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Long term effects of regenerative cutting in *Quercus cerris* L.

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Abstract
Quercus cerris (Turkey oak) is distributed in northern, western, and southern Anatolia. Although shelterwood systems manage these forests, degraded forests undergo artificial regeneration. In this context, the mature Turkey oak stands in the Sipahiler Forests sub-district affiliated with the Sütçüler Forest District Directorate in Isparta, which did not have natural regeneration conditions, were artificially regenerated by acorn point sowing under the stand shelter. Although the regeneration was successful, the seedlings did not realize sufficient growth. Three-year findings showed that "sapling cutting from ground level" was the most successful application among the four regeneration cuttings and one control in 2017. The existing study aims to reveal the effect of long-term regenerative cutting on Turkey oak. In this context, after seven years, in 2022, height and root collar diameter were measured. The height increment from 2014 to 2022 varied between 128.17 (Treatment 1) and 71.64 (Treatment 5 or Control). Root collar diameters for treatments were not statistically different at the end of five years. Amongst regenerative cutting, Treatment 1 (cutting all saplings in the plots from just above the ground level), after eight years (2014-2022), indicated the highest height increment in the condition of long-term effect. It is envisaged that this long-term study will help with the conversion from coppices to high forests in Türkiye and the management of all oaks as well as Turkey oaks.

Keywords: Artificial regeneration, sprouting, coppice, high forest.

Introduction

The genus *Quercus* L. is widely distributed in the temperate and subtropical regions of the northern hemisphere and has approximately 350-500 species growing in North and Central America, Colombia, Eurasia and North Africa (Yılmaz, 2018; Tekpınar et al. 2021). Kremer and Hipp (2020) view oaks as an evolutionary success in measures of distribution and diversity. They grouped the factors contributing to this success into four categories: the formation of wide diversity within populations and species; the ability to migrate rapidly, which contributes to ecological priority effects on lineage diversity; the high rate of evolutionary differentiation within clades, which facilitates solutions to ecological problems between clades; and the tendency to hybridize, which contributes to adaptive introgression and facilitates migration. Quercus genus constitutes approximately 30% of the forest area of Tukey Forest area; however, less is known about the species distribution, hybridization, morphological and genetic variation within and between populations in Turkey compared to Europe and North America (OGM 2021; Tekpınar et al. 2021).

Quercus genera comprise 17 species, including 24 taxa in Turkey Forest area (Yılmaz 2018). They cover 6.7 million hectares, of which 2.7 million hectares are accepted or normal (canopy closure of more than 11%), and 4.0 million hectares are degraded forest (canopy closure lower than 10%) (OGM, 2021). An application plan for the conversion of coppice to high forest was started by OGM (General Directorate of Forestry) in 2006 named "Action Plan for the Conversion of Coppice Forests into High Forest (2006-2015)" (OGM 2006; Taşdemir and Yıldızbakan 2023). The Plan aimed "to continuously provide the market's need for hardwood, to make forests healthier and more stable by preserving local races suitable for the growing environment, and to carry out sustainable forestry in which ecology and economy will be in harmony within nature and environmental awareness in society." In this context, the Action Plan aimed to convert 1 million ha of coppice forest into a high forest ha (OGM, 2006). Within the framework of efforts to convert coppices into high forests in Turkey's forests, almost all of which are oak species, the coppice forest area decreased from 9.3 million hectares (46% of total) in 1973 to 4.9 million hectares (23%of total) in 2010 and 995 thousand hectares (4% of total) in 2023 (OGM, 2024).

Turkey oak (*Quercus cerris* L.) is one of Turkey's most enormous distribution oaks. The fact that Turkey oak grows in dry conditions and is a thermophilic species increases its importance in terms of climate change (Simkova et al. 2023; Lados et al. 2024). Lados et al. (2024) also indicated that Turkey oak may have great potential to be a key tree species in Central and Western Europe under climate change conditions. They underlined that more detailed information on its phylogeny, phylogeography, phenotypic, and genetic variability was still needed for a more careful and reliable assessment of the species' adaptation potential when they reviewed 42 articles to support the evaluation of Turkey oak's adaptation potential under climate change.

