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SURVIVAL RATE OF OAK (*Quercus* L.) SEEDLINGS IN AN AGROFORESTRY SYSTEM ESTABLISH IN HORTINOVA NURSERY (CÂRCEA, DOLJ COUNTY)

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Abstract

Agroforestry systems play a crucial role in mitigating the impacts of climate change, particularly in vulnerable regions like southeastern Romania, where drought poses a significant challenge to young forest stands. In 2023, twenty 24 m x 24 m plots were established, incorporating a mix of forest species and agricultural crops. Of these, 9 plots included four oak species, namely pedunculate oak (Quercus robur L.), red oak (Q. rubra L.), Turkey oak (Q. cerris L.), and sessile oak [Q. petraea (Matt.) Liebl.], as key tree species in an agroforestry experiment located in Cârcea, near Craiova, Dolj County. This study aimed to evaluate the survival rate of the planted oak seedlings. Additionally, climatic data (temperature, relative humidity and precipitation) were gathered using six HoBo sensors (Onset Computer Corporation) and one iMETOS 3.3 data logger. Soil analyses were done at Dolj Office of Pedological and Agrochemical Studies. The findings further highlight the significance of integrating oak species into agroforestry systems in southeastern Romania.

Key words: *agroforestry systems, Craiova, Dolj, oak, Quercus.*

INTRODUCTION

In the last decades, agroforestry systems have received increasing attention both from scientists and landowners. They are defined as complex mixed systems with a combination of crops, livestock and forest trees and shrubs (Paris et al., 2019).

By providing a broad variety of products for humans and animals (Mihăilă et al., 2021) and several ecosystem services, such as biodiversity preservation, soil erosion control, carbon sequestration, microclimatic moderator (Moreno et al., 2018; Lehmann et al., 2020; Santos et al., 2022; Budău et al., 2023; Dmuchowski et al., 2024), agroforestry systems are present worldwide.

Particularly, these systems could be established around the coastal rivers, to stabilize the banks, improve water quality and soil quality (Kachova & Dincă, 2015).

Recently, it was reported that agroforestry systems play an important role in tourism in India (Parthiban et al., 2023) and ecotourism in the wood pasture across Transylvanian Hills (Vijulie et al., 2024).

Shelterbelts are among the most common types of agroforestry systems, being composed of several rows of trees and shrubs (Mușat et al., 2024). Good practices were also reported in Bulgaria, where, for example, in a mixed poplar and agricultural crop area, it was reported that the soil characteristics improved significantly, especially in C and N content (Hinkov & Kachova, 2024). Moreover, by installing shelterbelts higher than 10 meters on 4-5% of the agricultural lands, the yield could increase by 30-50% (Mușat et al., 2021). Even so, only small areas are designated as agroforestry systems across Romania, two examples being the experiments recently done at RODAGRIA Ogru farm and National Agricultural Research and Development Institute Fundulea, where alley cropping were introduced with two rows of common hazel (*Corylus avellana* L.) and three rows of Siberian elm (*Ulmus pumila* L.) on an area of 38 hectares (Tudora et al., 2022).

In the perspective of climate change, oaks (Genus *Quercus* L.) are preferred in several combinations of agroforestry cultures, including agroforestry systems, such as in Central and Eastern Romania (Crișan et al., 2022), Spain (Pérez-Girón et al., 2022) and Slovakia (Stefancik & Pastor, 2023). Moreover, oak-based cultures/agroforestry systems are appreciated also in livestock grazing (Marușca

et al., 2020; Wadud et al., 2024). In some cases, oak species could be a solution for afforestation of several categories of degraded lands, such as the sandy soils across southern-western part of Romania (Enescu, 2019; Enescu & Caradaică, 2023), but the selection of proper species should be done with caution taking into consideration that the Genus *Quercus* has a very complicated taxonomy, in some cases being very difficult to distinguish between closely related species (Curtu et al., 2011; Șofletea et al., 2011; Enescu et al., 2013). Oaks are very important also from the ecologic and economic perspective (Timiș-Gânsac et al., 2022), by providing a broad range of services and products, including non-wood forest products to humans (Abraham et al., 2015).
The aim of this study was to assess the survival rate of oak seedlings in an agroforestry system established in HortiNova Nursery.

