağaçlandırma alanı ilk grubu oluşturmuştur.

Anahtar Kelimeler: Meşe, Ağaçlandırma, Yaşama Yüzdesi, Adaptasyon, Büyüme

1. Introduction

Successful regeneration activities should be conducted in our oak (*Quercus* sp.) forests because the continuity of natural forest resources consisting of this important species can be ensured and their productivity can be increased only through successful natural and artificial regeneration efforts [1]. Regeneration is an urgent silvicultural problem in the majority of

Türkiye's oak stands and, in a significant portion of these problems, it is necessary to make use of artificial means for stand establishment or implement artificial regeneration as a complement or auxiliary to natural regeneration [2].

Oak forests, which were managed as coppices, have suffered from pressure and indiscriminate use resulting in ecological imbalances, been deforested, and turned into erosion-prone areas and it is possible to restore their productivity by converting the existing coppices into managed stands, where appropriate oak species, along with compatible coniferous species, can be afforested using seedlings or seeds, with adaptation to the ecological conditions of oak forest openings [3,4]. Saatçioğlu [5], stated that converting degraded or coppice oak areas in the Belgrade forests into forests is a silvicultural necessity for quickly making them productive and the oak species with the highest silvicultural and economic value and capability should be prioritized during the establishment of forest stands.

Afforestation efforts were carried out with oak (*Quercus* sp.) species for various purposes in different forest habitats (Northern Thrace, Inner Thrace, and Çatalca) and management directorates (Kırklareli, Vize, Demirköy, Istanbul) in the Thrace Region. In the present study, the success performances of afforestation activities conducted with oak at 9 sample sites in different periods in the Thrace Region were evaluated. Measurements, observations, and records were made on 400 m^2 sample plots regarding diameter-height, spacing-distance, volume, and some site characteristics to assess the success of oak afforestation activities. Thus, initial evaluations were made regarding the oak afforestation practices established at different times in the Thrace Region and some preliminary information for practitioners is provided here.

2. Material and Method

Material

Presentation of study area

As stated by [6, 7], the afforestation areas in Kırklareli, Vize Kömürköy, Pınarhisar Evciler, Osmancık, and Demirköy Lafya Deresi are located within the "North Thrace Mountainous Habitat," whereas the afforestation areas in Yeniköy and Ulukonak in Kırklareli and Celaliye in Lüleburgaz are located within the "Inner Thrace Habitat" region. Furthermore, the Istanbul Hasdal afforestation area, which was examined as part of the research, is located within the "Çatalca Peninsula Habitat" region (Figure 1).