Turkey oak extends from southern Europe to Asia Minor. Across its distribution range, it is mainly present in the Balkan and Italian Peninsulas. The western limit of its natural range is France, and its northern limit is in Germany, continuing eastward through Austria, Switzerland, eastern Czech Republic, Slovakia and Hungary. Therefore, Turkish oak is thought to be adaptable to various site conditions. It is relatively tolerant to drought (more than the other oak species of the same region) and air pollution. In addition, It can grow in a wide range of soil types, including weakly acid, pseudogley, or even shallow calcareous soils, as long as they are not too dry (de Rigo et al. 2016; Simone et al. 2019).

Some research on Turkey oak has been conducted by Kavgacı et al. (2020) and Taşdemir and Yıldızbakan (2023). These studies focused on converting coppice to high forest of Turkey oak. However, there has been limited long-term research on Turkey oak. Since it is one of forest tree species with the most extended rotation age, studying long-lived *Quercus* species, such as *Q. cerris*, could provide better insights for effective management and decision-making.

This study aimed to evaluate the effects of long-term regenerative cutting after point sowing and obtaining seedlings from point sowing of Turkey oak to establish a high forest. Additionally, it seeks to enhance understanding of Turkey oak management practices.

Material and Methods

The research was conducted in a Turkey oak stand in the Sipahiler Forest Sub-district of the Sütçüler Forest Directorate affiliated with the Isparta Forest Regional Directorate. Detailed information on material and methods can be found in Kavgacı et al. (2020). The altitude of the study area is about 1050 m. The randomized complete block design was used with four blocks. Including the control, five different treatments were applied (Table 1).

Table 1. Treatment numbers and their explanations.

Treatment no	Explanation of treatment
1	Cutting all saplings in the plots from just above the ground level
2	Cutting saplings from 10 cm height above the ground level
3	Leaving only one individual at each plot (excluding the lateral stems) and pruning
4	Leaving only one individual at each plot (excluding the lateral stems) without pruning
5	Control parcels without any cutting and pruning

Artificially regenerated in 2009 by the method of acorn point sowing under the stand shelter was made. Due to the slow growth of seedlings, regenerative cutting of seedlings in 2014 was made, and the heights of saplings were measured in cm and recorded. After that, saplings were measured after the vegetation period 2017, and evaluations were made and published as an article (Kavgacı et al. 2020). In 2022, saplings' height and root collar diameter were measured again to reveal the long-term effects of the treatments (Figure 1). Data was collected, and the following statistical model was used for ANOVA.

$$y_{ijk} = \mu + B_i + T_j + e_{ijk}$$

Where y_{ijk} is k^{th} sapling, j^{th} treatment at the i^{th} block; μ is overall mean; B_i is block (i=1, 2, 3, 4); T_j is treatment (j=1, 2, 3, 4, 5); e_{ijk} is experimental error.

