

TADEUSZ TYLKOWSKI

Height increment of 1-year shoots of the English oak (*Quercus robur* L.) and the northern red oak (*Q. borealis* Michx.=*Q. rubra* L.) on 4-year-old roots of seedlings raised from acorns stored over 1-5 winters*

INTRODUCTION

Considerable deficiency of acorns in years with bad crops causes mass sowing of acorns in forest nurseries in mast years which occur every 3-8 years for the English oak (Tyszkiewicz 1949) and 2-5 years for the northern red oak (Fowells 1965, Olson 1974). In consequence of increased sowings considerable nursery areas are occupied by many years' oak plants. This causes disadvantageous disturbances in the proportions between roots and assimilation organs after digging up the transplants.

The problem of irregular fructification of oaks could be partially overcome by long-term storage of acorns (Holmes and Buszewicz 1956, Suszka and Tylkowski 1980, 1981). Recent methods permit prolongation of storage from several months to 2 or 3 winters without serious decrease of germinative capacity of acorns.

Storage is always accompanied by ageing of seeds. In numerous studies on ageing of acorns Szczotka (1973, 1974, 1975, 1977) has found a gradual decrease or even a total loss of the ability to synthesise RNA and proteins, changes of the activity of auxins and abscisic acid as well as of amyolytic enzymes. Kulka (1973) indicated that the process of ageing is accompanied by degenerative changes concerning protoplast structure as well as physiological and biochemical functions. Barton (1961) observed the occurrence of mutants among seedlings raised from old seeds of various plant species.

Seed ageing accompanied by a reduction of germinative capacity and the decrease of height of 1-year seedlings raised from old acorns pre-

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sented the question concerning effects of long-term storage of acorns of the English and the northern red oak on growth of seedlings during the first years after transplanting in the nursery.

MATERIALS AND METHODS

In the experiment acorns of different provenances of the English oak and the northern red oak have been used. Seeds were collected in the years 1970 - 1975 and stored afterwards in controlled conditions (in dry peat or without any medium in containers with air access at a temperature of -1°C ; Suszka and Tyłkowski 1980, 1981). Data on this seed material are presented in Table 1.

Acorns of the English oak stored over 1, 2, 3 and 4 winters and acorns of the northern red oak stored over 2, 3, 4 and 5 winters have been sown in the nursery in 1975. In the autumn of 1975 large (L) and small (S) 1-year seedlings were collected and stored in a pit under the stand canopy till the next spring. In the spring of 1976 the seedlings were planted in the nursery in a random block design with 5 replicates (5 seedlings in each replicate). In two cases where less than 25 seedlings were available all plants have been used. This concerns seedlings of the northern red oak raised from seeds stored over 4 winters (large seedlings — 2 replicates with 5 seedlings in each) and 5 winters (only 6 small seedlings).

After planting all plants have been trimmed near the ground level, the arising buds were removed and only one bud was left for shoot formation. Side branches were also removed during the growing seasons. The same manipulations have been performed in the two consecutive vegetation periods. In autumn 1978 height of 1-year increments growing on 4-year roots was measured and the average values of this character were compared (Figs 1 and 2, Tables 2 and 3).

Table 1

Laboratory germinative capacity, seedling emergence in the nursery and mean height of the English oak and the northern red oak seedlings as dependent on the duration of storage at -1°C

Species	Number of winters of acorn storage	Provenance	Laboratory germinative capacity at 20°C %	Nursery seedling emergence %	Mean seedling height cm
<i>Quercus robur</i>	1	Dąbrowa Tarnowska	46.5	57.0	14.5
	2	Niepołomice	67.5	57.2	21.1
	4	Wymiarki	34.5	40.6	13.1
<i>Quercus borealis</i>	2	Dąbrowa Tarnowska	81.5	81.2	25.3
	3	Pokój	18.0	34.0	17.2
	4	Pokój	13.0	14.6	16.9
	5	Pokój	0.5	1.8	5.8

RESULTS

A part of the investigated plants has been lost during the three consecutive vegetation periods. Final measurements of height include greater number of large plants (L) — 97% than that of the small ones (S) — 87%.