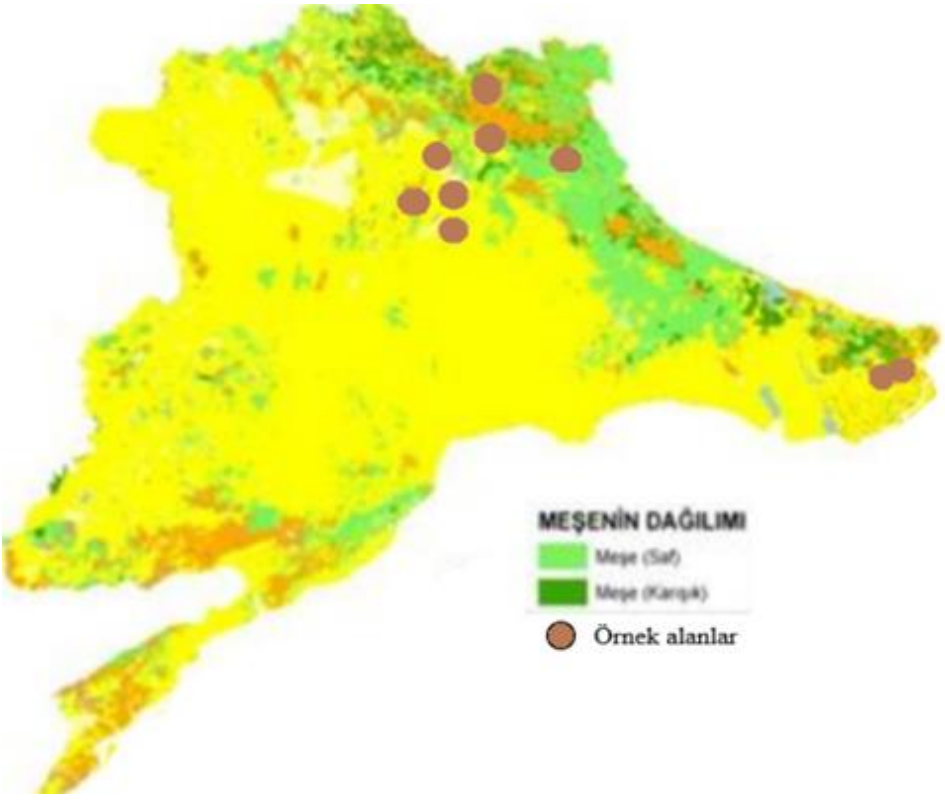

Figure 1. Study area [8]

Physiographical characteristics of the sample areas of 20 m x 20 m, which were selected by using the random block experimental design from the oak afforestation areas to best represent the afforestation areas established in different years and where the study was carried out are presented in Table 1.

Table 1. Presentation of afforestation areas

Business Administration	Location	Species	Planting area (ha)	Slope exposure	Height (m)	Slope (%)	Sample area (m^2)
Kırklareli - Pınarhisar	Evciler	*Q. petraea*	10.5	GB	512	40-45	400
Kırklareli – Lüleburgaz	Yeniköy	*Q. petraea*	21.5	GD-D	145	10-20	400
Kırklareli – Pınarhisar	Osmancık	*Q. petraea*	58	B-KB	187	10-30	400
Kırklareli – Lüleburgaz	Celaliye	*Q. cerris*	6	KB	164	0-20	400
Kırklareli – Merkez	Ulukonak	*Q. infectoria*	17	K-G	150	0-20	400
Demirköy – İncesırt	İncesırt	*Q. frainetto*	21.5	GB	388	0-20	400
Vize – Kömürköy	Kızılağaç	*Q. petraea*	10.1	K	180	30-40	400
İstanbul - Merkez	Hasdal 1-2	*Q. infectoria*	13.3	GB	180	0-20	400

Moreover, the current status of the afforestation areas, which were established with different oak species in different years and constitute the research area, and which also serve as a preliminary assessment, is presented in Figure 2.

Figure 2. Kırklareli-Yeniköy, b-Vize-Kömürköy-Kızılağaç, c-Demirköy-Lafyaderesi oak afforestation areas

Information regarding the edaphic characteristics specified in the implementation projects of the afforestation areas established with different oak species in different years was utilized in order to determine the edaphic characteristics of the oak afforestation areas where the study was carried out. Accordingly, except for the area in Demirköy characterized as "clay mud," the sample areas are generally characterized as "sandy mud" or "sandy-clay mud." Some soil properties of the oak afforestation areas, as well as the land preparation operations performed, are presented in Table 2. Furthermore, the climate types of the afforestation areas determined according to [9] are shown in Table 3.

Table 2. Some soil characteristics of oak afforestation areas by afforestation implementation projects

Locations	Years	Species	Soil processing	Bedrock	Depth (cm)	Soil species
Evciler	1997	Q. petraea	DTM+Pal. TR+2'li rip.	Gnays-Şist	M 31-60/F 60 üz	sandy loam
Yeniköy	2001	Q. petraea	DTM+Pal. TR+2'li rip.	Sediment	M, F 60 üz	Sandy-clay loam
Osmancık	1991	Q. petraea	DTM+Pal. TR+2'li rip.	Sediment	M, F 60 üz	sandy loam
Celaliye	1994	Q. cerris	DTI+Pal. TR+2'li rip.	Sediment	M, F 60 üz	sandy loam
Ulukonak	2004	Q. infectoria	DTM+Pal. TR+2'li rip.	Sediment	M, F 60 üz	Sandy-clay loam
Demirköy	1993	Q. frainetto	DTI + Pal TR+3'lü rip.	Effusive	M, F 60 üz	clay loam
Kömürköy	1983-1984	Q. petraea	DTM+Pal. TR+2'li rip.	Metamorphic	M 31-60/F 60 üz	sandy loam
Hasdal 1-2	2010-2011	Q. infectoria	DTM+ Pal. TR+3'lü rip.	Sediment	M, F 60 üz	sandy loam

