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Biometric indicators of common oak seedlings of various origins under different acorn storage conditions

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Abstract. Reforestation and increasing the productivity of oak stands are important tasks in forestry. The purpose of this study was to evaluate the impact of pre-sowing storage methods for common oak acorns and various propagation techniques on the biometric characteristics of common oak seedlings cultivated in forest stands. Indicators such as the height of the aboveground part, total and root weight, and the root collar diameter were evaluated. Special attention was paid to the influence of various

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methods of growing seedlings (container-grown stock, bare-root stock, and direct dibbling of acorns) on their physiological state. Analysis of the distribution of seedlings by condition categories (healthy, damaged, dead) established the best combinations of storage and cultivation. The results of the study showed that the method of storing acorns in trenches was the most effective, ensuring a high survival rate and the best biometric indicators of seedlings. Trench storage of acorns proved superior: container-grown seedlings (CGS) reached a height of 31.1-33.2 cm and a root mass of 8.8-10.8 g. When stratified in sand, the height was 31.2-31.4 cm. Storage in water showed the worst results: the height of CGS seedlings was 21.3-24.2 cm and root mass only 4.2-6.1 g. The proportion of healthy plants with the trench method was the highest (78-84%), while the maximum number of dead plants was recorded in sand (26-28%). The development of first- to third-order lateral roots and the taproot directly affected the survival and retention of the stands. Seedlings with CGS planted on a forest site and seedlings grown by dibbling acorns have more developed root systems. The obtained data are of practical importance for developing recommendations for improving the quality of common oak planting material

Keywords: *Quercus robur*; seedling height; root system; planting material; container-grown system

Introduction

Preserving the sowing quality of common oak (*Quercus robur* L.) acorns over winter is an important prerequisite for successful cultivation of high-quality planting material and effective reproduction of oak stands. Under climate change, with fluctuations in temperature and humidity, the search for optimal seed-storage methods becomes particularly relevant. The choice of storage method depends on the germination rate of the acorns and the growth intensity of the future stands. In this regard, the study of the influence of various methods of pre-sowing storage of acorns on the biometric indicators of common oak seedlings is of both scientific and practical importance for improving the effectiveness of reforestation measures.

The challenge of restoring oak (*Quercus robur* L.) forests becomes particularly acute in the context of global climate change, as confirmed by R. Vasylyshyn *et al.* (2023). An important stage of reproduction is the preservation of the genetic potential of seeds, since the physiological state of acorns after wintering directly correlates with the quality of future planting material. Overwintering common oak acorns must maintain their sowing quality until spring sowing. This avoids inflated seeding rates, improves germination, and prevents wasteful use of seed.

The development of seedlings' biometric indicators is crucial for the future accumulation of biomass by oak stands and their delivery of ecosystem functions. After high-quality common oak seed has been harvested, one of the main tasks is to preserve its germination capacity and quality before sowing. In forestry practice, acorns are most often stored in pits or trenches, less often in cellars or in running water. As technology advances, cold-storage rooms with controlled temperature and humidity are also used. The disadvantage of the latter is their cost and storage expenses. According to M. Aniszewska *et al.* (2020) and M. Kormanek *et al.* (2025), scarification and mechanical treatment of acorns before sowing after storage significantly improves the biometric parameters of seedlings, in particular, increases the total root length and the number of lateral roots, which is critical for the survival of the stands.

Experimental data of R. Yavorovskyi *et al.* (2023) also confirm that seedlings grown from acorns stored in sand-filled trenches show better subsequent growth. The study by O. Kranjec *et al.* (2022) and E. Kalemba *et al.* (2021) reported the possibility of applying thermotherapy (heat treatment of acorns) prior to storage, which had a positive effect on seedling height during the early stages of growth. However, storage conditions (in particular, temperatures from -1 to +3°C) affected the shape of the trunk and in some cases caused bifurcation. Storage at +3°C contributed to the development of fungi of the genus *Penicillium* sp., which reduced the germination energy. Seedlings grown from such acorns had less biomass. Thermotherapy proved effective, reducing the infection load and improving seedling survival. Yu. Andrusiak *et al.* (2024) in their studies treated common oak seedlings with growth stimulants Vernobiomag NPK and EcoStim-1 in different concentrations, which also gave positive results in seedling growth with the same storage of acorns compared to the control (without treatment). O. Danylenko (2024) reported that survival rates of container-grown (CGS) stands exceed those of bare-root (BRS) stands, a finding also confirmed in this study. The advantages of using container planting material of common oak in the creation of forest stands were also considered by P.B. Tarnopilsky *et al.* (2019), who analysed the growth, development of crowns and closing of *Quercus robur* L. plantings created using different types of planting material.

