**DOI:** 10.5604/01.3001.0010.0498

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# WINTER STORAGE OF PENDUNCULATE OAK *(QUERCUS ROBUR L.)* SEEDLINGS

## *ZIMOWE PRZECHOWYWANIE SADZONEK DĘBU SZYPUŁKOWEGO (QUERCUS ROBUR L.)*

**Słowa kluczowe: sadzonki dębu, zimowe przechowywanie, admitancja**
*Key words: Oak seedlings, winter storage, admittance*

**Abstract.** The aim of the study was to determine the effect of quality of Oak seedlings on their growth and vigour measured with their electrical admittance, in the first year after five methods of winter storage. The seedlings were stored in different package inside the cold room with controlled temperature and outdoors at the nursery yard in polystyrene growing cells.

## INTRODUCTION

The storage of seedlings in cold storage facilities has been increasing in importance in the forestry nursery practise. It allows elimination of influence of external environment in the most critical season of the year and allows more flexibility in management of various spring time nursery operations [Wesoły, Berft 2014]. The main aim of cold storage of tree seedlings is to keep them in a dormant condition by slowing down their metabolic processes. Storage of seedlings requires specialised infrastructure: a cold-store for seedlings. A building of this type is in the hold of the tree nursery of Jarocin Forest District. The storage building has got space sufficient to store part of annual nursery output which stays in the nursery for the winter, especially seedlings of species most susceptible to damage from frost like oak. The cold storage room is fitted with equipment to maintain and monitor the parameters inside. The most important of them is the temperature which needs to preserve the seedlings dormant without causing any frost damage and prevent any development of pathogens. The whole facility apart from the cold storage room consists of the indoor space to prepare seedling to outer environment before deployment to planting grounds.

Besides the above it is necessary to secure the plants from drying out by providing high relative air humidity of no less than 95%. This is especially crucial for storage of coniferous species which are subject to higher risk of losing the water due to their high area of evaporation. They require especially high humidity of storage room [Wesoły W. i in., 2010].

The problem of winter storage of tree seedlings for forestry purposes lies not only in securing their condition during the storage period but also in organising the process in the way which allows transport of them to planting area causing as little stress to plants as possible.

In recent years after the ways to humidify seedlings inside cold storage rooms had been developed, the number of such facilities started to increase. This applies to both bare root and container grown seedlings. This trend appears to be stable despite quite substantial number of seedlings being planted in autumn season [Berft M., i. in. 2014]. The Jarocin Forest District nursery came across the concept of packaging the seedlings in the way which would secure the planting material from drying out and would facilitate their transport to the forest for planting.

Physiological condition of seedlings, often named by the term “vigour” is considered as a good measure to assess quality of seedlings and their suitability for further planting [Wielgosz, Wesoły 2000]. The most useful methods to assess seedlings' vitality are the ones conducted in the field, which would not pose a risk of causing substantial damage to plants. One very useful and simple in application is method of checking plant vigour by measuring their electric conductivity [Blanchard R.O., Carter J.K., 1980; Pukacki P.M., 1982; Wesoły W., i in. 1998].

The measurement of electrical conductivity is done by connecting electrodes to plant tissues which forms an electric circuit. Directly measured value of electrical resistance of plant tissues measured with use of alternating current is the resultant of electrical resistance and electrical reactance. The sum of the two above values is called electrical impedance (Z). The inverse of reactance is called electrical admittance (Y). The unit of admittance in SI is siemens (S) [Wesoły W. i in. 1998].

The aim of this work is to compare the vigour and increment of cell grown seedlings of penduncculate oak stored over winter in the cold storage and outdoors on the nursery grounds.

## MATERIALS AND METHODS

The seedlings of penduncculate oak have been produced in Marbet cells (Photo 1) of improved durability V300, density of 60kg/m$^3$. All cells are made of polystyrene resistant to ageing and keep their utility properties for long time.

Five ways of winter storage of seedlings have been tested:

1. Storage inside the cold room, packed in a wire-made crate and wrapped with stretch wrap (Photo 2).
2. Storage inside the cold room inside a tightly tied paper bag (Photo 3).
3. Storage inside the cold room in an open paper bag (Photo 3).
4. Storage inside the cold room in bundles of 10 wrapped in stretch wrap (Photo 4).

5. Plants remaining in the cells outdoors at the nursery yard (Photo 5).
Due to the delayed start of storage room operations, the seedling were put into the room in second half of January and removed from there on March the 29th 2015.
At the nursery yard the seedlings have been stored in cells with wooden pallets underneath. In November the cells have been taken off the pallets, put directly onto the ground and covered with tree litter.

After the winter storage all seedling have been planted in plots in 3 series (Fig. 3). Measurement of electric admittance of them has been conducted on May 23rd and measurement of growth in the end of the growing season in November 2015.

