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TWO-YEAR SURVIVAL ASSESSMENT OF OAK (QUERCUS L.) SEEDLINGS IN AN AGROFORESTRY SYSTEM AT HORTINOVA NURSERY, CÂRCEA (DOLJ COUNTY)

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Abstract

Agroforestry integrates trees, crops, and/or livestock to provide ecological and economic benefits, and its importance has grown in recent decades, particularly in fragile environments like Southern Oltenia, Romania. This region faces increasing aridization, deforestation, and soil degradation, although remnant oak-dominated forests persist and several autochthonous oak species remain ecologically significant. The aim of this study was to assess the survival of four oak species within an agroforestry system at HortiNova Nursery after the second growing season. The experimental plot covered 1.15 ha and included 20 square plots, with plot no. 2 planted in November 2023 with 275 container-grown oak seedlings (135 pedunculate, 65 Turkey, 38 sessile, and 37 red oaks) intercropped with onions in 2024 and maize in 2025. Seedling survival was monitored at the end of each growing season, while temperature, relative humidity, and soil properties (pH, humus, nitrogen, phosphorus, and potassium) were recorded and analyzed. During the period from April 1 to September 15, 2025, air temperatures ranged from 1.57°C to 42.74°C (mean 22.02 ± 7.84°C) and relative humidity fluctuated between 16.45% and 89.34% (mean 54.86 ± 19.26%), with slightly higher variability compared to 2024. Soil conditions were suboptimal (pH 5.83, low humus, moderate nutrients), and oak seedling mortality in plot no. 2 was recorded as 19 pedunculate, 8 Turkey, 10 sessile, and 2 red oaks out of 275 planted.

***Key words**: agroforestry, Dolj, nursery, Quercus, oak*

INTRODUCTION

Agroforestry is a land management system that integrates trees and/or shrubs with crops and/or livestock to create ecological and economic benefits through mutually supportive interactions. These agroforestry systems have gained growing importance in recent decades (Parreira, 2023; Le et al., 2025). Among the most effective forms of agroforestry, agrosilvopastoral systems help mitigate the negative impacts of global warming on grasslands by improving grass cover, productivity, and livestock welfare (Marușca et al., 2025), while shelterbelts (Enescu, 2024) and other agroforestry practices (Enescu, 2025a) continue to attract worldwide attention for their wide-ranging benefits to both agriculture and the environment (Budău et al., 2023).

Agroforestry systems are attracting growing interest, particularly in fragile environments like Southern Oltenia in southwestern Romania, a region that used to have great tradition in this regard, as well as a significant potential (Enescu, 2025b).

Southern Oltenia, particularly Dolj County, is undergoing significant aridization driven by climate change and long-term human pressure, which has led to extensive deforestation and made it one of Romania’s poorest wood-covered regions (Păltineanu et al., 2009; Stringer et al., 2009; Prăvălie, 2013; Geacu et al., 2018). These anthropogenic and climatic factors, combined with the county’s predominance of agriculture and industry (Bercea & Dinucă, 2018; Sanda, 2019), have transformed forest lands and resulted in vast areas of sandy soils (Enescu, 2019).

Although Dolj County has limited forest vegetation, several well-known forests, such as Ciumela, Bratovoiești, Radovan, and Perișor, persist and are now included in various categories of protected areas (Boruz et al., 2011; Călina et al., 2013; Cojoacă & Niculescu, 2018).

In the Romanian woody flora, 7 autochthonous oak species exist, namely sessile oak [*Quercus petraea* (Matt.) Liebl.], pedunculate oak (*Q. robur* L.), Turkey oak (*Q. cerris* L.), Hungarian oak (*Q. frainetto* Ten.), greyish oak (*Q. pedunculiflora* K. Koch), downy oak (*Q. pubescens* Willd.) and Italian oak (*Q. virgiliana* Ten.), respectively (Șofletea et al., 2011; Enescu, 2017). Recently, several morphological and genetic studies were conducted on oaks, targeting especially the closely related ones (Curtu et al., 2011; Enescu et al., 2013; Hegedüs et al., 2025). While pedunculate oak and sessile oak are the most widespread in European forests, including those of Romania (Petrițan et al., 2025; Nicolescu et al., 2025), Turkey oak and Hungarian oak dominate the forests in the Oltenia Plain (Tomescu, 2005; Cojoacă et al., 2020).