The purpose of the study was to analyse and compare the growth parameters of seedlings on silvicultural sites established either by direct acorn dibbling into the planting area, or after nursery cultivation under different production technologies of planting material derived from acorns collected in stands of plus trees and high-quality normal trees, following storage using three methods: trench storage, storage in running water, and sand stratification in a cellar.

Materials and Methods

Field studies were conducted in the Bukovinian Pre-Carpathians at the State Enterprise "Hertsaivske State Special Forestry Enterprise of the Agro-Industrial Complex" (Chernivtsi Oblast, Ukraine). The material was collected in the fall of 2020 under the canopy of ripe high-quality oak stands. 2,000 acorns of common oak were collected from normal trees and 2,000 acorns from plus trees *Q. robur* (trees with improved hereditary traits). From these, 1,000 acorns of uniform size were selected and sorted using a vernier caliper, with possible deviations of ±0.1 cm in diameter and ±0.5 cm in length. Acorns were divided into three batches (333 acorns each): the first was stored in a trench using the conventional method, the second was stratified in the basement in sand, maintaining its moisture at 60-65% of full water-holding capacity (FWHC) at a temperature of +5°C, the third in running water.

In the following year (2021), for comparison of seedling growth parameters, acorns from each batch were first planted in a nursery to obtain bare-root seedlings (BRS) and in containers to obtain container-grown seedlings (CGS), and were then transplanted to the silvicultural site. In addition, acorns from each batch were directly dibble-planted on the silvicultural site (Fig. 1).

a b c

Figure 1. *Cultivation of common oak seedlings*

Note: a – dibbling of acorns on a forest site; b – using the BRS in the nursery; c – using the CGS

Source: photo by the authors

To assess how the growth and development of young oak depend on the acorn storage method and the type of planting material, 18 test plots were established on hilly terrain in fresh and moist hornbeam-oak forest types with grey forest loamy soils, each plot 0.5 ha in area. The climate of the area where the state special forestry enterprise was located is temperate continental, with an average annual air temperature of +8.2°C and an average annual precipitation of about 900 mm. Partial soil preparation was applied during the establishment of the stands. When planting seedlings of common oak using both CGS and BRS, the following spacing arrangements were applied: inter-row spacing – 5 m and intra-row spacing – 1.25 m (Fig. 2), whereas for direct acorn dibbling, the inter-row spacing – 6 m and the spacing between planting spots within the row – 0.5 m (Fig. 1a).

a  b 

Figure 2. *Afforested area planted with seedlings*

Note: a – BRS, b – CGS

Source: photo by the authors

At the end of the growing season, seedlings were sampled evenly across each test plot along transects, using the diagonal method, on all 18 stand variants. For each variant, 30 standard seedlings were excavated. According to DSTU 9234:2023 (2023), the height of a standard common oak seedling should exceed 15 cm, and the root collar diameter should be at least 4 mm. Simultaneously, the length of the root system in conditions of sufficient moisture should be at least 15 cm, insufficient moisture – 20 cm, and excessive – 10 cm. For seedlings with CGS, the height of the aboveground part was 20 cm or more (DSTU 9248:2023, 2023). The excavated seedlings were cleaned of soil, the roots were washed, dried to an air-dry state, and laboratory measurements were carried out. Aboveground height was measured with a tape measure, the root collar diameter with a caliper, and the air-dry mass of the aboveground part and the root system with electronic scales.