**Photo 1.** Penduncula te oak seedlings grown in polystyrene cells
*Source: W. Wesoły.*

**Photo 2.** Seedlings stored in an wire crate wrapped with a stretch wrap
*Source: W. Wesoły.*

**Photo 3.** Seedlings stored in bags
*Source: W.Wesoły.*

**Photo 4.** Seedlings stored in bundles wrapped with stretch wrap and placed in steel crates
*Source: W. Wesoły.*

**Photo 5.** Seedlings wintering in cells outdoors at the nursery grounds
*Source: W. Wesoły.*

**Photo 6.** Seedlings planted on the ground after storage in 3 series for each treatment
*Source: W. Wesoły.*

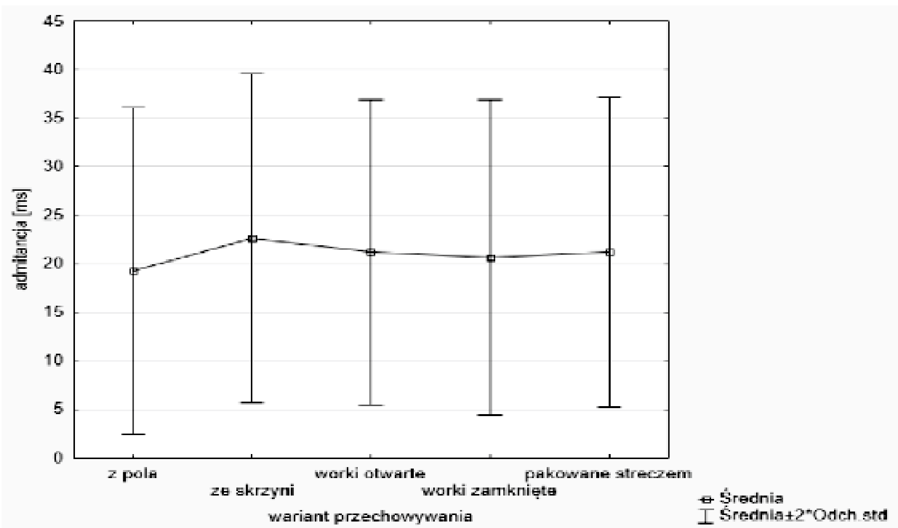
## RESULTS

No significant difference of admittance between seedlings stored inside cold room and ones wintering outdoors have been found (Table 1, Pic. 1). This means similar vigour of seedlings wintering outdoors and ones stored in the cold room. There was also no significant difference between various options of cold room stored seedlings (F=1.742, p=0,139).

**Table 1.** Variance analysis of vigour for seedlings stored in the cold room.

| *Type of variance* | *SS* | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Between storage options | 465,2 | 4 | 116,3 | 1,742 | 0,139926 |
| Within each storage option | 27378,9 | 410 | 66,8 | | |
| Total | 27844,1 | 414 | | | |

*Source: Own research.*




**Pic. 1.** Electrical admittance of seedling stored in five various options.
Y axis – admittance in ms (milisiemens), X axis - 5 storage options from left to right: Outdoor storage, wire crate in cold room, open bags in cold room, tied bags in cold room and bundles in stretch wrap in the cold room
*Source: Own research.*

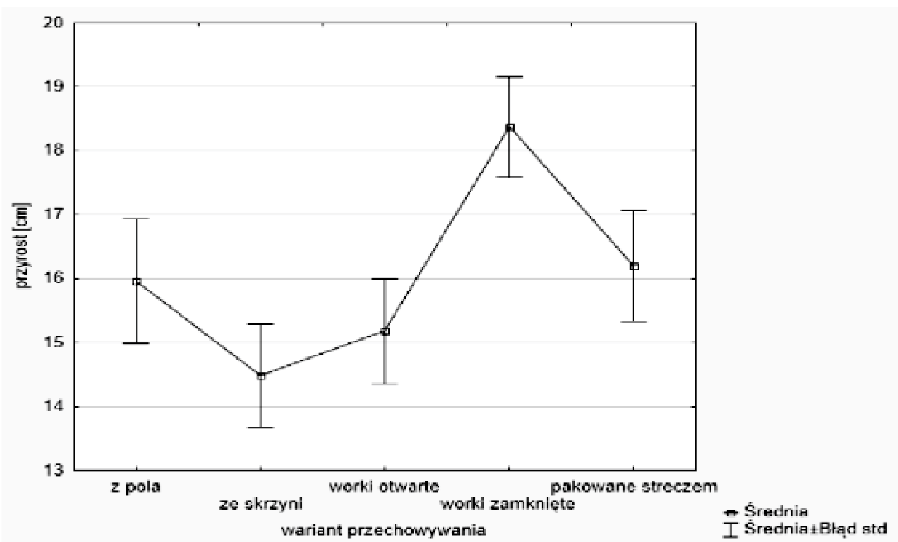
The values of measured increment of planted seedlings are shown on Pic. 2. Analysis has shown small but significant variation in growth between seedlings of different cold room storage options (Table 2 and Pic. 2). Higher increment (determined by Duncan test) was found for seedlings with better protection from drying during the storage period and the for the control lot wintering outdoors in the growing cells (F= 3,039 with p= 0,017).