The goal of this paper was to highlight the survival rate of four oak species included in the agroforestry system at the end of 2025.

MATERIALS AND METHODS

The experimental plot, located in Cârcea near Craiova (Dolj County, 44°16'53.6"N, 23°55'37.7"E), lies within the HortiNova Nursery, covering 1.15 hectares divided into 20 square plots featuring various combinations of trees, shrubs, cereals, and vegetables. In plot no. 2 four oak species were planted, namely pedunculate oak, sessile oak, Turkey oak and red oak (*Quercus rubra* L.). The container-grown oak seedlings were produced at HortiNova in 2023 and planted in November of the same year.

The seedlings were planted in 11 rows of 25 plants each, with a spacing of 2 meters between rows and 1 meter between seedlings within each row. Thus, a total of 275 oak seedlings were planted, comprising 135 pedunculate oaks, 65 Turkey oaks, 38 sessile oaks, and 37 red oaks. Among them, 16 pedunculate, 7 Turkey, and 8 sessile oaks did not survive at the end of 2024 growing season (Enescu, 2025b). During 2024, onions (*Allium cepa* L.) were planted between all rows, and in 2025, maize (*Zea mays* L.) seeds were sowed between the first four rows (Figure 1).

Figure 1. Up: oaks with onions (17th of June 2024), down: oaks with maize (9th of September 2025)

During the 2025 growing season, three cultivation works (*i.e.* weeding and loosening of the soil) were done, namely in 29th of April, 6th of June and 9th of September, respectively. During the first loosening of the soil, the maize was cultivated between the first four rows (Figure 2).

Figure 2. Up: sowing the maize (29^{th} of April 2025), down: oaks with maize (9^{th} of September 2025)

On 16^{th} of September 2025, a new counting was done in order to assess the survival rate at the end of the second growing season.

Temperature (°C) and relative humidity (RE; %) data recorded every 30 minutes by the HoBo U23-001A Data Logger (U23 Pro v2) were compiled in Microsoft Excel for the period from April 1 to September 15, 2025. HoBo sensor was installed at a height of 1.5 meters above the soil surface.

Soil analyses were carried out in plot no. 2 by the Dolj Office of Pedological and Agrochemical Studies, assessing soil pH, humus content (%), total nitrogen (%), and the concentrations of phosphorus (P) and potassium (K) in ppm.

RESULTS AND DISCUSSIONS

During the timeframe considered, air temperatures ranged from 1.57°C to 42.74°C, with a mean value of 22.02 ± 7.84°C. Relative humidity (RH) fluctuated between 16.45% and 89.34%, averaging 54.86 ± 19.26% (Figure 3).

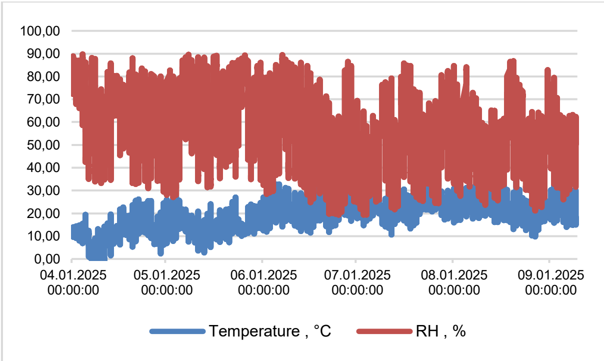

Figure 3. Temperature (°C) and relative humidity (RH, %) recorded from 1^{st} of April to 15^{th} of September 2025

During the same analyzed period, namely from 1^{st} of April to 15^{th} of September, both for 2024 (Enescu, 2025b) and 2025, temperature dynamics displayed a high degree of similarity between 2024 and 2025, with minor but noteworthy variations. In 2025, air temperatures ranged between 1.57°C and 42.74°C, while in 2024, the range extended from 1.65°C to 39.13°C.

The mean annual temperature increased slightly from 21.89 ± 7.23°C in 2024 to 22.02 ± 7.84°C in 2025.

Although the average difference of 0.13°C is marginal, the higher maximum temperature recorded in 2025 (approximately 3.6°C higher) indicates the occurrence of more intense heat events during that year.

The increase in standard deviation from 7.23°C to 7.84°C suggests greater thermal variability, reflecting potentially more abrupt shifts between diurnal and seasonal temperature extremes.