After measuring the biometric parameters of the seedlings, comparisons were made within each experiment based on plant height, stem diameter at the root collar, aboveground biomass, and root mass to determine the most effective method for establishing forest stands on silvicultural sites. In addition, seedlings were recorded at all experimental sites, dividing them into categories of condition (healthy, damaged, dead). The resulting data was entered in tables and processed using the MS Excel software suite, where diagrams of the results obtained were built.

Results and Discussion

The production of high-quality planting material for forest regeneration under current conditions requires the use of high-quality seed of appropriate provenance while maintaining its viability. The study used various methods of storing acorns and growing common oak seedlings. The main criteria for seed quality are its germination capacity, germination energy, and purity. Undoubtedly, the quality of seeds is affected by factors such as temperature and humidity during their development (especially precipitation in summer) (Debryniuk *et al.,* 2016). Due to the influence of changing environmental conditions, physiological and biochemical processes in the plant follow a rhythmic pattern, determined by the gradual growth and accumulation of organic matter (Bilous, 2009). When the accumulation of organic substances reaches its maximum, seeds develop most intensively (Terek & Patsula, 2011). Seeds that ripen in cold and rainy summers, with the highest amount of precipitation in June–August, and the minimum sum of average temperatures, have the lowest mass (Gerushinsky, 1996; Gordienko *et al.,* 1999). The amount of heat and solar radiation received by the plant is crucial.

Biometric indicators of one-year-old common oak seedlings grown from acorns collected in high-quality normal plantings under different winter storage conditions are shown in Table 1.

Table 1. *Biometric indicators of one-year-old seedlings of common oak grown from acorns collected in high-quality plantings from normal trees with various storage conditions*

Pre-sowing storage of acorns	Height of the plant, cm	Mass of the aboveground biomass in the air-dry state, g	Mass of the root system in the air-dry state, g	Root collar diameter, mm
With container-grown root system				
In trenches	31.1 ± 4.7	4.1 ± 1.7	8.8 ± 0.5	7.6 ± 1.2
In running water	24.2 ± 2.4	3.1 ± 1.1	4.2 ± 2.3	3.2 ± 2.3
In the cellar in sand	31.4 ± 3.8	3.7 ± 2.4	6.9 ± 2.1	3.5 ± 1.6
With bare-root system				
In trenches	30.1 ± 2.3	3.8 ± 1.4	2.8 ± 1.3	4.6 ± 2.3
In running water	24.2 ± 6.5	2.1 ± 1.0	1.9 ± 0.6	2.2 ± 0.5
In the cellar in sand	29.8 ± 3.6	2.9 ± 1.8	2.6 ± 1.2	3.5 ± 2.1
With dibble planting method				
In trenches	27.5 ± 3.1	3.9 ± 2.0	3.7 ± 2.1	4.5 ± 1.3
In running water	22.2 ± 5.9	2.4 ± 0.9	2.1 ± 0.9	2.0 ± 0.6
In the cellar in sand	28.6 ± 5.4	2.7 ± 1.5	3.4 ± 1.3	3.6 ± 0.9

Source: compiled by the authors

As can be seen from the table, when storing acorns in trenches, seedlings grown with CGS had the greatest height (31.1 cm), aboveground biomass (4.1 g), and air-dry root mass (8.8 g). Storage in running water had the lowest results in all indicators. Regardless of the cultivation method, these seedlings had the lowest height, aboveground biomass, and root mass. For storage in a cellar in the sand, the results were average, but in some cases close to the method of storage in trenches, in particular, CGS seedlings stored in the sand had a height of 31.4 cm, which was the highest among all variants.

Seedlings grown with CGS had the greatest height, aboveground biomass, and root mass, especially when acorns were stored in trenches. Growing seedlings with BRS and acorn dibbling gave less pronounced results, while the seedlings had approximately the same biometric indicators, although in some cases the method of acorn dibbling had slightly better indicators (Fig. 3). The height distribution diagram of the aboveground part of one-year-old common oak seedlings in Figure 3 shows a clear dependence on the method of storing acorns and the method of growing seedlings. The highest height was reached by seedlings grown from acorns stored in a cellar in the sand and grown with CGS – 31.4 cm, although seedlings grown from acorns stored in a trench were not inferior in height – 31.1 cm. These methods provided optimal conditions for preserving acorns in winter, which positively affected the further growth of seedlings. Seedlings grown from acorns stored in running water had the lowest average height of all growing methods, indicating that this storage method is the least effective.