**Table 2.** Differences of seedlings' growth between tested options of winter storage – variance analysis
*Source: Own work.*

| *Source of variance* | *SS* | *df* | *MS* | *F* | *p* |
|---|---|---|---|---|---|
| Between storage options | 744,7946 | 4 | 186,1987 | 3,039 | 0,017258 |
| Within each storage option | 25545,6 | 417 | 61,26044 | | |
| Total | 26290,4 | 421 | | | |

Table 2 cont.

| series No. | Duncan Test; variable: Increment. Uniform groups, α = ,05000<br>Deviation: MS between groups = 61,260, df = 417,00 | | | |
|---|---|---|---|---|
| | Storage option | Mean increment | 1 | 2 |
| 2 | Wire crate | 14,48214 | **** | |
| 3 | Open bags | 15,18072 | **** | |
| 1 | Outdoor | 15,96386 | **** | **** |
| 5 | Bundles wrapped with stretch wrap | 16,19048 | **** | **** |
| 4 | Tied bags | 18,36932 | | **** |




**Pic. 2.** Results of measurement of increment for various winter storage options of penduncuIate oak seedlings; Y axis: increment values in cm, X axis – storage options from left to right: outdoor storage, wire crate in cold room, open bags cold room, tied bags cold room, bundles in stretch wrap cold room
*Source: Own research.*

## DISCUSSION

There is the possibility that the lack of snow cover and very low precipitation during the early spring could result in drying out of substrate of seedlings stored outdoors on the growing field of nursery and cause a decrease in seedlings' vigour shown by measurements of electric admittance. In case of seedlings stored outdoors in polystyrene cells the threat of root dehumidification was found to be lower. For seedlings stored inside the cold room the substrate was covered which allowed keeping its humidity on the high level. It is thought that air humidification system inside a cold room would be beneficiary so covering of seedlings' root systems to protect them would not be a necessity.

Acclimatisation of seedlings to winter conditions is done without problems when there is a gradual increase of tolerance to dropping temperature [Green J.L., Fuchgami L.H., 1985]. The presence of small early frosts during night time with relatively higher temperature during the day allows better physiological adjustment of seedlings to wintering [Weiser C.J., 1970]. The above conditions in winter have occurred during the research period hence the seedlings stored outside the cold room would also be characterised by high vigour.

The simplest solution would be to deploy seedlings for planting already in autumn time without any storage at the nursery. Despite the increasing number of seedlings planted in autumn, planting in this season is not a part of "traditional" foresters' approach to timing of restocking operations in Poland and no dramatic change to that is predicted to occur in coming years [Wesoły i in. 2009]. In addition, the previous growing season was affected by a drought additionally contributing to reluctance of foresters for autumn planting (verbal communication with Forest District employees).

Unstable conditions of winter storage of forest tree seedlings linked to sudden drops of temperature and long periods of relatively high temperatures during winters result in reduced vigour of wintering seedlings [Wesoły i in. 1998]. Because of that any decisions to equip forest district nurseries with cold storage facilities are fully justified. In addition the storage of seedlings in cold rooms allows better management of the timescale of nursery work in the spring time as it enables the storing of seedlings for longer time in nurseries reducing the work load connected with spring removal of seedlings form the ground and their despatching to plant.

The results shown above concern a very short period of storage hence the analysis can should be treated as a pilot one. It is not possible to draw any long term conclusions on the basis of this analysis.

It is highly recommended to repeat this experiment, which is actually being done in the current winter season.

## CONCLUSIONS

1. No significant difference of vigour has been found for pendunculate oak seedlings in various options of cold room storage.
2. Results of experiment confirm high vigour of seedlings stored both inside cold room and ones stored outdoors.
3. Securing the root systems of seedlings from drying allows storage of seedlings inside cold rooms without any humidity control equipment.

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## STRESZCZENIE


Sadzonki dębu szypułkowego wyprodukowane w szkółce kontenerowej były przechowywane w komorach chłodniczych bez regulowanej wilgotności powietrza.

Przyjęto 5 warianty doświadczenia:

1. Przechowywanie w chłodni w drucianym koszu i w całości owinięte streczem.
2. Przechowywane w chłodni w zamkniętym worku papierowym.
3. Przechowywane w chłodni w otwartym worku papierowym.
4. Przechowywane w chłodni owinięte po 10 szt. streczem.
5. Pozostawione w kasetach na placu hodowlanym w szkółce.

Nie stwierdzono istotnych różnic między wariantami przechowywania w chłodni. Sadzonki z pola hodowlanego (przechowywane poza chłodnią) charakteryzowały się również wysoką żywotnością.

Pomiar przyrostów po pierwszym sezonie wegetacyjnym potwierdził niewielkie istotne różnice między wariantami przechowywania.


## SUMMARY


Container seedlings (1/0) of pendunculate oak were stored over winter in a cold-storage room without humidity control equipment. There were five options of storage tested:

1. in a wire crate wrapped by stretch film
2. tied paper bags
3. open paper bags
4. seedlings in bundles wrapped in stretch wrap
5. seedlings in polystyrene cells stored outdoors at nursery (during the winter)

There were no significant differences between options of cold storage. Seedlings wintering outdoors at nursery had also high seedling vigour measured by admittance. Measurement of the increment at the end of the first growing season after planting has shown significant differences between storage variants.