Mean height difference between L and S plants of the English oak increased from 9.9 - 20.3 cm to 30.6 - 48.7 cm after 3 vegetative periods when the 1-year increments were cut down while for the northern red oak these values were 13.1 - 31.1 and 31.3 - 53.3 cm respectively (Table 3).

The proportion between the height of 1-year increments of large and small plants $\left(\frac{\text{height S}}{\text{height L}} \cdot 100\right)$ expressed in percent after the first and the

Table 2

Mean one-year height increments of shoots on 1-year-old (1975) and 4-year-old (1978) roots of the English oak and the northern red oak

Species	Number of winters of acorn storage	Type of transplants*	Mean height increment of one-year-shoot		$\frac{S}{L} \cdot 100$ (1975) %	$\frac{S}{L} \cdot 100$ (1978) %	Height ratio in years	
			On 1-year-old root (1975) cm	On 4-year-old root (1978) cm			1978	1975
<i>Quercus robur</i>	1	S	13.0	57.0	41.9	62.4	4.4	2.9
		L	31.0	91.3				
	2	S	15.4	60.7	43.5	68.0	3.9	2.5
		L	35.4	89.2				
4	S	12.5	65.3	57.3	76.4	5.2	3.9	
	L	21.8	85.5					
<i>Quercus borealis</i>	2	S	20.0	101.2	39.3	68.6	5.1	2.9
		L	50.9	147.4				
	3	S	12.3	120.8	35.8	68.4	9.8	5.1
		L	34.4	176.5				
	4	S	11.4	129.3	46.5	81.3	11.3	6.5
L		24.5	159.1					
5	S	—	—	—	—	—	15.1	
		L	9.3	140.3				

* S — initially small transplants, L — initially large transplants

Table 3

Height differences between 1-year-old shoot of initially large and small transplants after 1 and 4 vegetative seasons (on a 1-year-old and 4-year-old root)

Species	Number of winters of acorn storage	Height differences between initially large and small seedlings	
		Seedlings on 1-year-old root cm	Seedlings on 4-year-old root cm
<i>Quercus robur</i>	1	18.1	30.6
	2	20.3	31.0
	4	9.9	48.7
<i>Quercus borealis</i>	2	22.2	45.1
	3	31.1	53.3
	4	13.1	31.3

QUERCUS ROBUR L.

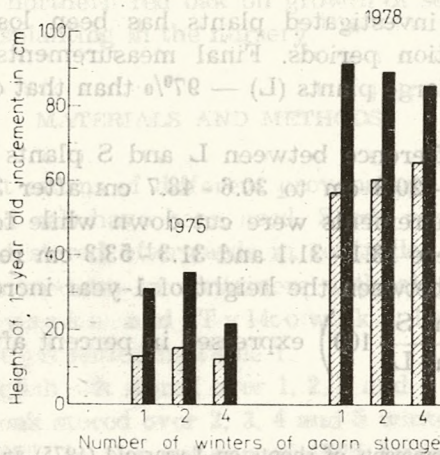


Fig. 1. Height of 1-year increments of the English oak on 1-year-old (1975) and 4-year-old (1978) roots of seedlings obtained from acorns stored over 1-4 winters. Hatched histograms — initially small plants, black histograms — initially large plants

fourth vegetative period was 41.9 - 57.3% and 62.4 - 76.4% respectively in the case of the English oak and 39.3 - 46.5% and 68.6 - 81.3% for the northern red oak. The higher values of this proportion concern 1-year increments of plants raised from acorns that were stored over the longest period (Figs 1 and 2, Table 2).

After completion of the experiment an arbitrary limits of height have been assumed which permit partition of 1-year shoot increments on 4-year-old roots into small and large ones. The following limits have been accepted for the English oak and the northern red oak respectively — 100 cm and 150 cm. It has been found that only 37.5 - 40.9% of plants initially accepted as large (L) and 4.8 - 13.6% of plants accepted previously as small (S) had after 3 consecutive trimmings 1-year increments equal or higher than 100 cm. Height of 1-year increments of the northern red oak plants (after 3 cuts) that were equal or higher than 150 cm were 52.0 - 80.0% of large plants (L) and 13.0 - 50.0% of small plants (S) (Table 4). It should be pointed out that in the case of the northern red oak the percentage of 1-year increments was higher than 150 cm (on 4-year roots) was greater for plants raised from acorns stored over a longer time.