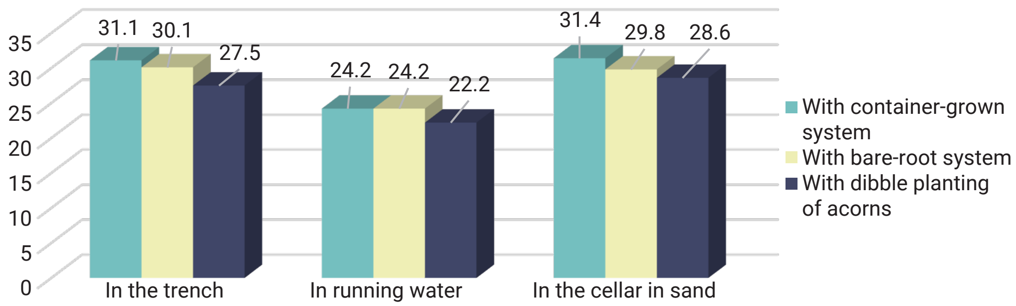

Figure 3. *Height of one-year-old seedlings of common oak (from acorns collected from high-quality normal plantings) with different methods of storing and growing planting material, cm*

Source: compiled by the authors

Table 2 contains data on biometric indicators of one-year-old seedlings of common oak. The method of storage in trenches proved to be the most effective. Analysis of experimental data showed that trench storage of seeds provided intensive development of plants with CGS, which reach a height of 33.2 cm and have a well-developed root system weighing 10.8 g.

Table 2. *Biometric indicators of one-year-old seedlings of common oak grown from acorns collected from plus trees with different storage conditions*

Pre-sowing storage of acorns	Height of the plant, cm	Mass of the aboveground biomass in the air-dry state, g	Mass of the root system in the air-dry state, g	Root collar diameter, mm
With container-grown root system				
In the trench	33.2±4.6	5.0±3.3	10.8±2.5	8.4±2.3
In running water	21.3±3.6	3.2±0.9	6.1±1.8	3.3±1.9
In the cellar in sand	31.2±2.3	4.4±2.8	9.4±4.1	6.5±1.8
With bare-root system				
In the trench	32.1±3.4	4.0±2.3	3.3±1.1	3.9±1.0
In running water	22.2±1.5	2.5±1.3	2.0±0.2	3.4±0.9
In the cellar in sand	30.8±2.7	2.4±0.6	3.3±0.9	4.1±1.7
With dibble planting method				
In the trench	28.1±4.7	3.1±0.6	3.8±2.0	4.3±1.2
In running water	20.3±2.4	2.2±1.9	2.3±0.9	2.5±0.6
In the cellar in sand	29.8±3.8	3.4±1.7	2.9±1.5	3.8±1.3

Source: compiled by the authors

The use of running water significantly suppressed the growth of seedlings, as evidenced by the lowest root collar diameter (3.3 mm) and a reduction in root mass by almost half compared to other methods. This indicates not only a slowdown in linear growth, but also a violation of the balance between the development of the aboveground and underground parts of the plant. Under such conditions, seedlings form a less developed supporting and absorbing root system, which can reduce their stability after planting out. It is particularly significant that even growing with CGS does not compensate for the negative impact of storing acorns in running water, since the indicators of such seedlings remain lower compared to trench storage and stratification in sand. Thus, the method of pre-sowing storage is the primary factor that determines the further growth potential of planting material. Stratification in sand produced an intermediate height (31.2 cm) but was inferior to the trench method in total aboveground biomass accumulation (Fig. 4).