Table 3. Climate types of oak afforestation areas determined according to [9]

Locations	Annual avg. precipitation (mm)	Annual avg. load. temp (C)	Climate type
Evciler	630.1	18.7	Semi-Moist
Yeniköy	575.8	18.4	Semi-Moist
Osmancık	575.8	18.4	Semi-Moist
Celaliye	575.8	18.4	Semi-Moist
Ulukonak	575.8	18.4	Semi-Moist
Demirköy	818	17.3	Mosit
Kömürköy	639.2	18.2	Semi-Moist
Hasdal 1-2	1088.8	17.4	Too Moist

Digital transportation network to be used in the implementation of the analysis and the evaluation of the analysis result; Data of the locations of Health Service Centers; border and population data of the neighborhoods within the study area; The vector data of the houses in the study area were used. Digital road network data of the study area has been obtained, and corrections have been made.

Method

Measurements and determinations made in afforestation areas

In this preliminary study carried out in order to determine the growth and adaptation capabilities of afforestation activities conducted with different oak species in different years, quantitative characteristics such as diameter at breast height (DBH) and total height were measured in sample plots taken randomly from afforestation areas by making use of the systematic sampling method. In addition, quality parameters such as stem straightness and crown condition were evaluated by using binary and ternary indices. The average values of DBH, height, and calculated volume per hectare were calculated for afforestation areas and oak species. The average volumes of oak species were calculated by using the yield table prepared by [10]. Furthermore, the survival percentage was calculated by utilizing the individual counts determined and reported per hectare based on the planting spacing distances applied to determine the adaptation performance of afforestation areas because the survival percentage (success rate) is an important variable used in order to evaluate afforestation investments from the early years, especially from a technical and biological perspective [11].

Statistical Analyses

The data related to average volume and survival percentage variables were included in statistical analyses for growth performance and adaptation ability due to age differences in afforestation areas, as well as the differences in planting spacings. For this purpose, the Kolmogorov-Smirnov (K-S) normality test was first applied to the data related to average volume and survival percentage variables. After determining that the data showed a normal distribution by using this test, the One-Way Analysis of Variance (ANOVA) was conducted in order to determine if there was a statistically significant difference between afforestation areas in terms of average volume and survival percentage variables. In case of a statistically significant difference between afforestation areas in terms of average volume and survival percentage variables found ANOVA, the Duncan test was used at a confidence level of $P < 0.05$ in order to determine the homogeneous groups. The SPSS 22.0 statistical package program was used in all these statistical analyses. The data of the survival percentage variable were subjected to Arc.Sin transformation before being subjected to statistical analyses.

3. Result

The number of trees per hectare and the survival percentage values determined in afforestation areas established with different oak species in different years are presented in Table 4. As a result of the variance analysis applied to the survival percentage data, a statistically significant difference at a confidence level of $P < 0.05$ was found between afforestation areas. Therefore, based on the results of the Duncan test conducted at a confidence level of $P < 0.05$ to form homogeneous groups, the Ulukonak oak afforestation area established with *Q. infectoria* with an 89% survival percentage was found to be in the first group, followed by the Celaliye afforestation area established with *Q. cerris* with a 78% survival percentage (Table 4).

Table 4. Duncan test results and individual count and survival percentage values by afforestation areas

Locaiton	Species	Range × Distance (m)	Individual number (ha/piece)	Survival percentage (%)
Pınarhisar	*Q. petraea*	2×1.5	2225	66bc
Yeniköy	*Q. petraea*	2×1.5	1575	47d
Osmancık	*Q. petraea*	2×1.5	1650	49d
Celaliye	*Q. cerris*	3×1.25	2075	78b
Ulukonak	*Q. infectoria*	3×1.25	2375	89a
Demirköy	*Q. frainetto*	2×1.0	3750	75b
Kömürköy	*Q. petraea*	1.0×1.0	5400	54c
Hasdal 1	*Q. infectoria*	1×1.5	3050	46d
Hasdal 2	*Q. infectoria*	2×1.5	1500	45d