MATERIALS AND METHODS

The experimental plot is situated in Cârcea, near Craiova (Dolj County; 44°16'53.6"N 23°55'37.7"E), within the HortiNova nursery, a private company.
The total area of 1.15 hectares was subdivided into 20 square plots, each featuring a unique combination of trees, shrubs, cereals, and vegetables. Among these, 9 plots were dedicated to oak-based tree and shrub combinations, with four oak species selected: pedunculate oak (*Quercus robur*), Turkey oak (*Q. cerris*), red oak (*Q. rubra*), and sessile oak (*Q. petraea*). The oak seedlings were grown at the HortiNova nursery during 2023 and were planted in November of the same year, in the same day, with the same workers and the same planting tools.
Oak seedlings were cultivated in containers (pots), with their roots contained within the potting medium (Figure 1).
Each subplot consisted of 11 or 12 rows, with 23 to 25 seedlings per row, spaced 2 meters apart between rows and 1 meter between seedlings within a row. On September 15, 2024, the seedlings were counted in each row across all 9 experimental subplots.
Climatic data was collected using six HoBo sensors and iMETOS 3.3 data logger. HoBo 1 was installed in plot no. 1, HoBo 2 in plot no. 3, HoBo 3 in plot no. 6, HoBo 4 in plot no. 9, HoBo 5 along the irrigation system, and HoBo 6 near plot no. 7 (Figure 2).

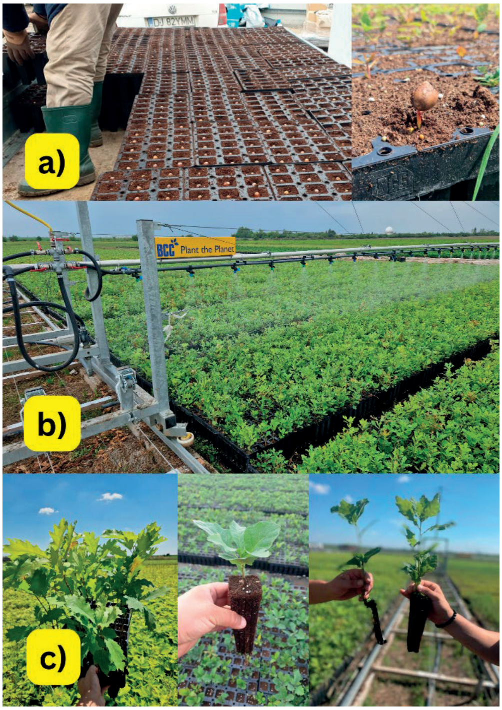

Figure 1. Producing oak seedlings with potted roots: a) placing the acorns into pots; b) regular and controlled watering of the potted seedlings; c) one-year-old oak seedlings in pots

Figure 2. Location of the 6 HoBo sensors
Source: Google Earth

In this survey, data on temperature (°C) and relative humidity (%) recorded by the HoBo 6 sensor, every 30 minutes, were compiled for the period from April 1st to September 15th, 2024, using Microsoft Office Excel.

Each HoBo sensor (model U23-001A Data Logger U23 Pro v2 Temperature/Relative Humidity) was placed at 1.5 meter above the soil level (Figure 3).

Figure 3. HoBo sensors

iMETOS 3.3 data logger was placed in the proximity of the experimental plots, 10 m away from plot no.3.

Soil analyses were conducted in plots no. 2 and 5 by the Dolj Office of Pedological and Agrochemical Studies, measuring pH (soil reaction), humus content (%), total nitrogen (%), as well as P and K (ppm).

RESULTS AND DISCUSSIONS

In total, 1.817 oak seedlings were planted (761 pedunculate oaks - "**P**", 227 sessile oaks - "**G**", 178 Turkey oaks - "**C**" and 651 red oaks - "**R**", respectively), out of which 1.486 survived after the first year (**81.7%**).

In 2024, the total recorded precipitation amounted to 238.8 mm (Figure 4).

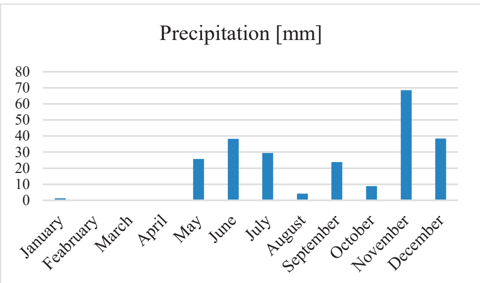

Figure 4. Monthly precipitation recorded in 2024

Nearly half of this rainfall occurred during the last three months of the year.

During the specified period, temperatures varied between 1.65°C and 39.13°C, with an average of 21.89 ± 7.23°C.

Regarding relative humidity (RH), values ranged from 17.95% to 88.53%, with an average of 54.50 ± 17.47% (Figure 5).

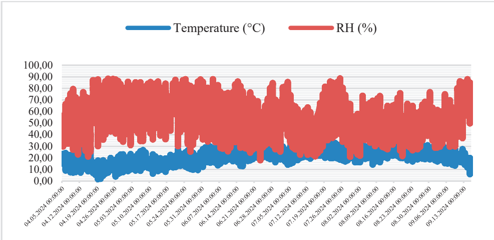

Figure 5. Temperature (°C) and relative humidity (%) recorded from 1st of April to 15th of September 2024

Soil analysis results are presented in Table 1.