Figure 4. *One-year-old plants (seedlings) of common oak planted on silvicultural sites (grown using the trench method of storing acorns with CGS)*

Source: photo by the authors

The results of stratification in sand indicate the relative stability of this method: in most indicators, it approaches trench storage, but does not provide the same level of development of the root system and the diameter of the root collar. It is the combination of a larger root weight and a larger root collar diameter in the trench storage variant that gives grounds to consider it as the most promising for obtaining physiologically sound seedlings with a higher potential survival rate. Storage in running water proved to be the least effective method. The height of seedlings grown from acorns stored in this way was significantly lower compared to other storage methods. Comparative analysis of methods of pre-sowing treatment of acorns, conducted by P.P. Yavorovskyi *et al.* (2022), showed the superiority of the conventional trench method over others. It was found that the share of conditioned planting material with this approach is almost twice as high as the results of storage in sand, where only 43-44% of high-quality seedlings were recorded. In addition to low productivity, the sandy substrate in the cellar leads to an increase in plant death by up to 26%, while the trench and running-water methods yield 87-90% standard planting stock.

Analysis of the height of one-year-old seedlings demonstrates a clear advantage of CGS cultivation over conventional methods, which is explained by the better preservation of the physiological integrity of the roots during growth. The highest growth rates with the trench storage method indicate the creation of optimal conditions for the development of the aboveground part. In addition, the lag in growth of seedlings obtained after storing acorns in running water indicates leaching of nutrients or partial hypoxia of the embryo, which further reduces the growth energy even if container technologies are used. Thus, the method of storing acorns is a key factor in the development of biometric parameters (Fig. 5).

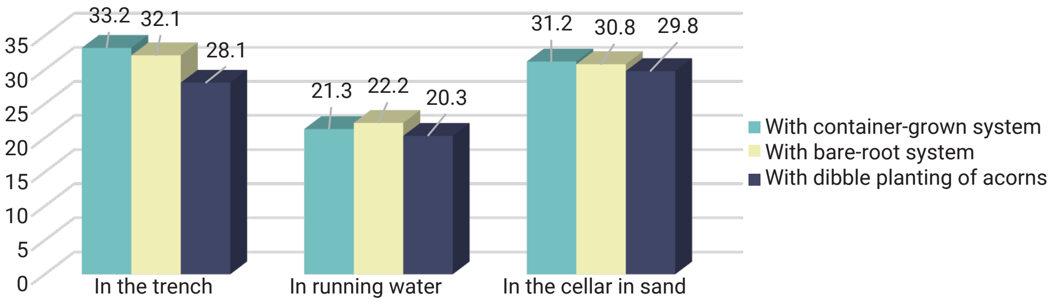

***Figure 5.** Height of one-year-old seedlings of common oak, grown from acorns collected from plus trees according to different methods of storage and types of cultivation, cm*

Source: compiled by the authors

Comparative analysis of the diagram indicates that it is most physiologically favourable with a maximum seedling height (33.2 cm) and a well-developed root system weighing 10.8 g. This indicates not only the active development of the aboveground part, but also the balanced formation of the root system, which is an important indicator of the quality of planting material. The advantage of the trench method can be traced for all cultivation options, but it is most clearly manifested in seedlings with CGS, where high values of height, root collar diameter, and root mass were combined. This may indicate that the stable temperature regime of the trench has the best effect on the acorn embryo. However, storage in running water produces a consistent lag in height regardless of the growing method, which indicates a systemic negative impact of this method even at the stage of seed material preservation. Even container cultivation, which generally provides better conditions for plant development, does not eliminate the consequences of such pre-sowing storage. Special attention should be paid to stratification in sand: in terms of seedling height, this method was close to trench, especially in variants with CGS and BRS. However, lower root mass and root collar diameter compared with trench storage indicate that the growth of the aboveground part is not always accompanied by the same level of development of the underground part.

Table 3 shows the distribution of one-year-old seedlings of common oak in three categories of condition: healthy, damaged, and dead, depending on three methods of pre-sowing storage of acorns (trench, in running water, in a cellar in the sand) and their origin (from plus trees and from high-quality normal plantings).