The average values of quantitative and morphological characteristics determined in sample plots taken from oak afforestation areas are given for each oak afforestation area in Table 5. Given these data, it was determined that the average diameter ranged between 2.3 and 5.1 cm in different-aged *Q. petraea* afforestation areas, between 2.0 and 3.6 cm in *Q. infectoria* afforestation areas, 3.5 cm in *Q. frainetto*, and 4.9 cm in *Q. cerris* (Table 5). The average height was found to vary between 2.36 and 5.58 m in *Q. petraea* afforestation areas, between 2.30 and 2.98 m in *Q. infectoria* afforestation areas, 3.62 m in *Q. frainetto*, and 3.93 m in *Q. cerris* (Table 5). As a result of the variance analysis applied to the average volume values found in the sample plots, a statistically significant difference was found between afforestation areas at a confidence level of $P < 0.05$. In this context, the Duncan test conducted at a confidence level of $P < 0.05$ resulted in the first group being formed by the oak afforestation area established with *Q. petraea* with an average

volume of 0.00930 m^3. The crown symmetry is generally "asymmetric" in all afforestation areas, regardless of oak species. Stem straightness is categorized as "curved" for all afforestation areas (Table 5).

Table 5. Average values of quantitative and morphological characteristics of oak species in afforestation areas

Locaiton	Species	Years	Range × Distance (m)	Average diameter (cm)	Average size (m)	Average volume (m^3)	Vertex symmetry	Body smoothness
Pınarhisar	Q. petraea	21	2×1.5	2.3	2.36	0.00246e	Asymmetric	Curve-Too Curve
Yeniköy	Q. petraea	17	2×1.5	4.3	3.33	0.00546c	Asymmetric	Curve - Smooth
Osmancık	Q. petraea	27	2×1.5-3×1.25	3.2	2.92	0.00338d	Asymmetric	Curve
Celaliye	Q. cerris	24	3×1.25	4.9	3.93	0.00741b	Asymmetric	Curve
Ulukonak	Q. infectoria	14	3×1.25	3.6	2.98	0.00416cd	Asymmetric	Too Curve
Demirköy	Q. frainetto	25	2×1.0	3.5	3.62	0.00508c	Asymmetric	Too Curve
Kömürköy	Q. petraea	35	1.0×1.0	5.1	5.58	0.00930a	Symmetric	Curve
Hasdal 1	Q. infectoria	8	1×1.5	1.6	2.47	0.00247e	Asymmetric	Curve
Hasdal 2	Q. infectoria	9	2×1.5	2	2.3	0.00209e	Asymmetric	Curve

In addition, the diameter and height performances of sessile oak and Hungarian oak were analyzed using the yield tables prepared by Şahin [12] and Şahin et al. [13], respectively. It was determined that the average diameter and height values were below the normal growth performances according to all yield tables (Table 6).

Table 6. Average diameter and height values of sessile oak and Hungarian oak in afforestation areas

					Average diameter (cm)			Average size (m)		
Order	Locations	Species	Years	Bonitet	Measurement	Eraslan [9]	Şahin et al. [13]	Measurement	Eraslan [9]	Şahin et al. [13]
1	Pınarhisar	Q. petraea	21	IV	2.3	4.36	2.8	2.36	18.5	5.60
2	Yeniköy	Q. petraea	17	III	4.3	3.24	3.6	3.33	22.5	6.00
3	Osmancık	Q. petraea	27	III	3.2	6.95	5.9	2.92	22.5	8.27
6	Demirköy	Q. frainetto	25	II	3.5	6.95	8.0	3.62	26.5	8.50
7	Kömürköy	Q. petraea	35	III-IV	5.1	6.45	9.5	5.58	18.5	11.75

4. Discussion

Within the scope of the research, it was determined in the preliminary assessment process that the afforestation areas established with different oak species in different years generally showed a development trend in the right direction in terms of fulfilling the projected or planned forest functions. It can be said that the afforestation functions anticipated or advocated by various researchers [14-16] Saatçioğlu, [5] were observed in the oak afforestation areas, which constitute the research material, in the Trakya Region. Considering the actual growing conditions, it is also of significant importance in terms of maintaining the ecological balance in the region and ensuring the continuity of the forest ecosystem.