DISCUSSION

Results of the present 3-year study concerning growth of 1-year-old oak plants raised from seeds stored over 1-5 winters are burdened with a certain error. This error could arise from the use of acorns of various

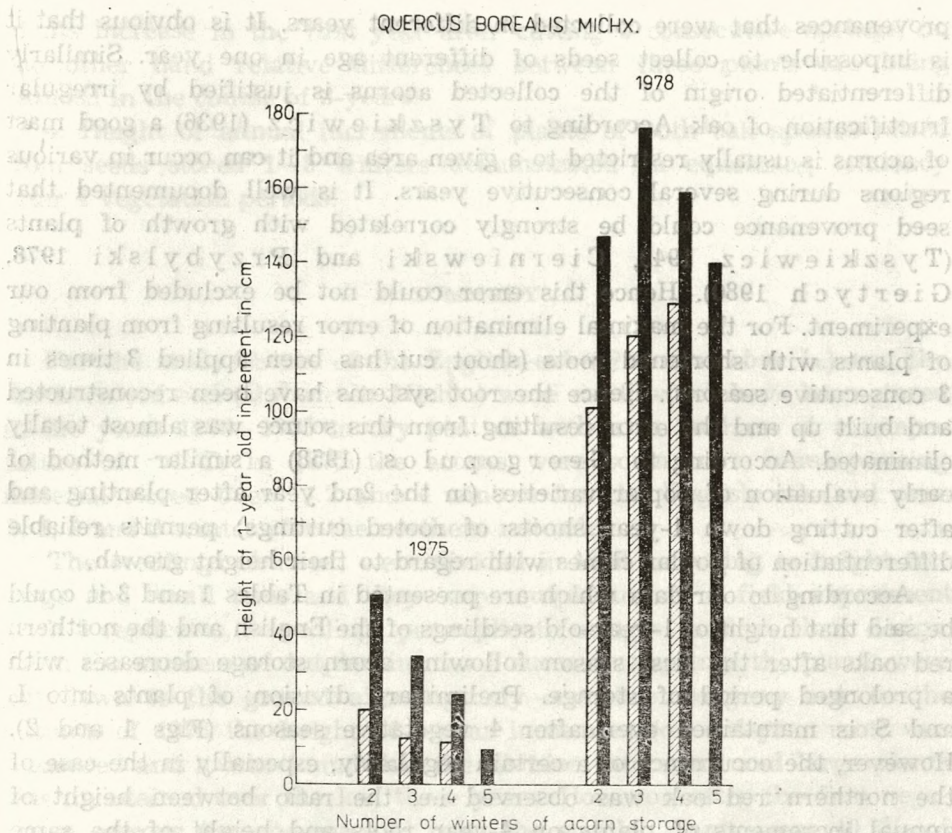


Fig. 2. Height of 1-year increments of the northern red oak on 1-year-old (1975) and 4-years-old (1978) roots of seedlings obtained from acorns stored over 2-5 winters. Hatched histograms — initially small plants, black histograms — initially large plants

Table 4

Percentage of the English oak plants with 1-year-old increment above 100 cm and the northern red oak plants with 1-year-old increment ≥ 150 cm (always on 4-years roots)

Species	Number of winters of acorn storage	One-year increment above 100 cm (<i>Q. robur</i>) or above 150 cm (<i>Q. borealis</i>)	
		L %	S %
<i>Quercus robur</i>	1	40.0	9.5
	2	40.9	13.6
	4	37.5	4.8
<i>Quercus borealis</i>	2	52.0	13.0
	3	76.0	20.8
	4	80.0	23.5
	5	-	50.0

L — initially large transplants, S — initially small transplants

provenances that were collected in different years. It is obvious that it is impossible to collect seeds of different age in one year. Similarly differentiated origin of the collected acorns is justified by irregular fructification of oak. According to Tyszkiewicz (1936) a good mast of acorns is usually restricted to a given area and it can occur in various regions during several consecutive years. It is well documented that seed provenance could be strongly correlated with growth of plants (Tyszkiewicz 1949, Cierniewski and Przybylski 1978, Giertych 1980). Hence this error could not be excluded from our experiment. For the maximal elimination of error resulting from planting of plants with shortened roots (shoot cut has been applied 3 times in 3 consecutive seasons). Hence the root systems have been reconstructed and built up and the error resulting from this source was almost totally eliminated. According to Georgopoulos (1958) a similar method of early evaluation of poplar varieties (in the 2nd year after planting and after cutting down 1-year shoots of rooted cuttings) permits reliable differentiation of poplar clones with regard to their height growth.