***Table 3.** Distribution of common oak seedlings by condition categories, %*

Pre-sowing storage of acorns	Healthy		Damaged		Dead	
	P	H	P	H	P	H
In the trench	78.2±3.9	84.2±4.1	6.4±0.6	6.4±0.5	15.4±0.9	9.4±0.8
In running water	67.3±3.4	73.3±3.6	16.5±0.8	16.5±0.7	16.2±0.7	10.2±0.9
In the cellar in sand	68.4±3.3	70.4±3.4	3.6±0.2	3.6±0.3	28.0±1.5	26.0±1.6

Note: P – acorns collected from plus trees, H – acorns collected from high-quality normal plantings

Source: compiled by the authors

Analysis of the data in Table 3 allows drawing the following conclusions about the viability of common oak seedlings. The determining factor in the condition of seedlings is the method of storing acorns, and not their genetic origin. The highest yield of healthy plants is provided by storage in trenches (78.2-84.2%), while stratification in sand leads to a significant increase in the proportion of dead seedlings by 1.8-2.8 times, compared to other methods. In all storage variants, seed from normal plantings outperformed seed from plus trees. In particular, the proportion of dead seedlings from acorns of normal plantings is lower by 6-10%, which indicates their higher adaptive ability in the early stages of development. Storage in running water, despite the relatively high proportion of healthy seedlings (67-73%), produces the largest number of damaged plants (16.5%), which is 2.5-4.5 times higher than other options. Data analysis also shows that acorns collected from high-quality normal plantings show better germination rates and resistance to adverse environmental factors. For all storage methods, the proportion of healthy seedlings grown from these acorns was higher, and the proportion of dead ones was lower compared to acorns from plus trees. For example, when stored in trenches, the proportion of healthy seedlings from high-quality normal plantings was 84.2 ± 4.1%, while from plus trees – 78.2 ± 3.9%. The choice of a specific type of planting material during artificial reforestation has an impact on the stability and productivity of future stands.

In addition to the type of planting material, growth indicators were an important component of assessing its quality. Further study of the growth of common oak seedlings was carried out on silvicultural sites. When establishing the stands, partial tillage was used, and common oak seedlings from CGS and BRS were planted. Survival was determined by the ratio of the number of viable seedlings at the time of their registration to the initial number of planted plants, expressed in percent (Fig. 6).

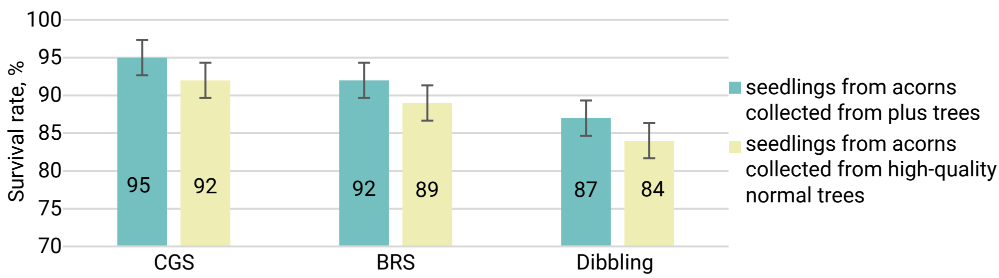

***Figure 6.** Survival rate of the stands, %*

Note: CGS – container-grown system; BRS – bare-root system

Source: compiled by the authors

It was found that the survival rate of seedlings with CGS grown from acorns that were collected from plus trees was 95%, for crops that were created from seedlings grown from acorns that were collected in high-quality plantings – 92%. For crops created by seedlings with a BRS, 92% and 89%, respectively. Survival rate of stands established by dibble planting reached only 87% for oak seedlings grown from acorns of plus trees and 84% for stands established from seedlings produced from acorns collected in high-quality stands. This can be explained by suppression from herbaceous cover and coppice regrowth of secondary tree species and shrubs.

In common oak plants created by dibble planting acorns on a silvicultural site, the establishment of a taproot and lateral roots of the first and second orders is observed (Fig. 7). While in seedlings with CGS planted in a silvicultural site, the plant continues to form a branched root system and begins to form a taproot that could not have formed in the container. Seedlings grown in a nursery under open-field conditions had damaged root systems, and during the first year on the silvicultural site the plants restored root-shoot balance through development of lateral roots, and only later began to redevelop a taproot.