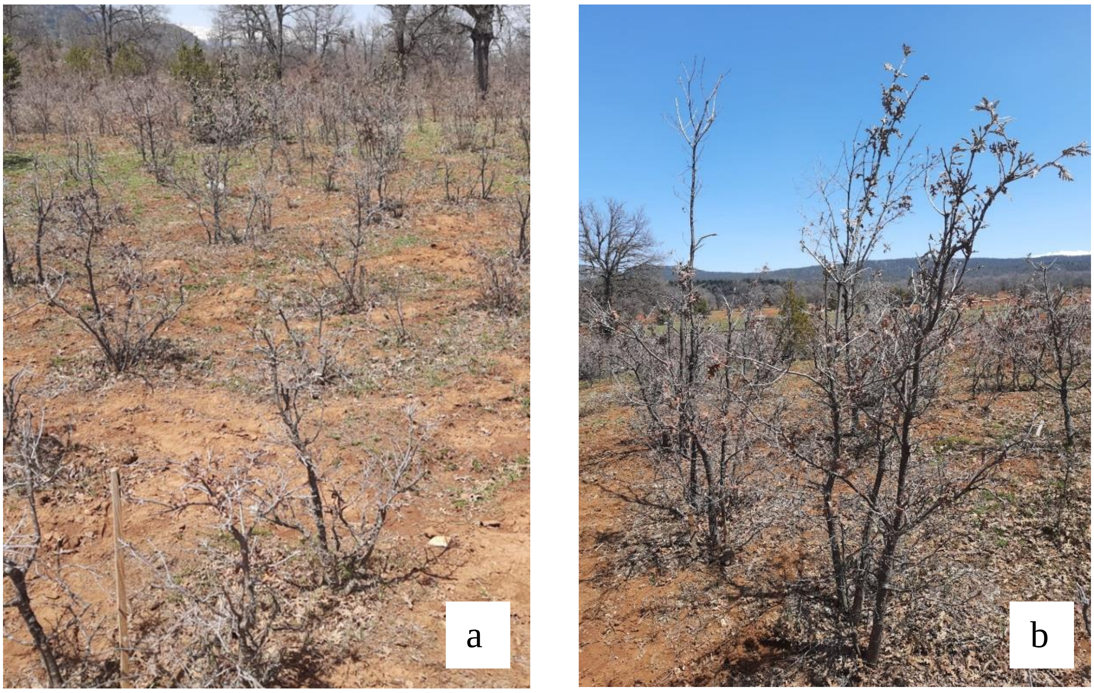

Figure 1. General view of test area (a), some individuals in test area (b)

Results

Regenerative cutting was realized in 2014, and saplings, including different treatments, were measured in 2022. Table 2 shows descriptive statistics for height and root collar diameter for 2022. As seen in Table 2, the sapling height reached a maximum of 254 cm (Treatment 4), and the root collar diameter reached 92.7 mm (Treatment 4). The lowest height was 50 cm (Treatment 5), and the lowest root collar diameter was 6.9 mm (Treatment 5). A comparable variation existed for both traits at the individual level for treatments, but treatment means were close to each other.

Table 2. Descriptive statistics for height and root collar diameter in 2022. See Table 1 for treatment numbers.

Traits	Treatment	N Obs.	Min.	Max.	Range (Max-Min)	Mean	Std Dev	Std Error
Height (cm)	1	57	70	246	176	130.07	47.59	6.3
	2	57	72	183	111	118.11	27.74	3.67
	3	57	62	254	192	126.91	42.82	5.67
	4	52	63	230	192	130.85	41.22	5.72
	5	56	50	195	145	112.5	35.36	4.73
Root collar dimater (mm)	1	57	12	53.8	41.8	32.43	10.55	1.4
	2	57	14.4	51.1	36.7	32.18	9.29	1.23
	3	57	13.1	66.5	53.4	32.31	11.84	1.57
	4	52	14.5	92.7	78.2	35.52	13.13	1.82
	5	56	6.9	57.4	50.5	30.98	11.22	1.5

The analysis of variance for traits is presented in Table 3. There were no statistical differences amongst treatments in 2022. In other words, no difference exists between the effects of the treatments applied in 2014.

Table 3. ANOVA for height and root collar diameter in 2022

Variance source	DF	Height			Root collar diameter		
		Mean Square	F Value	Pr > F	Mean Square	F Value	Pr > F
Block	3	1238.85	9.09	0.0021	94.03	9.63	0.0016
Treatment	4	230.25	1.69	0.2168	12.21	1.25	0.3422
Error	12	136.32			9.77		

The variance of height increment from 2014 to 2022, from 2017 to 2022 and from 2014 to 2017 was presented in Table 4. Height increments from 2014 to 2017 and 2022 were statistically significant. However, height increments from 2017 to 2002 were not statistically significant.

Table 4. Height increment between years (2014 and 2022, 2017 and 2022, and 2014 and 2017)

Variance source	DF	Increment from 2014 to 2022			Increment from 2017 to 2022			Increment from 2014 to 2017		
		Mean square	F value	Pr > F	Mean square	F value	Pr > F	Mean square	F value	Pr > F
Block	3	3357.81	10.00	0.0014	494.13	6.90	0.0059	154.75	3.28	0.0588
Treatment	4	7652.47	17.09	<.0001	106.95	1.49	0.2655	1513.51	32.04	<.0001
Error	12	111.93495			71.66			47.24		

A multiple comparison test for height increment was given in Table 5. The best treatment was Treatment 1 in increments from 2014 to 2022, while the best treatments were Treatment 1 and 2 in increments from 2014 to 2017.