According to our data which are presented in Tables 1 and 3 it could be said that height of 1-year-old seedlings of the English and the northern red oaks after the first season following acorn storage decreases with a prolonged period of storage. Preliminary division of plants into L and S is maintained even after 4 vegetative seasons (Figs 1 and 2). However, the occurrence of a certain regularity, especially in the case of the northern red oak was observed i.e. the ratio between height of annual increments of plants on 4-year roots and height of the same plants when 1-year-old increased with the age of the stored acorns (Table 2). The value of this ratio in the case of S plants increased more dynamically than in L plants. The above regularity which was observed after 4 vegetative seasons permits the suggestion that in the next years differences between height of small and large plants will be reduced independently of the time of acorn storage.

Small height of the English oak plants raised from seeds that were stored over 1 winter resulted presumably from the low quality of the used acorns.

CONCLUSIONS

1. Height of 1-year-old seedlings of the English and the northern red oaks decreases with prolonged time of acorn storage.
2. Preliminary (after the 1st vegetative period) division of plants into small and large ones is maintained after 4 vegetative seasons despite the yearly cutting of 1-year increments.
3. Height differences between 1-year increments of big and small

plants increase in the first year after cutting 3 consecutive springs, on the other hand relative differences between these plants are being reduced in the course of 3-years.

4. Height of annual increments of plants of both oak species raised from seeds stored 1-5 winters demonstrated an equalizing tendency after 4 vegetation periods.

SUMMARY

For the study acorns of the English oak (*Quercus robur* L.) and the northern red oak (*Q. borealis* Michx.) were used, which have been stored in the years 1970-1975 in dry peat or without a medium at a temperature of -1°C . In 1975 the acorns were sown in a nursery using material stored over 1, 2 and 4 winters for the English oak and over 2, 3, 4 and 5 winters for the northern red oak.

The seedlings obtained were divided in 1976 according to height into large and small ones and they were outplanted in a field experiment with 5 replicates, 5 seedlings per replicate using a random block design. From the moment of outplanting for 3 successive springs the plants were cut down to the ground allowing only one shoot to grow out. In the autumn of 1978 the height of 1-year increment (on a 4-year root) was measured and it was found that the division into small and large plants was maintained over the last three years. However, after the first vegetative seasons (on one-year-old root) the smaller plants were 40.5% of the bigger ones for the English oak and 47.5% for the northern red oak while after 3 seasons (on a 4-years-old root) respective values were 68.9% and 72.8%.

The experiment has shown that the decline in seedling height obtained with the number of years of storage disappears after a few trimmings and is later undertaken with a considerable intensity. Long term storage of acorns does not appear to have any permanently negative effects on the growth of seedling obtained.

Institute of Dendrology
62-035 Kórnik, Poland

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TADEUSZ TYLKOWSKI

Wzrost na wysokość jednorocznych pędów dębu szypułkowego (*Quercus robur* L. i dębu czerwonego (*Q. borealis* Michx. = *Q. rubra* L.) na czteroletnim korzeniu siewek z żołądzi przechowywanych przez 1-5 zim

Streszczenie

Do badań użyto żołądzi dębu szypułkowego (*Quercus robur* L.) i dębu czerwonego (*Q. borealis* Michx.), które przechowywano w latach 1970-1975 w suchym torfie lub bez podłoża w temperaturze -1°C . W roku 1975 wysiano w szkółce żołądzie dębu szypułkowego przechowywane przez 1, 2 i 4 zimy oraz żołądzie dębu czerwonego przechowywane przez 2, 3, 4 i 5 zim.