Table 1. Results of soil analysis

Plot	pH	Humus (%)	N (%)	P (ppm)	K (ppm)
2	5.83	3.16	0.16	66	242
5	5.75	2.76	0.14	20.8	246

These results indicate poor soil quality, as the ideal pH range is between 6.0 and 7.5.

According to the Romanian Methodology for Soil Studies (Florea et al., 1987), the humus content is low, the nitrogen (N) content is moderate, and the phosphorus (P) and potassium (K) contents are moderate to high.

Figure 6 illustrates the results from plot no. 2, with the seedlings that did not survive highlighted in red. A total of 275 oak seedlings were planted, including 135 pedunculate oaks, 65 Turkey oaks, 38 sessile oaks, and 37 red oaks. Of these, 16 pedunculate oaks, 7 Turkey oaks, and 8 sessile oaks did not survive.

	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**
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**
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**
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 6. Distribution of oak seedlings in plot no. 2

Figure 7 displays the results from plot number 5, where 250 pedunculate oak seedlings and 50 Turkey oak seedlings were planted. Of these, 82 pedunculate oaks and 8 Turkey oaks did not survive.

	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	C	C	P	C	P	P	C	C	P	C	P	P	P	P	P	P	C	P	P	C	P	P	P	C	C
R2	P	C	C	P	P	P	P	P	P	P	P	P	P	C	P	P	P	P	P	P	C	P	P	P	P
R3	P	P	C	P	P	P	P	P	P	P	C	P	P	P	P	C	P	C	P	C	P	P	C	P	P
R4	P	P	P	P	P	C	P	P	C	P	P	P	C	P	P	P	P	P	P	P	P	P	P	P	P
R5	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R6	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C	P	C	P	C	C	C	C	P	P
R7	C	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C	P	P	P	P
R8	C	P	P	C	C	P	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R9	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R10	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C	P	C
R11	P	C	C	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R12	P	P	P	P	P	C	C	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C	P

Figure 7. Distribution of oak seedlings in plot no. 5

In plot number 10, 136 red oak seedlings and 8 sessile oak seedlings were alternately planted alongside 144 Siberian elm (*Ulmus pumila* L.) seedlings, marked with "U". Of these, only 28 red oaks and 3 sessile oaks failed to survive (Figure 8).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
R1	R	R	R	G	G	G	G	R	R	R	G	G	G	R	R	R	R	R	R	G	R	R	R	R
R2	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
R3	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R4	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
R5	R	R	R	R	R	R	R	R	C	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R6	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
R7	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R8	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
R9	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R10	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
R11	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R12	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U

Figure 8. Distribution of oak seedlings in plot no. 10

In plot number 11, 138 pedunculate oak seedlings (marked "P"), 92 wild privet (*Ligustrum vulgare* L.) seedlings (marked "L"), and 23 Siberian elm (*Ulmus pumila* L.) seedlings (marked "U") were planted alternately. Of these, 23 pedunculate oaks, 34 wild privets, and 9 Siberian elms did not survive (Figure 9).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
R1	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R2	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
R3	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
R5	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R6	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
R7	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R8	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
R9	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
R10	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
R11	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

Figure 9. Distribution of oak seedlings in plot no. 11

Figure 10 displays the results from plot number 12, where 271 red oak seedlings, 3 Turkey oak seedlings and 2 pedunculate oak seedlings were planted. Of these, 51 red oaks did not survive.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
R1	R	R	R	P	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R2	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R3	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R4	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R5	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R6	C	R	P	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R7	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	C	R	R
R8	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	C	R	R	R	R	R	R
R9	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R10	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R11	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R12	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