Phenotypic traits of all living organisms are shaped by genetic structure [17-19] and environmental conditions [20]. Environmental conditions consist primarily of climatic [21, 22] and edaphic [23] conditions. Indeed, when evaluated for the current actual structure, it can be stated that the edaphic conditions, which are one of the important ecological factors for the development of oak species from the early years, as in all plants, do not pose significant problems or create a significant development and adaptation issue for oak afforestation areas. As [24] and [12] stated, the region where afforestation was carried out exhibits a suitable structure in terms of all ecological factors and especially edaphic characteristics regarding oak afforestation studies.

In light of the initial and preliminary assessments, although the initial values, especially in terms of the survival percentage (success rate) that is the most important indicator of adaptability, had relatively low values for oak species used in afforestation activities and afforestation areas (Table 4), it should be noted that it is still difficult to reach a definitive judgment based on these evaluations. In terms of this variable, oak species, which have different varieties with a wide geographic variation in different growing conditions, can occasionally have low survival percentage values due to their

sensitive characteristics in terms of plant nutrition [25-28]. However, especially considering the negative effects of global warming on all organism populations, this finding further emphasizes the importance of oaks and oak forests both for the continuity of other organism groups in the forest ecosystem and for soil preservation characteristics [29, 30]. Actually, previous studies emphasized that the most significant effects of global warming will manifest itself in the form of a general increase in temperature and drought [31, 32]. In this process, oaks, which stand out with their drought tolerance and high adaptability, have a special importance.

The oak afforestation carried out using different oak species, which constitute the research material, has not yet exhibited very highperformance values in terms of quantitative and morphological characteristics that are quite important indicators of growth performance, as given in Table 5. Especially considering the site differences in terms of breast height diameter, height, and volume variables, it tends to show a performance below the expected level. However, it should be noted that different conditions may arise in afforestation areas due to the changing effects of both biotic and abiotic factors each year, and especially the influence of these factors on growth performance may vary [33]. Saatçioğlu [2] stated that site productivity can have a significant effect on the development of oak afforestation and the Site II areas in Belgrad Forest are suitable conditions for oaks. Accordingly, it would be suitable to test the growth performance of oak varieties under conditions suitable for the Site II in the Thrace Region.

5. Conclusion

Considering the results obtained from the present preliminary research, it can be stated that the afforestation activities conducted with different oak varieties in the Thrace region are highly beneficial and significant in terms of preserving the ecological balance, nature, and multidimensional forest ecosystems of the region. Therefore, it is crucial to ensure the preservation and continuity of these afforestation projects, which will provide high benefits for the health of the local community and soil preservation. Consequently, all necessary measures, especially maintenance works, should be conducted in afforestation areas in accordance with the appropriate technical procedures. Oak afforestation areas, which are not yet able to fully perform their ecological and technical functions due to social pressures and grazing damages, must be particularly protected. In addition, aiming to enhance the contributions of this species to the national economy, oak afforestation should be continued in suitable areas determined using multidimensional decision-making techniques in order to meet the raw material needs of the local population and the country's forest industry. Furthermore, it should always be kept in mind that the success of afforestation- efforts involving sensitive broad-leaved species like oak is remarkably affected by the quality of seedlings. In this context, successful local origins to be used in such oak afforestation should be identified, improved seed sources should be established from them, and high-quality and durable seedlings raised from seeds collected from these sources should be used for afforestation and artificial regeneration practices in open areas, both in our Thrace region and in different parts of our country.

Conflict of Interest

The authors declare that they have no competing interests.

Ethics Committee Approval

N/A

Author Contribution

Conceptualization: H.B.Ö., M.T., N.Ş. V.A., M.Ö., H.Ş.; Investigation: H.B.Ö., M.T., N.Ş. V.A., M.Ö., H.Ş.; Material and Methodology: H.B.Ö., M.T., N.Ş.; Visualization: V.A., M.Ö., H.Ş.; Writing-Original Draft: V.A., M.Ö., H.Ş.; Writing-review & Editing: V.A., M.Ö., H.Ş.; Other: All authors have read and agreed to the published version of manuscript.

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6. References

[1] Özel, H. B., & Ertekin, M. (2010). İstanbul-Bentler yöresindeki doğal sapsız meşe (Quercus petraea (mattuschka) lieb.) gençliklerinde ilk büyümelerin değerlendirilmesi. Bartın Orman Fakültesi Dergisi, 12(18), 67-76.