Uzyskane siewki podzielono na podstawie wysokości na duże i małe, a wiosną

1976 r. posadzono je w doświadczeniu polowym w 5 powtórzeniach po 5 sadzonek w układzie bloków losowanych. Od momentu wysadzenia przez 3 kolejne wiosny przycinano sadzonki do powierzchni gruntu na bezpieki pozwalając wyrosnąć tylko 1 pędowi. Jesienią 1978 r. dokonano pomiaru wysokości jednorocznego przyrostu (na czteroletnim korzeniu) i stwierdzono, że podział na małe i duże rośliny utrzymał się przez ostatnie 3 lata. Po pierwszym okresie wegetacyjnym wysokość jednorocznych przyrostów siewek małych (na jednorocznym korzeniu) wynosiła 40,5% wysokości siewek dużych dębu szypułkowego i 47,5% wysokości siewek dużych dębu czerwonego, natomiast po 3 sezonach wegetacyjnych (na czteroletnim korzeniu) odpowiednio 68,9% i 72,8%.

W doświadczeniu tym wykazano, że słabnący w miarę przedłużania przechowywania wzrost siewek uzyskanych z przechowywanych żołędzi jest po kilku przycięciach podejmowany na nowo z dużą intensywnością. Długoletnie przechowywanie żołędzi nie wywołuje więc, jak się zdaje, trwale ujemnych skutków we wzroście siewek.

ТАДЕУШ ТЫЛЬКОВСКИ

Rost po wysokości 1-letnich pobегов дуба черешчатого (Quercus robur L.) и дуба красного (Q. borealis Michx. = Q. rubra L.) четырехлетних сеянцев выращенных с желудей хранимых в течение 1-5 зим

Резюме

Исследования проводили на желудях дуба черешчатого (*Quercus robur* L.) и дуба красного (*Q. borealis* Michx.), которые хранились в 1970-1975 гг. в сухом торфу либо без субстрата при температуре -1°C . В 1975 году выселили в питомнике желуды дуба черешчатого, которые до этого хранили в течение 1, 2 и 4 зим и желуды дуба красного хранившиеся 2, 3, 4 и 5 зим.

Полученные сеянцы разделили по высоте на большие и малые. Их высадили в полевых условиях по 5 саженцев в 5 повторностях при рандомизированном размещении блоков. Начиная с момента посадки, в течение 3 весен, саженцы подрезывали до уровня земли, оставляя на них только один побег. Осенью 1978 года была замерена высота однолетнего побега (на четырехлетнем корне). Отмечено, что разделение на большие и малые растения удерживалось последние 3 года. После первого вегетационного сезона высота однолетних приростов малых сеянцев (на однолетнем корне) равнялась 40,5% высоты больших сеянцев дуба черешчатого и 47,5% высоты больших сеянцев дуба красного, а после 3 вегетационных периодов соответственно 68,9% и 72,8%.

В этом опыте было доказано, что ослабевающий по мере продления периода хранения рост саженцев выращенных с хранимых желудей, заново возрастает с большой интенсивностью после нескольких подрезок. Таким образом, очевидно, многолетнее хранение желудей не сказывается отрицательно на росте сеянцев.

1976 r. porażono je w doświadczaniu polowym w 2 powtórzeniach po 3 zaszczepki w najbardziej korzystnych warunkach. Od momentu wysadzenia przez 3 kolejne lata przycinano zaszczepki do powiększenia ich na bieżąco. W tym celu wycięto w nich 1-2 gałęzie, które w poprzednim roku były już w pełni rozwinięte. W tym celu wycięto w nich 1-2 gałęzie, które w poprzednim roku były już w pełni rozwinięte. W tym celu wycięto w nich 1-2 gałęzie, które w poprzednim roku były już w pełni rozwinięte.

ТАБЛИЦА ТИПОВЫХ РЕЗУЛЬТАТОВ РАБОТЫ

№	№	№	№	№	№	№	№	№	№
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20

Резюме

В работе описаны результаты работы по созданию высокопродуктивных насаждений из дуба (Quercus robur L.) в условиях лесного хозяйства. В 1970-1973 гг. в питомнике жемчужины созданы насаждения из дуба, которые характеризуются высокой продуктивностью. В 1975 году выяснено, что насаждения жемчужины имеют высокую продуктивность. В 1975 году выяснено, что насаждения жемчужины имеют высокую продуктивность. В 1975 году выяснено, что насаждения жемчужины имеют высокую продуктивность.