Table 5. Multiple comparison test for height increments, different letters show a different group

Treatments	Increment from 2014 to 2022 Means	Increment from 2014 to 2017 Means	Increment from 2017 to 2022 Means
1	128.17 a	74.22 a	53.95 a
2	107.73 ab	60.68 a	47.05 a
4	89.44 bc	37.68 b	51.76 a
3	85.73 c	32.50 b	53.23 a
5	71.64 c	30.03 b	41.62 a

Height means of years (2014, 2017 and 2022) are in Figure 1. Treatment 1 (cutting all saplings in the plots from just above the ground level) was no different than other treatments in 2017 and 2022, although they were different in 2014.

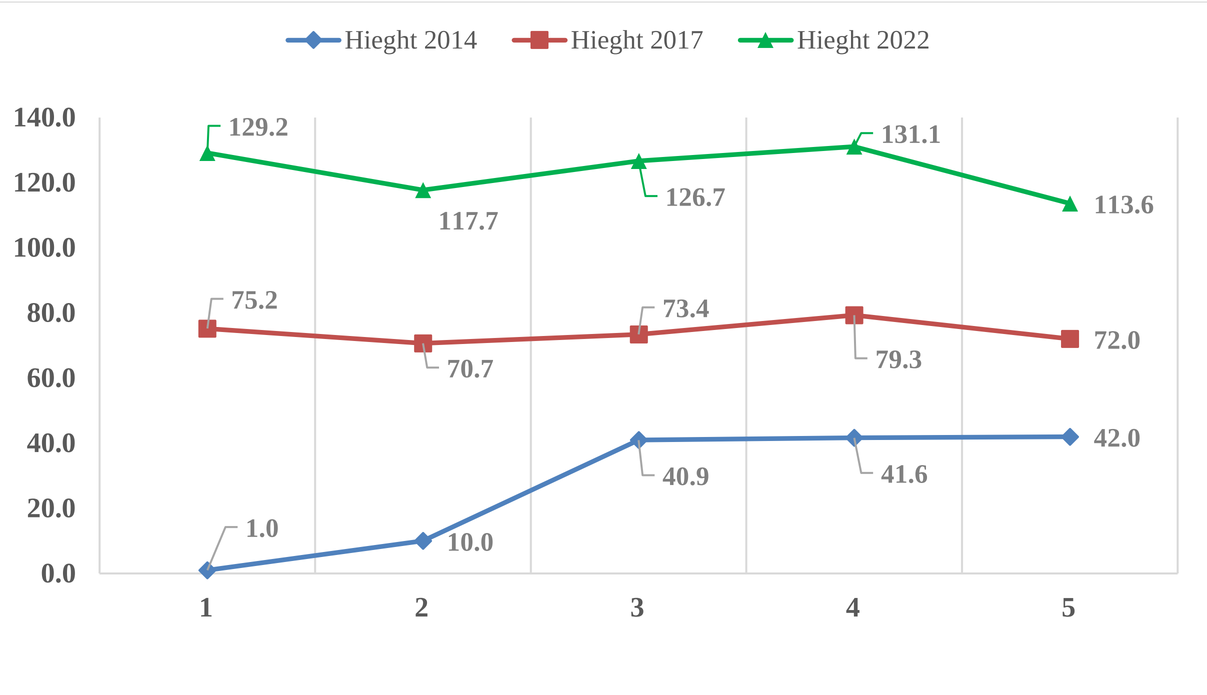

Figure 1. Height means of years for treatments, there is no difference between treatments for height in 2017 and height in 2022, in contrast to height in 2014

Discussion

Acorn points sowing under the stand shelter was applied in 2009, and regenerative cutting was done just before the vegetation period in 2014. In 2017 and 2022, all saplings in five treatments were measured, and the 2017 data was published as an article (Kavgacı et al. 2020). After point sowing, 13 years passed, and after regeneration cutting, eight years passed in 2022. The regeneration cutting of the three-year effect (2017) showed Treatment 1 and Treatment 2 were the best, and there was no difference in height between treatments (Kavgacı et al. 2020). Now, Treatment 1 was the best in terms of height increment effects. Similarly to 2017, there were no differences in height and root collar diameter. These studies related to oak species are essential due to limited research on the long-term impact of regenerative cutting. On the other hand, OGM, responsible for managing forests, started the conversion of coppices to high forests in 2006. Oak management of OGM needs research on oak species.