[2] Saatçioğlu, F. (1979). Silvikültür Tekniği (Silvikültür II), İ.Ü Orman Fakültesi, (Silvikültür II), 2490(268), 556.

[3] Taşdemir, C., & Karatay H. (2007). Elazığ Yöresinde İran Palamut Meşesi (Quercus brantii Lindl.) ve Saçlı Meşe (Quercus cerris L.)'de Bazı Fidanlık ve Ağaçlandırma Tekniklerinin Araştırılması. Güneydoğu Anadolu Ormancılık Araştırma Enstitüsü Müdürlüğü, Araştırma Bülteni, 23049.
[4] Saatçioğlu, F. (1952). Türkiye'de Ağaçlandırmanın Önemine ve Problemlerine Toplu Bakış, İstanbul Üniversitesi Orman Fakültesi Dergisi, Seri A,2(1), 60-70.
[5] Saatçioğlu, F., (1960). Belgrad Ormanı'nda Çeşitli Aletlerle Yapılan Meşe Dikimlerine Ait Denemeler ve Sonuçları. İ.Ü. Orman Fakültesi Dergisi.
[6] Kantarcı, M. D. (1976). Trakya Orman Mıntıkalarının Bölgesel Orman Yetişme Muhiti Özelliklerine Göre Doğal Ağaç Ve Çalı Türleri Đle Sınıflandırılması, Đstanbul Üniversitesi Orman Fakültesi Dergisi, Seri. İstanbul Üniversitesi Orman Fakültesi Dergisi, Seri: A, 26(2).
[7] Kantarcı, M. D. (2018). Kuzey Trakya Yetişme Ortamı Bölgesi Ormanları ve İklim Değişikliği İle Hava Kirliliğinin Orman Ekosistemlerine Etkileri Üzerine Ekolojik Bir Değerlendirme, İstanbul Orman Bölge Müdürlüğü Yayını.
[8] Şahin, A. (2016). Marmara Bölgesindeki meşe ormanlarının yayılışı, işletme amaçları ve planlanması. Orman Genel Müdürlüğü Marmara Ormancılık Araştırma Enstitüsü, Uluslararası Katılımlı Meşe Çalıştayı Bildiriler Kitabı, s. 27-51. 18-20 Ekim, İğneada–Kırklareli.
[9] Erinç, S. (1965). Yağış Müessiriyeti Üzerine Bir Deneme ve Yeni Bir İndis, İstanbul Üniversitesi, Coğrafya Enstitüsü, 41.
[10] Eraslan, İ. (1954). Trakya ve bilhassa Demirköy mıntıkası meşe ormanlarının amenajman esasları hakkında araştırmalar, Meşe Hasılat Tablosu. OGM Yayınları, 132(13).
[11] Ürgenç, S. (1986). Ağaçlandırma Tekniği, İstanbul Üniversitesi Orman Fakültesi Dergisi 3314(375), 5250.
[12] Şahin, A., 2020. Marmara Bölgesindeki Sapsız Meşe (Quercus petraea (Mattuschka) Liebl.) Meşcerelerinin Hasılatı ve Amenajman Esasları. İstanbul Üniversitesi-Cerrahpaşa Lisansüstü Eğitim Enstitüsü. Doktora Tezi. İstanbul.
[13] Şahin, A., Özdemir, E., Aylak Özdemir, G., Biricik, Y., Korkmaz, Ü., Saraçoğlu, Ö. 2021. Macar Meşesi (Quercus frainetto Ten.) Meşcerelerinin Hasılatı (Proje No: 10.3201/2014-2018-2020). Marmara Ormancılık Araştırma Enstitüsü Müdürlüğü, Araştırma Projesi Sonuç Raporu, 237 sayfa, İstanbul.
[14] Uğurlu, S., & Çevik, I. (1991). Güneydoğu Anadolu Bölgesinde bazi meşe türlerinin ekim yoluyla ağaçlandirma tekniği. Ormancilik Araştirma Enstitüsü Müdürlüğü.
[15] Boydak, M., & Çalışkan, S. (2014). Ağaçlandırma, Ormancılığı Geliştirme ve Orman Yangınları ile Mücadele Hizmetlerini Destekleme Vakfı.
[16] Kalkan, B., Karakurt, H., Özkan, K., Tiryaki, O., & Güneş, Ö. (2021). Elazığ yöresinde meşe ekimlerinin gelişimi ile bazı yetişme ortamı özellikleri arasındaki ilişkiler. Ormancılık Araştırma Dergisi, 8(1), 27-41.
[17] Imren, E., Kurt, R., Yucedag, C., Bilir, N., Ozel, H. B., Cetin, M., & Sevik, H. (2021). Selection of superior clones by the multi-dimensional decision making techniques in Scots pine seed orchard. Journal of Forests, 8(1), 13-22.