Figure 7. *Study of root systems of seedlings grown from acorns under different storage methods*

Note: a – in the sand; b – in the trench; c – in the water

Source: photo by the authors

Studies of the root systems of common oak plants have showed that plants established by acorn dibbling developed a taproot system with lateral roots predominantly of the first order, oriented vertically towards available soil moisture. In common oak plants grown with CGS, lateral roots of the first and third orders predominate. The average depth of penetration of common oak roots in the areas of reforestation created by acorn dibbling was 38.2 ± 3.18 cm, and from seedlings with CGS – 29.2 ± 5.14 cm. In the root systems of common oak seedlings established by acorn dibbling, lateral roots of the first to third orders with predominantly horizontal orientation prevailed. Based on the results of the study by M. Zadworny *et al.* (2014), such seedlings have better access to water during times of water scarcity. In plants grown from seedlings in open-field conditions, lateral roots of the first to third orders predominate. To restore the root-shoot balance, the lateral roots spread out in a horizontal plane, maximising the moisture that comes with precipitation. Thus, first-order lateral roots and minor branches of second- and third-order roots were formed. In the areas of reforestation, seedlings with CGS revealed an optimally developed root system, formed mainly in the upper horizons of the soil, but without the existing taproot. Consequently, the root systems of common oak plants in silvicultural sites formed by seedlings with CGS and acorn dibbling are more developed and vigorous. This is consistent with the data by G.A. Hoss (2004), who examined the characteristics of oak cultivation with BRSs and described the technological conditions for producing bare-root planting stock. What is common to the results of this study is that the quality of the root system is determined not only by the biological characteristics of oak, but also by the method of growing planting material. The study by G.A. Hoss (2004) focused primarily on the production protocol of oaks with BRSs, whereas the present study compares multiple afforestation technologies, including planting seedlings with CGS, BRS, and direct acorn dibbling. Therefore, the results obtained extended the conclusions of G.A. Hoss (2004), as they showed that CGS and dibbling provide more powerful root system development in the first year after crop establishment, whereas seedlings with BRS need time to restore the root-shoot balance after transplanting. Similar conclusions can be traced in the paper by O.S. Ostapchuk & O.V. Sovakov (2019), who studied the influence of methods of creating forest stands on the development of the root system of common oak in the conditions of a young hornbeam-oak stand. The researchers found that the length and nature of root system development significantly depend on whether the crops were created by sowing acorns or planting seedlings. This directly correlates with the results of the current study: when acorns are dibble planted, the taproot system is more actively formed in plants, while seedlings with CGS are dominated by lateral roots of the first or third orders, formed mainly in the upper horizons of the soil. Thus, common to both studies is the conclusion that the method of creating crops determines not only the intensity of growth, but also the architecture of the root system.

In addition to various storage conditions for acorns, the further growth of common oak will also be affected by the types of cultivation of its planting material. CGS have several advantages compared to seedlings grown under open-field conditions, but they are characterised by higher production costs. From the results of experimental studies of O. Danylenko (2024) for growing seedlings with CGS, the volume of containers also has an impact. One-year-old saplings with CGS with a container volume of 1,407 cm^3 had a height of 31.7 cm, and with a container volume of 510 cm^3 – 19.5 cm. One-year-old seedlings of common oak planted with a BRS had a height of 19.6 cm, but already at the end of the second year of their growth, the height of oak plants with CGS in both variants exceeded its height when planted with BRS. V. Lukyanets *et al.* (2022) reported that, under traditional trench storage of acorns, from the fourth year onwards seedlings planted by dibbling slightly outperformed oak seedlings from bare-root stock by 1-2%. Oak planted with a BRS from the age of 5 gave significantly lower results compared to dibble planting and CGS.

The results obtained for acorn dibbling are consistent with the findings of M. Löf *et al.* (2019), who considered direct oak seeding as a promising but sensitive method for restoring oak forests. In this context, the lower survival rate of plants created by dibble planting compared to seedlings with CGS can be explained by stronger competition of grass vegetation and less controlled conditions of initial growth in the silvicultural site.