Turkey oak belongs to the Cerris section and has an extensive distribution in Asia Minor, and only oak species that form tall trunks and economically valuable stands in the Cerris section (Odabaşı et al.2004). On the other hand, Tukey oak has been assumed to be a minor oak species due to its invaluable wood structure (Saatçioğlu, 1976). Similarly, Simone et al. (2019) and Najip et al. (2021) also underlined that the timber of Turkey oak has no valuable technological properties. Recently, the Cerris section has gained importance due to its resistance to dry and adaptation to climate change (Moricz et al. 2021; Simkova et al. 2023; Lados et al. 2024). In addition, oaks have a vital role in evolution due to superior features like hybridization, high diversity, and the ability to migrate rapidly (Kremer and Hipp 2020). Therefore, Turkey oak should be considered for drought and climate change. In addition, oaks have evolution potential due to phenotypic plasticity and hybridization capability.

Descriptive statistics provide some information about the study. Means were close to each other. However, notable variation exists at the individual level; in addition, the lowest value (both height and root collar diameter) was in Treatment 5, the range between maximum and minimum height was highest (192 cm) in Treatment 3, and the range of root collar diameter was 78.2 mm in Treatment 4 showing the regenerative cutting and thinning/spacing as a preferable for management of Turkey oak. In this context, cutting potential growth is highly variable at an individual level for treatments after regeneration.

There was no significant difference between Treatments for height and root collar diameter in 2022; after eight years of regeneration cutting for treatments, the same effect of treatments in both traits was observed. Treatment differences in 2014 disappeared in 2017 and 2022. In other words, Treatment 1 (Cutting all saplings in the plots from just above the ground level) has reached the level of other treatments in 2017 and 2022 since 2014. On the other hand, considering Treatments 3 and 4, including thinning, Manatti et al. (2020) applied three methods: thinning from below, selective thinning, and no management for Turkey oak. The selective thinning method was the best. Therefore, appropriate thinning method may be used to convert from coppice to high forest oaks in Turkey, including Turkey oak, in the future.

Height increment from 2014 to 2022 was the highest for Treatment 1 and the lowest for Treatment 3 and Treatment 5 (control). However, Treatment 1 and 2 was highest and others statistically equal and the lowest in height increment from 2014 to 2017. On the other hand, height increments from 2017-2022 were statistically equal for all treatments. Considering height increment, differences from the beginning have continued and slightly changed between 2014-2022 and 2014-2017. That is, Treatment 1 was the best for the long term (8 years). Therefore, regenerative cutting above ground level may use to increase growth energy of saplings in management for Turkey oak.

Enhancing sprouting potential through silvicultural treatments is challenging, but forest managers can anticipate some regeneration from stump sprouts in most oak stands managed under even-aged silvicultural systems. After cutting, the sprouts group declined from 10 stems in the first decade to 1.5 in the fourth decade (Gould et al. 2007). On the other hand, a sprout can grow up to 1 m per year, depending on many factors, such as tree species, habitat conditions, the stump's age, or the timing of the logging operation (Del Tredici 2001; Simkova et al. 2023). Height annual increment means for Turkey Oak were changed from 16.4 cm (131.1/8=16.4) for Treatment 4 since 2014 to 8.7 cm (113.6/13=8.7) for Treatment 5 (control) since 2009. These increments were very low compared to Simkova et al. (2023). However, regeneration cutting has an increment of almost twice the control's height increment (Treatment 5) in the existing study. In this context, regeneration cutting should be used for coppice conversion to the high forest after seeding acorns. Treatments 1 and 2 should be preferred for the long term by managers considering the need for more experiments in different conditions and places in the distribution of Turkey oak. On the other hand, existing study experiments should be kept, and tending (thinning) studies can also be conducted, like those of Manatti et al. (2020). In addition, as Kavgacı et al. (2020) suggested, observations should be continued due to helpful knowledge for managing high Turkey oak forests.