[18] Özel, H. B., Şevik, H., Onat, S. M., & Yigit, N. (2022). The effect of geographic location and seed storage time on the content of fatty acids in stone pine (Pinus pinea L.) seeds. BioResources, 17(3), 5038.
[19] Macnair, M. R. (1987). Heavy metal tolerance in plants: a model evolutionary system. Trends in Ecology & Evolution, 2(12), 354-359.
[20] Liang, J., Chen, C., Song, X., Han, Y., & Liang, Z. (2011). Assessment of heavy metal pollution in soil and plants from Dunhua sewage irrigation area. International journal of electrochemical science, 6(11), 5314-5324.
[21] Isinkaralar K. (2022). Some atmospheric trace metals deposition in selected trees as a possible biomonitor. Romanian Biotechnological Letters, 27(1), 3227-3236.
[22] Yayla, E. E., Sevik, H., & Isinkaralar, K. (2022). Detection of landscape species as a low-cost biomonitoring study: Cr, Mn, and Zn pollution in an urban air quality. Environmental monitoring and assessment, 194(10), 687.
[23] Işınkaralar, Ö., & Şevik, H. (2023). A Statistical Analysis of Traffic-Related Pollution and City Center Dynamics in Ankara: The Cases of Ulus and Kızılay. Journal of Ankara Studies, 11(1), 25-35.
[24] Pirinc Bayraktar, E., Isinkaralar, O., & Isinkaralar, K. (2022). Usability of several species for monitoring and reducing the heavy metal pollution threatening the public health in urban environment of Ankara. World Journal of Advanced Research and Reviews, 14(3), 276-283.
[25] Işınkaralar, K. (2022). Evaluation of environmental barium concentration biomonitoring in tree rings. Turkish Journal of Agriculture-Food Science and Technology, 10(4), 754-759.
[26] Rajkumar, M., Sandhya, S., Prasad, M. N. V., & Freitas, H. (2012). Perspectives of plant-associated microbes in heavy metal phytoremediation. Biotechnology advances, 30(6), 1562-1574.
[27] Gamalero, E., Lingua, G., Berta, G., & Glick, B. R. (2009). Beneficial role of plant growth promoting bacteria and arbuscular mycorrhizal fungi on plant responses to heavy metal stress. Canadian journal of microbiology, 55(5), 501-514.
[28] Işınkaralar, K., & Erdem, R. (2022). The effect of atmospheric deposition on potassium accumulation in several tree species as a biomonitor. Environmental Research and Technology, 5(1), 94-100.

[29] Badr, N., Fawzy, M., & Al-Qahtani, K. M. (2012). Phytoremediation: An ecological solution to heavy-metal-polluted soil and evaluation of plant removal ability. World Applied Sciences Journal, 16(9), 1292-1301.
[30] Malik, R. N., Husain, S. Z., & Nazir, I. (2010). Heavy metal contamination and accumulation in soil and wild plant species from industrial area of Islamabad, Pakistan. Pak J Bot, 42(1), 291-301.
[31] Jung, M. C. (2008). Heavy metal concentrations in soils and factors affecting metal uptake by plants in the vicinity of a Korean Cu-W mine. Sensors, 8(4), 2413-2423.
[32] Nabi, R. B. S., Tayade, R., Hussain, A., Kulkarni, K. P., Imran, Q. M., Mun, B. G., & Yun, B. W. (2019). Nitric oxide regulates plant responses to drought, salinity, and heavy metal stress. Environmental and Experimental Botany, 161, 120-133.
[33] Shaw, B. P., Sahu, S. K., & Mishra, R. K. (2004). Heavy metal induced oxidative damage in terrestrial plants. Heavy metal stress in plants: from biomolecules to ecosystems, 84-126.