Figure 10. Distribution of oak seedlings in plot no. 12

In plot number 13, 156 sessile oak seedlings, 27 pedunculate oak seedlings, 81 honey locust (*Gleditsia triacanthos* L.) seedlings (marked "Gl") and 15 field maple (*Acer campestre* L.) seedlings (marked "J") were planted. Of these, only 2 sessile oaks and 48 honey locust seedlings failed to survive (Figure 11).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
R1	P	G	G	P	G	G	G	G	G	G	G	G	G	G	P	G	G	G	G	G	G	G	G	G
R2	Gl	Gl	Gl	Gl	Gl	Gl	Gl	J	Gl	Gl	Gl	Gl	Gl	Gl	J	Gl	Gl	Gl	J	Gl	P	P	P	P
R3	Gl	G	G	Gl	G	P	G	G	G	P	P	G	P	G	G	G	G	G	G	G	G	G	G	G
R4	Gl	Gl	Gl	Gl	Gl	Gl	Gl	Gl	Gl	Gl	Gl	Gl	J	J	J	Gl	Gl	P	G	G	G	G	P	Gl
R5	P	P	P	P	G	G	P	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
R6	Gl	Gl	Gl	Gl	Gl	Gl	J	Gl	Gl	Gl	Gl	J	Gl	Gl	Gl	Gl	Gl	G	G	G	G	P	P	G
R7	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
R8	Gl	J	J	Gl	Gl	Gl	Gl	Gl	Gl	J	Gl	Gl	Gl	G	P	P	P	P	P	Gl	Gl	G	P	P
R9	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
R10	Gl	Gl	Gl	J	J	Gl	Gl	Gl	Gl	Gl	Gl	J	Gl	G	G	G	G	G	G	G	G	G	G	Gl
R11	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
R12	Gl	Gl	J	Gl	Gl	Gl	Gl	Gl	Gl	Gl	G	G	G	G	G	G	G	G	G	G	G	G	G	G

Figure 11. Distribution of oak seedlings in plot no. 13

Figure 12 displays the results from plot 14, where 171 red oak seedlings, 3 pedunculate oak seedlings, 16 sessile oak seedlings and 86 dogwood seedlings (marked "S") were planted. Of these, 20 red oaks, 2 sessile oaks and 31 dogwood seedlings did not survive.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
R1	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	G	G	G	G	P	G	G	G	P
R3	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	G	G	G	G	G
R4	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	G	G	P	G	G
R5	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R6	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R
R7	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R8	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R	R	R	R	R
R9	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R10	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R	R	R
R11	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R12	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	R	R	R	R	R	R	R	R

Figure 12. Distribution of oak seedlings in plot no. 14

In plot number 15, 9 sessile oak seedlings, 68 pedunculate oak seedlings, 60 Turkey oak seedlings, 36 red oak seedlings and 103 sycamore maple (*Acer pseudoplatanus* L.) seedlings (marked “Pa”) were planted. Of these, only 2 sessile oaks, 8 pedunculate oaks, 7 Turkey oaks, 6 red oaks and 23 sycamore maples failed to survive (Figure 13).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
R1	G	G	G	G	G	P	P	P	P	C	C	C	C	C	C	C	C	C	C	G	C	G	P
R2	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	R	R	R	R	R	R	R
R3	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C	P	P	P	P	P	P	P	P
R4	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	R	R	R	R	R
R5	P	P	C	P	C	C	C	P	C	P	C	P	P	C	P	C	P	P	P	C	C	C	C
R6	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa
R7	C	C	C	C	C	C	C	C	C	P	P	P	P	P	P	G	C	G	C	C	C	C	P
R8	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	R	C	P	P	C	P	C	P	C	P	P	P
R9	P	C	C	P	C	P	C	P	C	P	C	C	P	C	C	C	C	C	C	C	P	P	C
R10	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	P	C	P	P	P	P	P	C	P	C	P
R11	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa	Pa
R12	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R

Figure 13. Distribution of oak seedlings in plot no. 15

In the last oak-based plot (*i.e.* plot no. 17), 138 pedunculate oak seedlings and 138 green ash (*Fraxinus pennsylvanica* Marshall) seedlings (marked “F”). Out of these, 58 pedunculate oaks and 18 green ashes did not survive (Figure 14).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
R1	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R2	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
R3	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R4	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
R5	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R6	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
R7	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R8	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
R9	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R10	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
R11	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
R12	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Figure 14. Distribution of oak seedlings in plot no. 17

Out of the 761 pedunculate oak seedlings planted, 187 (24.6%) failed to survive. The survival rates for the other oak species were higher, with red oak having a mortality rate of 16.1%, Turkey oak 12.4%, and sessile oak 7.5%.

CONCLUSIONS

Despite the challenging site conditions, including poor soil quality and rainfall, the survival rates for all four oak species were quite high. In 2024, nearly half of the total precipitation occurred in the last three months of the year, suggesting that fluctuating rainfall patterns likely influenced seedling survival, especially during periods of drought or excessive moisture.

The performance of **sessile oak** was particularly impressive, as this species typically prefers conditions with higher precipitation. These results indicate that sessile oak is the most resilient species under the given conditions. However, overall survival could be further improved with better soil quality and a more strategic planting approach that reduces competition and ensures adequate water and nutrients.

Although the production costs for potted root seedlings are higher than those for traditional bare-root methods, the outcomes of this study are promising. With only an 18.3% loss, this suggests that replanting needs will be lower, potentially leading to a significant reduction in future costs.

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