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References

de Rigo, D., Enescu, C. M., Houston Durrant, T., Caudullo, G. (2016). Quercus cerris in Europe: distribution, habitat, usage and threats. In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), European Atlas of Forest Tree Species. Publ. Off. EU, Luxembourg, pp. e01b479

Gould, P. J., Fei, S., Steiner, K. C. (2007). Modeling sprout-origin oak regeneration in the central Appalachians. Canadian Journal of Forest Research, 37(1), 170-177.

Kavgacı, A., Örtel, E., Alan, M., Çobanoğlu, A. (2020). Effects of regenerative cutting on the height growth of Turkey oak (Quercus cerris) saplings. Eurasian Journal of Forest Science, 8(1), 84-92.

Kremer, A., Hipp, A. L. (2020). Oaks: an evolutionary success story. New Phytologist, 226(4), 987-1011.

Lados, B. B., Benke, A., Borovics, A., Köbölkuti, Z. A., Molnár, C. É., Nagy, L., Gy Tóth, E., Cseke, K. (2024). What we know about Turkey oak (Quercus cerris L.)—from evolutionary history to species ecology. Forestry: An International Journal of Forest Research, 97(4), 497-511.

Móricz, N., Illés, G., Mészáros, I., Garamszegi, B., Berki, I., Bakacsi, Z., Jozsef ´ Kampel, J., Szabo, O., Rasztovits, E., Cseke, K.,Bereczki, K., Németh, T. M. (2021). Different drought sensitivity traits of young sessile oak (*Quercus petraea* (Matt.) Liebl.) and Turkey oak (*Quercus cerris* L.) stands along a precipitation gradient in Hungary. Forest Ecology and Management, 492, 119165.

Najib, R., Houri, T., Khairallah, Y., Khalil, M. (2021). Quercus cerris L.: An Overview. Forestry Studies, 74(1), 1-9.

OGM. (2021). Türkiye Orman Varlığı (2020). Orman Genel Müdürlüğü (OGM), Orman İdaresi ve Planlama Dairesi Başkanlığı.

OGM. (2024). Orman Genel Müdürlüğü (OGM) Resmi İstatistikler (https://www.ogm.gov.tr/tr/e-kutuphane/resmi-istatistikler Access date: 30.12.2024).

Saatçioğlu, F. (1976). Silvikültürün Biyolojik Esasları ve Prensipleri. İstanbul Üniversitesi, Orman Fakültesi Yayınları İ.Ü. Yayin No: 2187, O.F. Yayin No: 222, İkinci Baskı, İstanbul.

Simeone, M. C., Zhelev, P. and Kandemir, G. (2019). EUFORGEN Technical Guidelines for

genetic conservation and use of Turkey oak (*Quercus cerris*), European Forest Genetic Resources Programme (EUFORGEN), European Forest Institute. 6 pages.

Šimková, M., Vacek, S., Šimůnek, V., Vacek, Z., Cukor, J., Hájek, V., Bílek, L., Prok˚upková, A., Štefanˇcík, I., Sitková, Z., Lukáčik, I. (2023). Turkey oak (Quercus cerris L.) resilience to climate change: Insights from coppice forests in Southern and Central Europe. Forests, 14(12), 2403.

Taşdemir, C., Yıldızbakan, A. (2023). Kahramanmaraş ve Adana illerindeki saçlı meşe (Quercus cerris) ormanlarının koruya tahvil açısından değerlendirilmesi. Ormancılık Araştırma Dergisi, 10(Özel Sayı), 12-25.

Tekpinar, A. D., Aktaş, C., Kansu, Ç., Duman, H., Kaya, Z. (2021). Phylogeography and phylogeny of genus *Quercus* L. (*Fagaceae*) in Turkey implied by variations of trnT $^{(UGU)}$-L $^{(UAA)}$-F $^{(GAA)}$ chloroplast DNA region. Tree Genetics & Genomes, 17, 1-18.

Yılmaz, H. (2018). *Quercus* L. (Ed. Ü. Akkemik) Türkiye'nin Doğal-Egzotik Ağaç ve Çalıları. Orman Genel Müdürlüğü Yayınları, Ankara. s: 338-356.

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