Consequently, the reproduction of highly productive and biologically resilient oak forests is one of the priority tasks of contemporary forestry in Ukraine. The success of reforestation critically depends on the initial stage of plant ontogenesis, where biometric indicators of seedlings play a key role: the height of the plant, the root collar diameter and, above all, the development of the root system. The conducted study convincingly showed that the morphometric parameters of one-year-old seedlings of common oak (*Quercus robur* L.) were formed under the complex influence of two main factors: the genetic origin of seeds and methods of storing acorns during the dormant period (conditions of harvesting, processing, and winter storage). Therefore, the various methods of creating forest stands with their own specifics of storing oak acorns and creating planting material with different technologies are not only prerequisites for conventional methods, but also provide the best growth indicators, which, in turn, has a positive effect on the survival rate of crops. The method of seed storage directly correlates with the architecture of the root system of future seedlings.

Conclusions

In the current conditions of climate change, ensuring high viability and competitiveness of planting material requires a transition to contemporary standards for growing seedlings for forest reproduction. Based on the conducted research, it was found that the key to optimising the growth processes of common oak seedlings is the combination of an efficient method of seed storage and advanced cultivation technology. The most effective method of pre-sowing preparation was to store acorns in trenches. This method best preserved sowing quality, yielding up to 84.2% of healthy seedlings with high growth potential. Compared to stratification in sand, storage in trenches reduced the proportion of dead plants by 1.8-2.8 times. The best results were shown by seedlings grown using CGS technology. The use of a container-grown system results in higher height and root collar diameter compared to open-field production or acorn dibbling, which can be explained by reduced transplant stress and better development of a fibrous root system within a confined substrate volume. Studies have confirmed that the use of acorns from high-quality normal plantings provided better adaptive capacity and growth intensity of one-year-old seedlings compared to seeds from plus trees, such seedlings have 6-10% higher viability for all the storage methods tested. The experimental data demonstrate the value of natural methods for improving the growth of common oak.

Further research will focus on the condition and growth of established forest stands to clarify the practical application of these methods. These studies may continue up to the stage of crown closure, which facilitates, in the long term, the recommendation of specific applications of the proposed methods of acorn stratification and planting material technologies prior to the transfer of the sites to forest-covered areas.

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Conflict of Interest

None.

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Біометричні показники сіянців дуба звичайного різного походження за різних способів зберігання жолудів

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Анотація. Питання лісовідновлення та підвищення продуктивності дубових насаджень має важливе значення для лісового господарства. Мета роботи полягла в оцінці впливу передпосівних способів зберігання жолудів дуба звичайного та різних технологій вирощування садивного матеріалу на біометричні показники сіянців дуба звичайного, які висаджені на лісокультурні площі. Оцінювалися такі показники, як висота надземної частини, загальна та коренева маса, а також діаметр біля кореневої шийки. Особлива увага приділялася впливу різних методів вирощування сіянців (із закритою та відкритою кореневою системою, а також методом шпигування) на їхній фізіологічний стан. Аналіз розподілу сіянців за категоріями стану (здорові, пошкоджені, загиблі) дозволив встановити кращі комбінації зберігання та вирощування. Результати дослідження показали, що спосіб зберігання жолудів у траншеях виявився найбільш оптимальним, забезпечуючи високу приживлюваність та найкращі біометричні показники сіянців. Доведено перевагу траншейного зберігання жолудів: сіянці із закритою кореневою системою (ЗКС) досягли висоти 31,1-33,2 см та маси коренів 8,8-10,8 г. При стратифікації в піску висота склала 31,2-31,4 см. Найгірші результати показало зберігання у воді: висота сіянців ЗКС становила 21,3-24,2 см, маса коренів лише 4,2-6,1 г. Частка здорових рослин при траншейному методі була найвищою (78-84 %), тоді як у піску зафіксовано максимум загиблих (26-28 %). Формування бічних коренів першого-третього порядку та стрижневого кореня мають прямий вплив на приживлюваність та збереженість лісових культур. Висаджені на лісокультурну площу сіянці із ЗКС та сіянці вирощені шляхом шпигування жолудів мають більш розвинені кореневі системи. Отримані дані мають практичне значення для розробки рекомендацій щодо підвищення якості садивного матеріалу дуба звичайного

Ключові слова: *Quercus robur*; висота сіянців; коренева система; садивний матеріал; закрита коренева система