Relative humidity (RH) values also exhibited close correspondence between the two years. In 2025, RH varied between 16.45% and 89.34%, while in 2024 it ranged from 17.95% to 88.53%. The mean RH remained relatively stable, with only a marginal increase from 54.50 ± 17.47% in 2024 to 54.86 ± 19.26% in 2025. However, the broader standard deviation observed in 2025 indicates slightly higher variability, suggesting that periods of low humidity were occasionally more pronounced.

Overall, the comparison indicates that 2025 was marginally warmer and more variable than 2024, both in terms of temperature and relative humidity. Despite the small absolute differences, the increased climatic variability could contribute to greater physiological stress on seedlings, especially during critical stages of growth.

The soil had a pH of 5.83, a humus content of 3.16%, and contained 0.16% total nitrogen (N). The available phosphorus (P) and potassium (K) levels were 66 ppm and 242 ppm, respectively.

These results suggest that the soil quality is relatively poor, given that the optimal pH range for most plant species lies between 6.0 and 7.5. According to the Romanian Methodology for Soil Studies (Florea et al., 1987), the humus content is considered low, the nitrogen (N) level is moderate, while the phosphorus (P) and potassium (K) concentrations are moderate to high.

Figure 4 presents the results for plot no. 2, with seedlings that failed to survive in 2024 (highlighted in red), and in 2025 (highlighted in orange), respectively.

A total of 275 oak seedlings were established, consisting of 135 pedunculate oaks (P), 65 Turkey oaks (C), 38 sessile oaks (G), and 37 red oaks (R).

At the end of 2025 growing season, mortality was observed in 19 pedunculate oaks (14.1%), 8 Turkey oaks (12.3%), 10 sessile oaks (26.3%), and 2 red oaks (5.4%), respectively. Red oaks exhibited the highest survival rate, while sessile oaks experienced the greatest mortality, indicating species-specific differences in seedling resilience under the conditions of the 2024 and 2025 growing seasons.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
R1	P	P	P	P	P	P	P	P	P	P	P	C	P	P	P	P	P	C	C	C	P	P	P	P	P
	Zea mays																								
R2	C	C	C	P	P	C	P	P	C	G	P	P	P	C	P	P	P	P	P	C	P	C	C	P	P
	Zea mays																								
R3	P	P	C	G	C	G	C	G	G	G	G	C	G	G	G	G	G	G	G	G	C	C	G	G	G
	Zea mays																								
R4	R	C	P	P	R	R	P	C	R	R	R	R	P	R	R	R	R	R	R	R	R	R	R	R	R
R5	P	P	P	P	P	P	P	P	C	C	P	P	P	P	C	P	P	C	P	P	P	P	P	P	P
R6	P	G	G	P	G	C	P	G	C	C	C	C	C	G	C	P	P	G	C	C	C	C	G	C	C
R7	C	P	P	G	G	G	P	P	P	P	P	P	P	P	P	C	P	P	P	C	C	P	G	G	G
R8	P	P	R	R	C	R	C	R	C	C	C	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R9	P	P	P	P	P	P	C	P	P	P	P	P	P	P	P	C	P	P	P	P	P	P	P	P	P
R10	G	P	P	P	P	P	P	C	C	P	P	C	P	P	P	C	C	P	P	C	C	P	C	G	G
R11	P	C	C	P	P	G	P	P	P	P	P	C	G	G	G	P	C	C	P	C	C	C	P	P	P

Figure 4. Distribution of the four oak seedlings in plot no. 2 (P-pedunculate oak, C-Turkey oak, G-sessile oak, R-red oak)

CONCLUSIONS

The 2025 growing season was characterized by slightly higher mean temperatures and more extreme heat events compared to 2024, accompanied by increased thermal and humidity variability.

Soil conditions in the study area were suboptimal for oak growth, being slightly acidic with low humus content and moderate nutrient levels.

Oak seedling survival varied among species, with red oaks showing the highest resilience, while sessile and pedunculate oaks experienced greater mortality.

These findings indicate that the combined effects of climatic variability and marginal soil quality significantly influenced seedling performance, highlighting the importance of species-specific responses in the composition of agroforestry systems under changing environmental conditions.

The overall survival rate of 85.8% in plot no. 2 at the end of the second growing season is highly promising, supporting the potential introduction of oak species into agroforestry systems under site conditions like those in Cârcea.

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